# Spark Fundamentals

*Creating a Spark application*

## Contents

## Creating a Spark application

This lab exercise will show you how to create a Spark application, link and compile it with the respective programming languages, and run the applications on the Spark cluster.  The goal of this lab exercise is to show you how to create and run a Spark program. It is not to focus on how to program in Scala, Python, or Java. The business logic can be anything you need it to be for your application.

After completing this hands-on lab, you should be able to:

- Create, compile, and run Spark applications using Scala, Java and Python

Allow 30-60 minutes to complete this section of lab.

## 1.1 Creating a Spark application using Scala

The full class is available on the image under the *examples* subfolder of Spark or you can also find it on Spark's website. In this exercise, you will go through the steps needed to create a SparkPi program, to estimate the value of Pi. Remember that the goal of these applications is to learn the context of Spark, and not necessarily programming in Scala.

The application will be packaged using SBT. This has been set up on the system already and added to the $PATH variable, so you can invoke it anywhere.

__1. Open up a docker terminal.

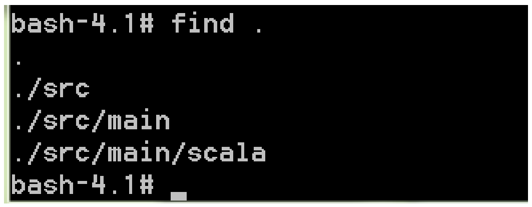
__2. Create a new subdirectory /home/virtuser/SparkPi:

mkdir -p /home/virtuser/SparkPi

__3. Under the SparkPi directory, set up the typical directory structure for your application. Once that is in place and you have your application code written, you can package it up into a JAR using sbt and run it using spark-submit.

mkdir -p /home/virtuser/SparkPi/src/main/scala

Your directory should look like this:



```
bash-4.1# find .
.
./src
./src/main
./src/main/scala
bash-4.1# _
```

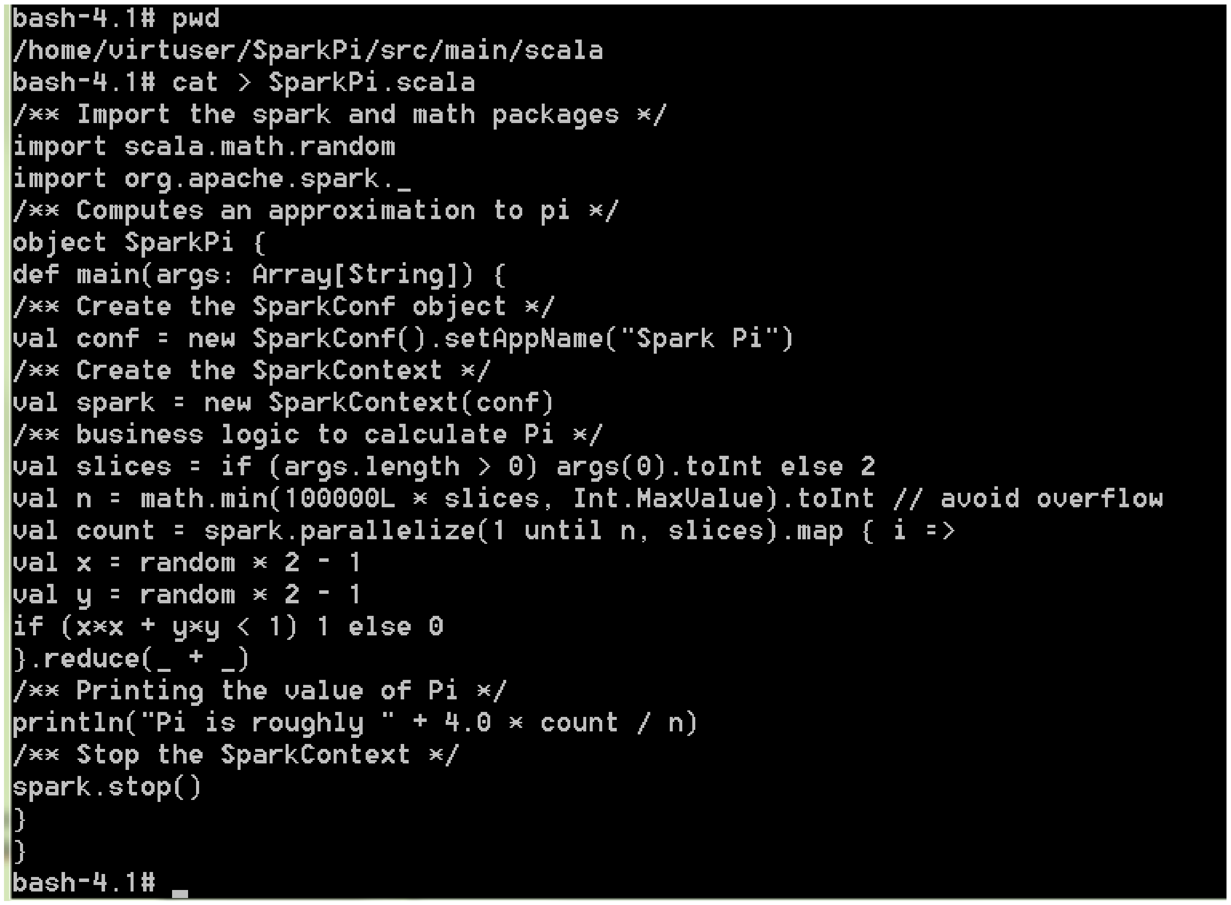
__4. The *SparkPi.scala* file will be under *src/main/scala/* directory. Change to the scala directory and create this file:

```
cat > SparkPi.scala
```

