> library(swirl)

| Hi! Type swirl() when you are ready to begin.

> swirl()

| Welcome to swirl!

| Please sign in. If you've been here before, use the same name as you did then. If you

| are new, call yourself something unique.

What shall I call you? Johnny

| Please choose a course, or type 0 to exit swirl.

1: R Programming

2: Take me to the swirl course repository!

Selection: 1

| Please choose a lesson, or type 0 to return to course menu.

1: Basic Building Blocks 2: Workspace and Files

3: Sequences of Numbers 4: Vectors

5: Missing Values 6: Subsetting Vectors

7: Matrices and Data Frames 8: Logic

9: Functions 10: lapply and sapply

11: vapply and tapply 12: Looking at Data

13: Simulation 14: Dates and Times

15: Base Graphics

Selection: 9

| | 0%

| Functions are one of the fundamental building blocks of the R language. They are

| small pieces of reusable code that can be treated like any other R object.

...

|== | 2%

| If you've worked through any other part of this course, you've probably used some

| functions already. Functions are usually characterized by the name of the function

| followed by parentheses.

...

|=== | 4%

| Let's try using a few basic functions just for fun. The Sys.Date() function returns a

| string representing today's date. Type Sys.Date() below and see what happens.

> Sys.Date()

[1] "2015-03-08"

| All that practice is paying off!

|===== | 6%

| Most functions in R return a value. Functions like Sys.Date() return a value based on

| your computer's environment, while other functions manipulate input data in order to

| compute a return value.

...

|====== | 8%

| The mean() function takes a vector of numbers as input, and returns the average of

| all of the numbers in the input vector. Inputs to functions are often called

| arguments. Providing arguments to a function is also sometimes called passing

| arguments to that function. Arguments you want to pass to a function go inside the

| function's parentheses. Try passing the argument c(2, 4, 5) to the mean() function.

> mean(c(2, 5, 5))

[1] 4

| You almost had it, but not quite. Try again. Or, type info() for more options.

| Compute the average of 2, 4, and 5 by typing: mean(c(2, 4, 5))

> mean(c(2, 4, 5))

[1] 3.666667

| Your dedication is inspiring!

|======== | 10%

| Functions usually take arguments which are variables that the function operates on.

| For example, the mean() function takes a vector as as argument, like in the case of

| mean(c(2,6,8)). The mean() function then adds up all of the numbers in the vector and

| divides that sum by the length of the vector.

...

|========== | 12%

| In the following question you will be asked to modify a script that will appear as

| soon as you move on from this question. When you have finished modifying the script,

| save your changes to the script and type submit() and the script will be evaluated.

| There will be some comments in the script that opens up, so be sure to read them!

Now edit and save the R script boring\_function.R.

# You're about to write your first function! Just like you would assign a value

# to a variable with the assignment operator, you assign functions in the following

# way:

#

# function\_name <- function(arg1, arg2){

# # Maipulate arguments in some way

# # Return a value

# }

#

# The "variable name" you assign will become the name of your function. arg1 and

# arg2 represent the arguments of your function. You can maipulate the arguments

# you specify within the function. After sourcing the function, you can use the

# function by typing:

#

# function\_name(value1, value2)

#

# Below we will create a function called boring\_function. This function takes

# the argument `x` as input, and returns the value of x without modifying it.

# Delete the pound sign in front of the x to make the function work! Be sure to

# save this script and type submit() in the console after you make your changes.

boring\_function <- function(x) {

x

}

Back to console.

|=========== | 15%

| The last R expression to be evaluated in a function will become the return value of

| that function. We want this function to take one argument, x, and return x without

| modifying it. Delete the pound sign so that x is returned without any modification.

| Make sure to save your script before you type submit().

> submit()

| Sourcing your script...

| Great job!

|============= | 17%

| Now that you've created your first function let's test it! Type: boring\_function('My

| first function!'). If your function works, it should just return the string: 'My

| first function!'

> boring\_function('my first function!')

[1] "my first function!"

| Keep trying! Or, type info() for more options.

| Test boring\_function by typing: boring\_function('My first function!')

> boring\_function('My first function!')

[1] "My first function!"

| Excellent work!

|=============== | 19%

| Congratulations on writing your first function. By writing functions, you can gain

| serious insight into how R works. As John Chambers, the creator of R once said:

|

| To understand computations in R, two slogans are helpful: 1. Everything that exists

| is an object. 2. Everything that happens is a function call.