__5. At this point, copy and paste the contents here into the newly created file:

```
/** Import the spark and math packages */

import scala.math.random

import org.apache.spark._

/** Computes an approximation to pi */

object SparkPi {

def main(args: Array[String]) {

/** Create the SparkConf object */
val conf = new SparkConf().setAppName("Spark Pi")

/** Create the SparkContext */

val spark = new SparkContext(conf)

/** business logic to calculate Pi */

val slices = if (args.length > 0) args(0).toInt else 2

val n = math.min(100000L * slices, Int.MaxValue).toInt // avoid
overflow

val count = spark.parallelize(1 until n, slices).map { i =>

val x = random * 2 - 1

val y = random * 2 - 1

if (x*x + y*y < 1) 1 else 0

}.reduce(_ + _)

/** Printing the value of Pi */

println("Pi is roughly " + 4.0 * count / n)

/** Stop the SparkContext */

spark.stop()

}

}
```

__6. To quit out of the file, type CTRL + D



```
bash-4.1# pwd
/home/virtuser/SparkPi/src/main/scala
bash-4.1# cat > SparkPi.scala
/** Import the spark and math packages */
import scala.math.random
import org.apache.spark._
/** Computes an approximation to pi */
object SparkPi {
def main(args: Array[String]) {
/** Create the SparkConf object */
val conf = new SparkConf().setAppName("Spark Pi")
/** Create the SparkContext */
val spark = new SparkContext(conf)
/** business logic to calculate Pi */
val slices = if (args.length > 0) args(0).toInt else 2
val n = math.min(100000L * slices, Int.MaxValue).toInt // avoid overflow
val count = spark.parallelize(1 until n, slices).map { i =>
val x = random * 2 - 1
val y = random * 2 - 1
if (x*x + y*y < 1) 1 else 0
}.reduce(_ + _)
/** Printing the value of Pi */
println("Pi is roughly " + 4.0 * count / n)
/** Stop the SparkContext */
spark.stop()
}
}
bash-4.1# _
```

__7. Remember, you can have any business logic you need for your application in your scala class. This is just a sample class. Let's spend a few moments analyzing the content of SparkPi.scala. Type in the following to view the content:

```
more SparkPi.scala
```

__8. The next two lines are the required packages for this application.

```
import scala.math.random

import org.apache.spark._
```