...

|================ | 21%

| If you want to see the source code for any function, just type the function name

| without any arguments or parentheses. Let's try this out with the function you just

| created. Type: boring\_function to view its source code.

> boring\_function

function(x) {

x

}

| Your dedication is inspiring!

|================== | 23%

| Time to make a more useful function! We're going to replicate the functionality of

| the mean() function by creating a function called: my\_mean(). Remember that to

| calculate the average of all of the numbers in a vector you find the sum of all the

| numbers in the vector, and then divide that sum by the number of numbers in the

| vector.

...

|==================== | 25%

| Make sure to save your script before you type submit().

...

Now edit and save the R script my\_mean.R.

# You're free to implement the function my\_mean however you want, as long as it

# returns the average of all of the numbers in `my\_vector`.

#

# Hint #1: sum() returns the sum of a vector.

# Ex: sum(c(1, 2, 3)) evaluates to 6

#

# Hint #2: length() returns the size of a vector.

# Ex: length(c(1, 2, 3)) evaluates to 3

#

# Hint #3: The mean of all the numbers in a vector is equal to the sum of all of

# the numbers in the vector divided by the size of the vector.

#

# Note for those of you feeling super clever: Please do not use the mean()

# function while writing this function. We're trying to teach you something

# here!

#

# Be sure to save this script and type submit() in the console after you make

# your changes.

my\_mean <- function(my\_vector) {

# Write your code here!

# Remember: the last expression evaluated will be returned!

sum(my\_vector) / length(my\_vector)

}

Now back to R Console.

|==================== | 25%

| Make sure to save your script before you type submit().

> submit()

| Sourcing your script...

| Excellent job!

|===================== | 27%

| Now test out your my\_mean() function by finding the mean of the vector c(4, 5, 10).

> my\_mean(c(4, 5, 10))

[1] 6.333333

| You got it!

|======================= | 29%

| Next, let's try writing a function with default arguments. You can set default values

| for a function's argumets, and this can be useful if you think someone who uses your

| funciton will set a certain argument to the same value most of the time.

...

|======================== | 31%

| Make sure to save your script before you type submit().

Now edit and save remainder.R.

# Let me show you an example of a function I'm going to make up called

# increment(). Most of the time I want to use this function to increase the

# value of a number by one. This function will take two arguments: "number" and

# "by" where "number" is the digit I want to increment and "by" is the amount I

# want to increment "number" by. I've written the function below.

#

# increment <- function(number, by = 1){

# number + by

# }

#

# If you take a look in between the parentheses you can see that I've set

# "by" equal to 1. This means that the "by" argument will have the default

# value of 1.

#

# I can now use the increment function without providing a value for "by":

# increment(5) will evaluate to 6.

#

# However if I want to provide a value for the "by" argument I still can! The

# expression: increment(5, 2) will evaluate to 7.

#

# You're going to write a function called "remainder." remainder() will take

# two arguments: "num" and "divisor" where "num" is divided by "divisor" and

# the remainder is returned. Imagine that you usually want to know the remainder

# when you divide by 2, so set the default value of "divisor" to 2. Please be

# sure that "num" is the first argument and "divisor" is the second argument.

#

# Hint #1: You can use the modulus operator %% to find the remainder.

# Ex: 7 %% 4 evaluates to 3.

#

# Remember to set appropriate default values! Be sure to save this

# script and type submit() in the console after you write the function.

remainder <- function(num, divisor = 2) {

# Write your code here!

# Remember: the last expression evaluated will be returned!

num %% divisor

}

Now back to console.

> submit()

| Sourcing your script...

| You are amazing!

|========================== | 33%

| Let's do some testing of the remainder function. Run remainder(5) and see what

| happens.

> remainder(5)

[1] 1

| You are amazing!

|============================ | 35%

| Let's take a moment to examine what just happened. You provided one argument to the

| function, and R matched that argument to 'num' since 'num' is the first argument. The

| default value for 'divisor' is 2, so the function used the default value you

| provided.

...

|============================= | 38%

| Now let's test the remainder function by providing two arguments. Type: remainder(11,

| 5) and let's see what happens.