__9. Next you create the SparkConf object to define the application's name.

```
val conf = new SparkConf().setAppName("Spark Pi")
```

__10. Create the SparkContext:

```
val spark = new SparkContext(conf)
```

__11. The rest that follows is the business logic required to calculate the value of Pi.

```
val slices = if (args.length > 0) args(0).toInt else 2
val n = math.min(100000L * slices, Int.MaxValue).toInt // avoid
overflow
```

__12. Create an RDD by using transformations and actions:

```
val count = spark.parallelize(1 until n, slices).map { i =>

val x = random * 2 - 1

val y = random * 2 - 1

if (x*x + y*y < 1) 1 else 0

}.reduce(_ + _)
```

__13. Print out the value of Pi:

```
println("Pi is roughly " + 4.0 * count / n)
```

__14. Finally, the last line is to stop the SparkContext:

```
spark.stop()
```

__15. At this point, you have completed the SparkPi.scala class. The application depends on the Spark API, so you will also include a sbt configuration file, SparkPi.sbt. This file adds a repository that Spark depends on. Change to the home directory of the SparkPi folder:

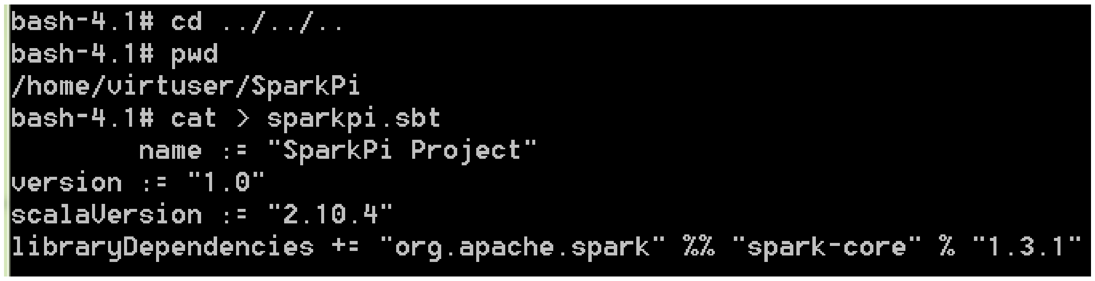
cd ../../..

__16. and create this file.

```
cat > sparkpi.sbt
```

__17. Copy and paste this into the sparkpi.sbt file:

```
name := "SparkPi Project"

version := "1.0"

scalaVersion := "2.10.4"

libraryDependencies += "org.apache.spark" %% "spark-core" % "1.3.1"
```



```
bash-4.1# cd ../../..
bash-4.1# pwd
/home/virtuser/SparkPi
bash-4.1# cat > sparkpi.sbt
        name := "SparkPi Project"
version := "1.0"
scalaVersion := "2.10.4"
libraryDependencies += "org.apache.spark" %% "spark-core" % "1.3.1"
```

__18. Now your folder structure under SparkPi should look like this:

```
./sparkpi.sbt

./src

./src/main

./src/main/scala

./src/main/scala/SparkPi.scala
```

__19. While in the top directory of the SparkPi application, run the sbt tool to create the JAR file:

```
sbt package
```

It will take a long time to create the package initially because of all the dependencies. Step out for a cup of coffee or tea or grab a snack.

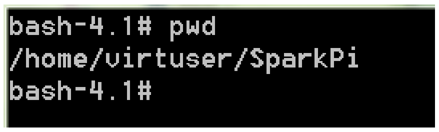
Note: You may need to return back into the bash and start the Hadoop service. Use these commands