> remainder(11, 5)

[1] 1

| Perseverance, that's the answer.

|=============================== | 40%

| Once again, the arguments have been matched appropriately.

...

|================================ | 42%

| You can also explicitly specify arguments in a function. When you explicitly

| designate argument values by name, the ordering of the arguments becomes unimportant.

| You can try this out by typing: remainder(divisor = 11, num = 5).

> remainder(divisor = 11, num = 5)

[1] 5

| All that practice is paying off!

|================================== | 44%

| As you can see, there is a significant difference between remainder(11, 5) and

| remainder(divisor = 11, num = 5)!

...

|==================================== | 46%

| R can also partially match arguments. Try typing remainder(4, div = 2) to see this

| feature in action.

> remainder(4, div = 2)

[1] 0

| All that practice is paying off!

|===================================== | 48%

| A word of warning: in general you want to make your code as easy to understand as

| possible. Switching around the orders of arguments by specifying their names or only

| using partial argument names can be confusing, so use these features with caution!

...

|======================================= | 50%

| With all of this talk about arguments, you may be wondering if there is a way you can

| see a function's arguments (besides looking at the documentation). Thankfully, you

| can use the args() function! Type: args(remainder) to examine the arguments for the

| remainder function.

> args(remainder)

function (num, divisor = 2)

NULL

| You're the best!

|========================================= | 52%

| You may not realize it but I just tricked you into doing something pretty

| interesting! args() is a function, remainder() is a function, yet remainder was an

| argument for args(). Yes it's true: you can pass functions as arguments! This is a

| very powerful concept. Let's write a script to see how it works.

...

|========================================== | 54%

| Make sure to save your script before you type submit().

Now edit and save the R script evaluate.R.

# You can pass functions as arguments to other functions just like you can pass

# data to functions. Let's say you define the following functions:

#

# add\_two\_numbers <- function(num1, num2){

# num1 + num2

# }

#

# multiply\_two\_numbers <- function(num1, num2){

# num1 \* num2

# }

#

# some\_function <- function(func){

# func(2, 4)

# }

#

# As you can see we use the argument name "func" like a function inside of

# "some\_function()." By passing functions as arguments

# some\_function(add\_two\_numbers) will evaluate to 6, while

# some\_function(multiply\_two\_numbers) will evaluate to 8.

#

# Finish the function definition below so that if a function is passed into the

# "func" argument and some data (like a vector) is passed into the dat argument

# the evaluate() function will return the result of dat being passed as an

# argument to func.

#

# Hints: This exercise is a little tricky so I'll provide a few example of how

# evaluate() should act:

# 1. evaluate(sum, c(2, 4, 6)) should evaluate to 12

# 2. evaluate(median, c(7, 40, 9)) should evaluate to 9

# 3. evaluate(floor, 11.1) should evaluate to 11

evaluate <- function(func, dat){

# Write your code here!

# Remember: the last expression evaluated will be returned!

func(dat)

}

Now back to console.

> submit()

| Sourcing your script...

| You got it right!

|============================================ | 56%

| Let's take your new evaluate() function for a spin! Use evaluate to find the standard

| deviation of the vector c(1.4, 3.6, 7.9, 8.8).

> evaluate(std, c(1.4, 3.6, 7.9, 8.8))

Error in evaluate(std, c(1.4, 3.6, 7.9, 8.8)) : object 'std' not found

> evaluate(sd, c(1.4, 3.6, 7.9, 8.8))

[1] 3.514138

| Excellent work!

|============================================= | 58%

| The idea of passing functions as arguments to other functions is an important and

| fundamental concept in programming.

...

|=============================================== | 60%

| You may be surprised to learn that you can pass a function as an argument without

| first defining the passed function. Functions that are not named are appropriately

| known as anonymous functions.

...

|================================================= | 62%

| Let's use the evaluate function to explore how anonymous functions work. For the

| first argument of the evaluate function we're going to write a tiny function that

| fits on one line. In the second argument we'll pass some data to the tiny anonymous

| function in the first argument.