docker start bdu_spark

docker attach bdu_spark

/etc/bootstrap.sh

__20. Make sure you are in your SparkPi directory.

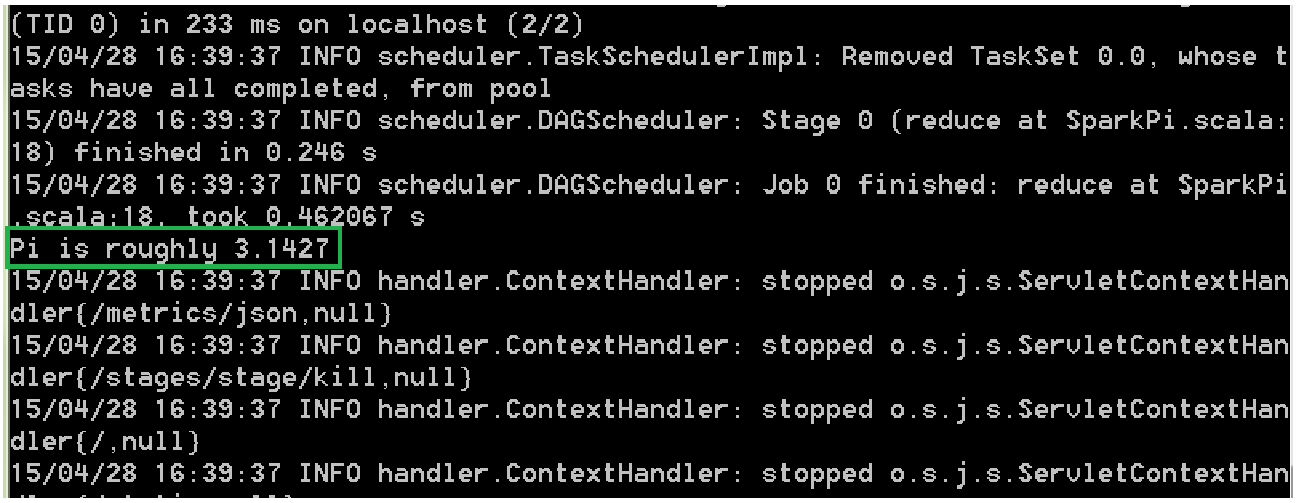


```
bash-4.1# pwd
/home/virtuser/SparkPi
bash-4.1#
```

__21. Use spark-submit to run the application.

```
$SPARK_HOME/bin/spark-submit \

--class "SparkPi" \

--master local[4] \

target/scala-2.10/sparkpi-project_2.10-1.0.jar
```

__22. In the midst of all the output, you should be able to find out the calculated value of Pi.



```
(TID 0) in 233 ms on localhost (2/2)
15/04/28 16:39:37 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 0.0, whose t
asks have all completed, from pool
15/04/28 16:39:37 INFO scheduler.DAGScheduler: Stage 0 (reduce at SparkPi.scala:
18) finished in 0.246 s
15/04/28 16:39:37 INFO scheduler.DAGScheduler: Job 0 finished: reduce at SparkPi
.scala:18, took 0.462067 s
Pi is roughly 3.1427
15/04/28 16:39:37 INFO handler.ContextHandler: stopped o.s.j.s.ServletContextHan
dler{/metrics/json,null}
15/04/28 16:39:37 INFO handler.ContextHandler: stopped o.s.j.s.ServletContextHan
dler{/stages/stage/kill,null}
15/04/28 16:39:37 INFO handler.ContextHandler: stopped o.s.j.s.ServletContextHan
dler{/,null}
15/04/28 16:39:37 INFO handler.ContextHandler: stopped o.s.j.s.ServletContextHan
```

__23. Congratulations, you created and ran a Spark application using Scala!

## 1.2 Creating a Spark application using Java – REFERENCE ONLY

This section is provided as **A REFERENCE ONLY**. I will not be going through this.

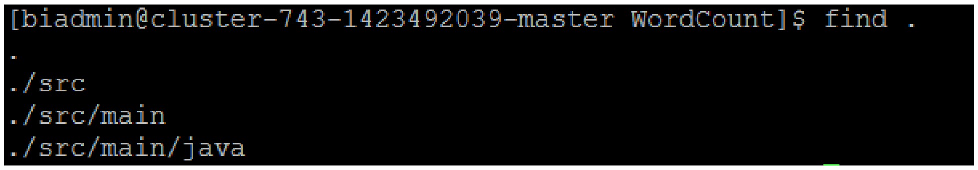
The full class is available on the image under the *examples* subfolder of Spark or you can also find it on Spark's website. In this exercise, you will go through the steps needed to create a WordCount program.