...

|================================================== | 65%

| Type the following command and then we'll discuss how it works:

| evaluate(function(x){x+1}, 6)

> evaluate(funcion(x){x+1}, 6)

Error: unexpected '{' in "evaluate(funcion(x){"

> evaluate

function(func, dat){

# Write your code here!

# Remember: the last expression evaluated will be returned!

func(dat)

}

| That's not the answer I was looking for, but try again. Or, type info() for more

| options.

| Just type the command evaluate(function(x){x+1}, 6)

> evaluate(function(x){x+1}, 6)

[1] 7

| Excellent job!

|==================================================== | 67%

| The first argument is a tiny anonymous function that takes one argument `x` and

| returns `x+1`. We passed the number 6 into this function so the entire expression

| evaluates to 7.

...

|====================================================== | 69%

| Try using evaluate() along with an anonymous function to return the first element of

| the vector c(8, 4, 0). Your anonymous function should only take one argument which

| should be a variable `x`.

> evaluate(function(x){x[1]}, c(8, 4, 0))

[1] 8

| You are quite good my friend!

|======================================================= | 71%

| Now try using evaluate() along with an anonymous function to return the last element

| of the vector c(8, 4, 0). Your anonymous function should only take one argument which

| should be a variable `x`.

> evaluate(function(x){x[-1]}, c(8, 4, 0))

[1] 4 0

| Nice try, but that's not exactly what I was hoping for. Try again. Or, type info()

| for more options.

| You may need to recall how to index vector elements. Remember that your anonymous

| function should only have one argument, and that argument should be named `x`. Using

| the length() function in your anonymous function may help you.

> evaluate(function(x){x[length(x)]}, c(8, 4, 0))

[1] 0

| That's a job well done!

|========================================================= | 73%

| For the rest of the course we're going to use the paste() function frequently. Type

| ?paste so we can take a look at the documentation for the paste function.

> ?paste

| You are amazing!

|========================================================== | 75%

| As you can see the first argument of paste() is `...` which is referred to as an

| ellipsis or simply dot-dot-dot. The ellipsis allows an indefinite number of arguments

| to be passed into a function. In the case of paste() any number of strings can be

| passed as arguments and paste() will return all of the strings combined into one

| string.

...

|============================================================ | 77%

| Just to see how paste() works, type paste("Programming", "is", "fun!")

> paste("Programming", "is", "fun!")

[1] "Programming is fun!"

| That's the answer I was looking for.

|============================================================== | 79%

| Time to write our own modified version of paste().

...

|=============================================================== | 81%

| Make sure to save your script before you type submit().

Now edit and save the R script telegram.R.

# The ellipses can be used to pass on arguments to other functions that are

# used within the function you're writing. Usually a function that has the

# ellipses as an argument has the ellipses as the last argument. The usage of

# such a function would look like:

#

# ellipses\_func(arg1, arg2 = TRUE, ...)

#

# In the above example arg1 has no default value, so a value must be provided

# for arg1. arg2 has a default value, and other arguments can come after arg2

# depending on how they're defined in the ellipses\_func() documentation.

# Interestingly the usage for the paste function is as follows:

#

# paste (..., sep = " ", collapse = NULL)

#

# Notice that the ellipses is the first argument, and all other arguments after

# the ellipses have default values. This is a strict rule in R programming: all

# arguments after an ellipses must have default values. Take a look at the

# simon\_says function below:

#

# simon\_says <- function(...){

# paste("Simon says:", ...)

# }

#

# The simon\_says function works just like the paste function, except the

# begining of every string is prepended by the string "Simon says:"

#

# Telegrams used to be peppered with the words START and STOP in order to

# demarcate the beginning and end of sentences. Write a function below called

# telegram that formats sentences for telegrams.

# For example the expression `telegram("Good", "morning")` should evaluate to:

# "START Good morning STOP"

telegram <- function(...){

paste("START", ..., "STOP", sep = " ")

}

Now back to console.

> submit()

| Sourcing your script...

| You are doing so well!

|================================================================= | 83%

| Now let's test out your telegram function. Use your new telegram function passing in

| whatever arguments you wish!

> telegram(c("Hello", "world", ",", "how", "are", "we", "today", "?"))

[1] "START Hello STOP" "START world STOP" "START , STOP" "START how STOP"

[5] "START are STOP" "START we STOP" "START today STOP" "START ? STOP"

| Nice work!

|=================================================================== | 85%

| Make sure to save your script before you type submit().

> play()

| Entering play mode. Experiment as you please, then type nxt() when you are ready to

| resume the lesson.