The application will be packaged using Maven, but any similar system build will work. This has been set up on the system already and added to the $PATH variable, so you can invoke it anywhere.

__1. Open up a terminal.

__2. Navigate to your home directory (e.g. /home/virtuser) and create a new subdirectory, WordCount.

__3. Under the WordCount directory, set up the typical directory structure for your application. Once that is in place and you have your application code written, you can package it up into a JAR using mvn and run it using spark-submit. Your directory should look like this:



```
[biadmin@cluster-743-1423492039-master WordCount]$ find .
.
./src
./src/main
./src/main/java
```

__4. The *WordCount.java* file will be under *src/main/java/* directory. Change to the java directory and create this file:

```
cat > WordCount.java
```

__5. At this point, copy and paste the contents here into the newly created file:

```
/** Import the required classes */

import scala.Tuple2;

import org.apache.spark.SparkConf;

import org.apache.spark.api.java.JavaPairRDD;

import org.apache.spark.api.java.JavaRDD;

import org.apache.spark.api.java.JavaSparkContext;

import org.apache.spark.api.java.function.FlatMapFunction;

import org.apache.spark.api.java.function.Function2;

import org.apache.spark.api.java.function.PairFunction;

import java.util.Arrays;

import java.util.List;

import java.util.regex.Pattern;


/** Setting up the class */

public final class WordCount {

private static final Pattern SPACE = Pattern.compile(" ");

public static void main(String[] args) throws Exception {

if (args.length < 1) {

System.err.println("Usage: JavaWordCount <file>");

System.exit(1);

}


/** Create the SparkConf */

SparkConf sparkConf = new SparkConf().setAppName("WordCount");
```

```
/** Create the SparkContext*/

JavaSparkContext ctx = new JavaSparkContext(sparkConf);


/** Create the RDDs and apply transformation and actions on them */

JavaRDD<String> lines = ctx.textFile(args[0], 1);

JavaRDD<String> words = lines.flatMap(new FlatMapFunction<String,
String>() {

@Override

public Iterable<String> call(String s) {

return Arrays.asList(SPACE.split(s));

}

});


/** Mapping each word to a 1 */

JavaPairRDD<String, Integer> ones = words.mapToPair(new
PairFunction<String, String, Integer>() {

@Override

public Tuple2<String, Integer> call(String s) {

return new Tuple2<String, Integer>(s, 1);

}

});


/** Adding up the values */

JavaPairRDD<String, Integer> counts = ones.reduceByKey(new
Function2<Integer, Integer, Integer>() {

@Override

public Integer call(Integer i1, Integer i2) {

return i1 + i2;
}
});

/** Invoke an action to get it to return the values */
List<Tuple2<String, Integer>> output = counts.collect();
for (Tuple2<?,?> tuple : output) {
System.out.println(tuple._1() + ": " + tuple._2());
}

/** Stop the SparkContext */
ctx.stop();
}
}
```

__6. To quit out of the file, type CTRL + D

__7. Remember, you can have any business logic you need for your application in your java class. This is just one example. Let's spend a few moments analyzing the content of WordCount.java. Type in the following to view the content:

```
more WordCount.java
```

__8. The next several lines are the required packages for this application.

```
import scala.Tuple2;
import org.apache.spark.SparkConf;
import org.apache.spark.api.java.JavaPairRDD;
import org.apache.spark.api.java.JavaRDD;
import org.apache.spark.api.java.JavaSparkContext;
import org.apache.spark.api.java.function.FlatMapFunction;
import org.apache.spark.api.java.function.Function2;
import org.apache.spark.api.java.function.PairFunction;
import java.util.Arrays;

import java.util.List;

import java.util.regex.Pattern;
```

__9. Set up the class and then create the SparkConf object to define the application's name.

```
val conf = new SparkConf().setAppName("Spark Pi")
```

__10. Create the SparkContext – in Java this is called JavaSparkContext but we will use SparkContext for short:

```
JavaSparkContext ctx = new JavaSparkContext(sparkConf);
```

__11. The rest that follows is the business logic required to do a word count. You have seen this before, so I will not go over it here.

__12. Print out the value.

```
/** Invoke an action to get it to return the values */

List<Tuple2<String, Integer>> output = counts.collect();

for (Tuple2<?,?> tuple : output) {

System.out.println(tuple._1() + ": " + tuple._2());

}
```

__13. Finally, the last line is to stop the SparkContext:

```
ctx.stop();
```

__14. At this point, you have completed the WordCount.java class. The application depends on the Spark API, so you will also include a mvn configuration file, pom.xml This file adds a repository that Spark depends on. Change to the home directory of the WordCount folder and create this file.

```
cat > pom.xml
```

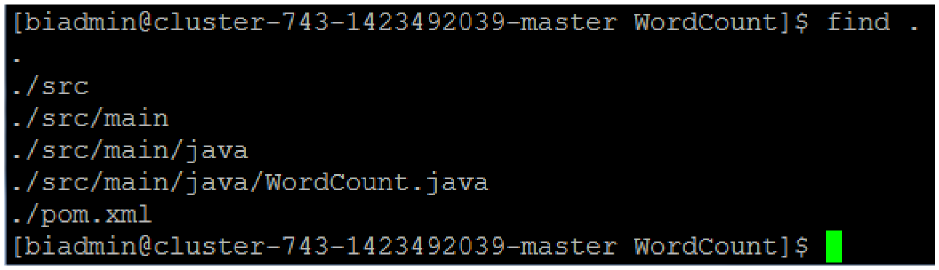
__15. Copy and paste this into the pom.xml file:

```
<project>

  <groupId>edu.berkeley</groupId>

  <artifactId>word-count</artifactId>

  <modelVersion>4.0.0</modelVersion>

  <name>Word Count</name>
```

```
    <packaging>jar</packaging>

    <version>1.0</version>

    <dependencies>

      <dependency> <!-- Spark dependency -->

        <groupId>org.apache.spark</groupId>

        <artifactId>spark-core_2.10</artifactId>

        <version>1.2.1</version>

      </dependency>

    </dependencies>

  </project>
```

__16. CTRL + D to exit out of the file.

__17. Now your folder structure under WordCount should look like this:

__18. 

```
[biadmin@cluster-743-1423492039-master WordCount]$ find .
.
./src
./src/main
./src/main/java
./src/main/java/WordCount.java
./pom.xml
[biadmin@cluster-743-1423492039-master WordCount]$ 
```

__19. While in the top directory of the WordCount application, run the mvn tool to create the JAR file:

```
mvn package
```

It will take a while to package the java class initially. Just like before with Scala, you can take another quick break while it is downloading the dependencies.

__20. Then, use spark-submit to run the application. Update the path of the README.md file to the appropriate path on HDFS

```
$SPARK_HOME/bin/spark-submit \

--class "WordCount" \

--master local[4] \

target/word-count-1.0.jar \

/tmp/README.md
```

__21. In the midst of everything, you should see the output of the application.

__22. Congratulations, you created and ran a Spark application using Java!

## 1.3 Creating a Spark application using Python

For the Python example, you are going to create Python application to calculate Pi. Running Python application is actually quite simple. For applications that use custom classes or third-party libraries, you would add the dependencies to the spark-submit through its –py=files argument by packing them in a .zip file.