> telegram("Good", "morning")

[1] "START Good morning STOP"

> telegram(c("Good", "morning"))

[1] "START Good STOP" "START morning STOP"

> nxt()

| Resuming lesson...

| Make sure to save your script before you type submit().

Now edit and save the R script mad\_lib.R.

# Let's explore how to "unpack" arguments from an ellipses when you use the

# ellipses as an argument in a function. Below I have an example function that

# is supposed to add two explicitly named arguments called alpha and beta.

#

# add\_alpha\_and\_beta <- function(...){

# # First we must capture the ellipsis inside of a list

# # and then assign the list to a variable. Let's name this

# # variable `args`.

#

# args <- list(...)

#

# # We're now going to assume that there are two named arguments within args

# # with the names `alpha` and `beta.` We can extract named arguments from

# # the args list by used the name of the argument and double brackets. The

# # `args` variable is just a regular list after all!

#

# alpha <- args[["alpha"]]

# beta <- args[["beta"]]

#

# # Then we return the sum of alpha and beta.

#

# alpha + beta

# }

#

# Have you ever played Mad Libs before? The function below will construct a

# sentence from parts of speech that you provide as arguments. We'll write most

# of the function, but you'll need to unpack the appropriate arguments from the

# ellipses.

mad\_libs <- function(...){

# Do your argument unpacking here!

args <- list(...)

place <- args[["place"]]

adjective <- args[["adjective"]]

noun <- args[["noun"]]

# Don't modify any code below this comment.

# Notice the variables you'll need to create in order for the code below to

# be functional!

paste("News from", place, "today where", adjective, "students took to the streets in protest of the new", noun, "being installed on campus.")

}

Now back to console.

> submit()

| Sourcing your script...

| That's a job well done!

|==================================================================== | 88%

| Time to use your mad\_libs function. Make sure to name the place, adjective, and noun

| arguments in order for your function to work.

> mad\_libs(place = London, adjustive = "beautiful", noun = "dog")

Error in mad\_libs(place = London, adjustive = "beautiful", noun = "dog") :

object 'London' not found

> mad\_libs(place = "London", adjustive = "beautiful", noun = "dog")

[1] "News from London today where students took to the streets in protest of the new dog being installed on campus."

| Nice work!

|====================================================================== | 90%

| We're coming to the end of this lesson, but there's still one more idea you should be

| made aware of.

...

|======================================================================== | 92%

| You're familiar with adding, subtracting, multiplying, and dividing numbers in R. To

| do this you use the +, -, \*, and / symbols. These symbols are called binary operators

| because they take two inputs, an input from the left and an input from the right.

...

|========================================================================= | 94%

| In R you can define your own binary operators. In the next script I'll show you how.

...

|=========================================================================== | 96%

| Make sure to save your script before you type submit().

Now edit and save the R script bin\_op.R.

# The syntax for creating new binary operators in R is unlike anything else in

# R, but it allows you to define a new syntax for your function. I would only

# recommend making your own binary operator if you plan on using it often!

#

# User-defined binary operators have the following syntax:

# %[whatever]%

# where [whatever] represents any valid variable name.

#

# Let's say I wanted to define a binary operator that multiplied two numbers and

# then added one to the product. An implementation of that operator is below:

#

# "%mult\_add\_one%" <- function(left, right){ # Notice the quotation marks!

# left \* right + 1

# }

#

# I could then use this binary operator like `4 %mult\_add\_one% 5` which would

# evaluate to 21.

#

# Write your own binary operator below from absolute scratch! Your binary

# operator must be called %p% so that the expression:

#

# "Good" %p% "job!"

#

# will evaluate to: "Good job!"

"%p%" <- function(left, right){ # Remember to add arguments!

paste(left, right, sep = " ")

}

Now back to console.

> submit()

| Sourcing your script...

| Excellent job!

|============================================================================ | 98%

| You made your own binary operator! Let's test it out. Paste together the strings:

| 'I', 'love', 'R!' using your new binary operator.

> "I" %p% "love" % "R!"

Error: unexpected input in ""I" %p% "love" % "R!""

> "I" %p% "love" %p% "R!"

[1] "I love R!"

| You got it right!

|==============================================================================| 100%

| We've come to the end of our lesson! Go out there and write some great functions!