__23. Create a PythonPi directory under /home/virtuser.

mkdir /home/virtuser/PythonPi

__24. Change into the new PythonPi directory,

__25. Create a Python file. Type in:

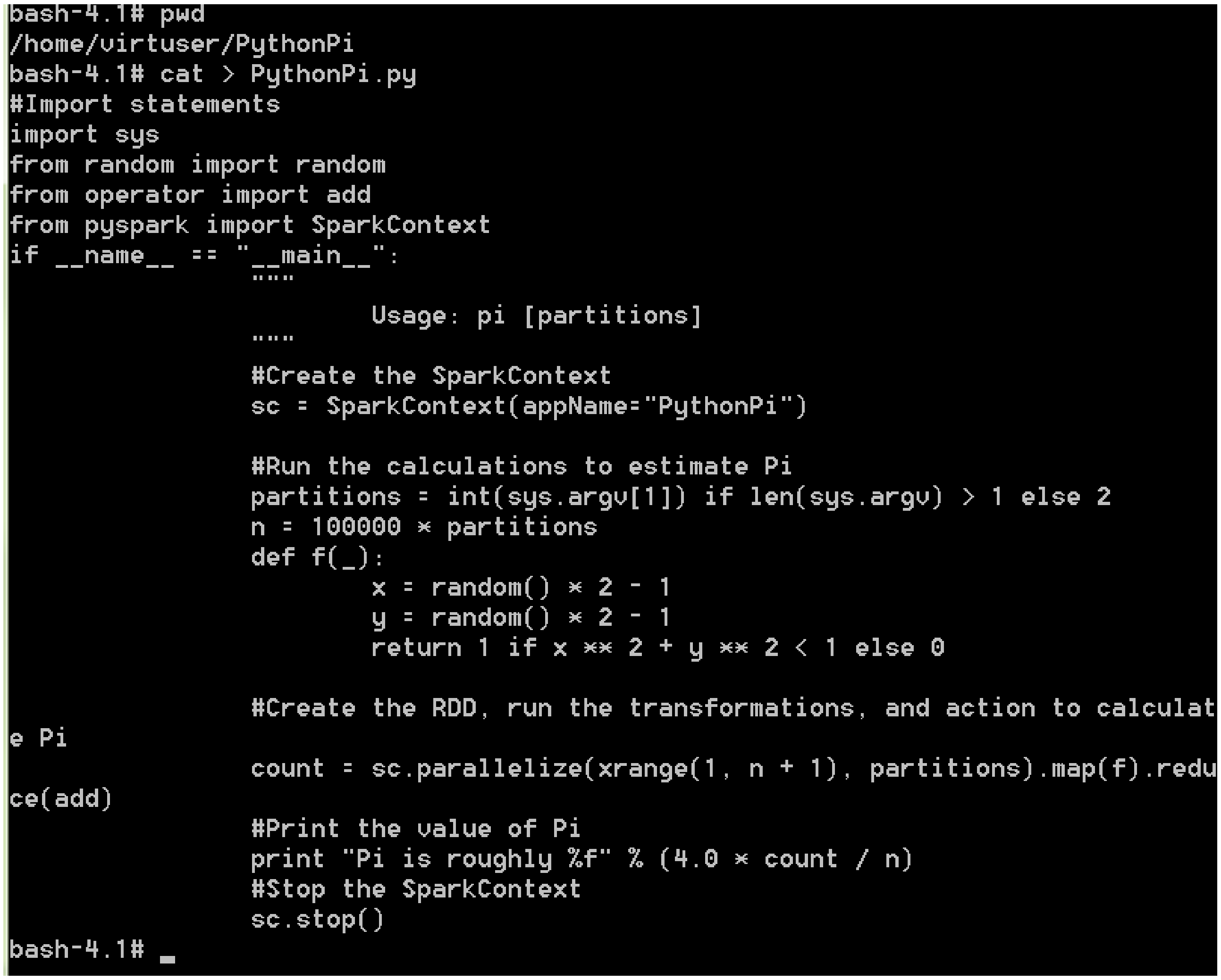
cat > PythonPi.py

__26. In PythonPi.py, paste these lines of code:

```
#Import statements

import sys

from random import random

from operator import add

from pyspark import SparkContext

if __name__ == "__main__":

      """

            Usage: pi [partitions]

      """

      #Create the SparkContext

      sc = SparkContext(appName="PythonPi")


      #Run the calculations to estimate Pi
```

```
        partitions = int(sys.argv[1]) if len(sys.argv) > 1 else 2

        n = 100000 * partitions

        def f(_):

              x = random() * 2 - 1

              y = random() * 2 - 1

              return 1 if x ** 2 + y ** 2 < 1 else 0


        #Create the RDD, run the transformations, and action to calculate
  Pi

        count = sc.parallelize(xrange(1, n + 1),
  partitions).map(f).reduce(add)

        #Print the value of Pi

        print "Pi is roughly %f" % (4.0 * count / n)

        #Stop the SparkContext

        sc.stop()
```

__27. CTRL+D to get out of the file.

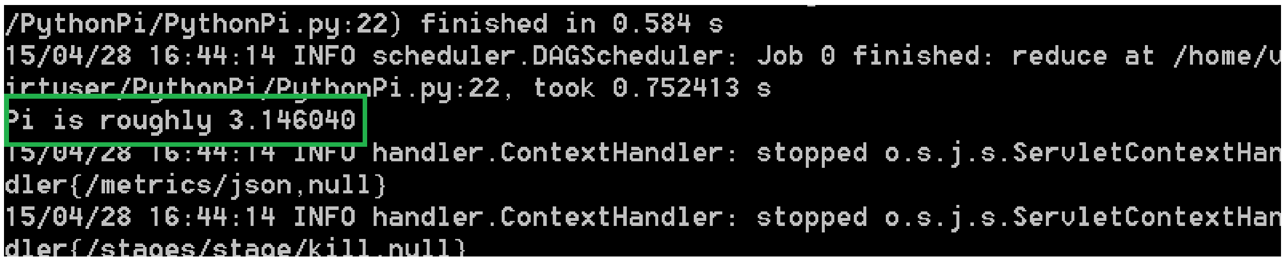


```
bash-4.1# pwd
/home/virtuser/PythonPi
bash-4.1# cat > PythonPi.py
#Import statements
import sys
from random import random
from operator import add
from pyspark import SparkContext
if __name__ == "__main__":
                """
                        Usage: pi [partitions]
                """
                #Create the SparkContext
                sc = SparkContext(appName="PythonPi")

                #Run the calculations to estimate Pi
                partitions = int(sys.argv[1]) if len(sys.argv) > 1 else 2
                n = 100000 * partitions
                def f(_):
                        x = random() * 2 - 1
                        y = random() * 2 - 1
                        return 1 if x ** 2 + y ** 2 < 1 else 0

                #Create the RDD, run the transformations, and action to calculat
e Pi
                count = sc.parallelize(xrange(1, n + 1), partitions).map(f).redu
ce(add)
                #Print the value of Pi
                print "Pi is roughly %f" % (4.0 * count / n)
                #Stop the SparkContext
                sc.stop()
bash-4.1# _
```

For Python classes, if you don't have any dependencies, then, use spark-submit to run the application. There's no need to package up the class.

```
$SPARK_HOME/bin/spark-submit \

--master local[4] \

PythonPi.py
```

__28. Again, in the midst of the output, you should see the results of the application.



```
/PythonPi/PythonPi.py:22) finished in 0.584 s
15/04/28 16:44:14 INFO scheduler.DAGScheduler: Job 0 finished: reduce at /home/v
irtuser/PythonPi/PythonPi.py:22, took 0.752413 s
Pi is roughly 3.146040
15/04/28 16:44:14 INFO handler.ContextHandler: stopped o.s.j.s.ServletContextHan
dler{/metrics/json,null}
15/04/28 16:44:14 INFO handler.ContextHandler: stopped o.s.j.s.ServletContextHan
dler{/stages/stage/kill,null}
```

__29. Congratulations, you created and ran a Spark application using Python!

## Summary

Having completed this exercise, you should know how to create, compile and run a Scala and a Python application.  Each application requires some import statements followed by the creation of the SparkConf and a SparkContext to be use within the program. Once you have the SparkContext, you code up the business logic for the application. At the end of the application, be sure to stop the SparkContext. For all three types of application, you run it with spark-submit. If there are dependencies required, you would supply it alongside the code. You can use sbt, maven, or other system builds to create the JAR packages required for the application.

## NOTES

NOTES