Functional Programming in R

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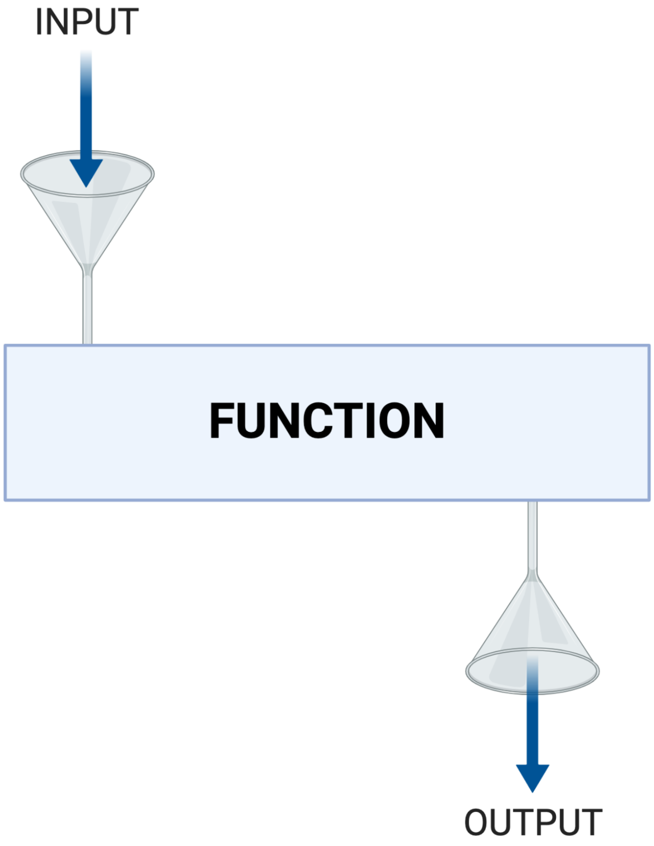
Outline

1. Functions
2. Iteration and Loop Functions
3. Conditional Statements

Functions

What is a function?

- A function is a reusable piece of code that does a specific task



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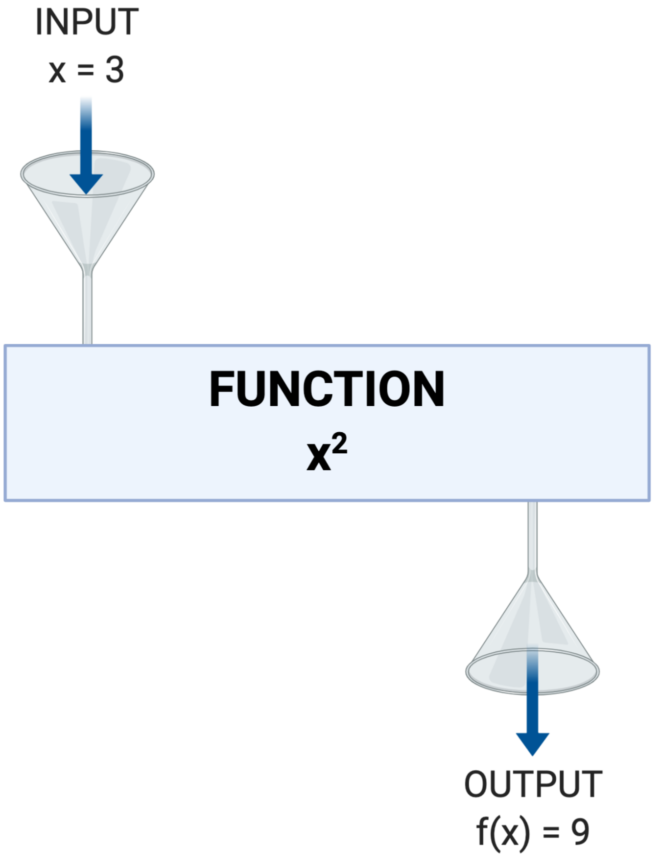
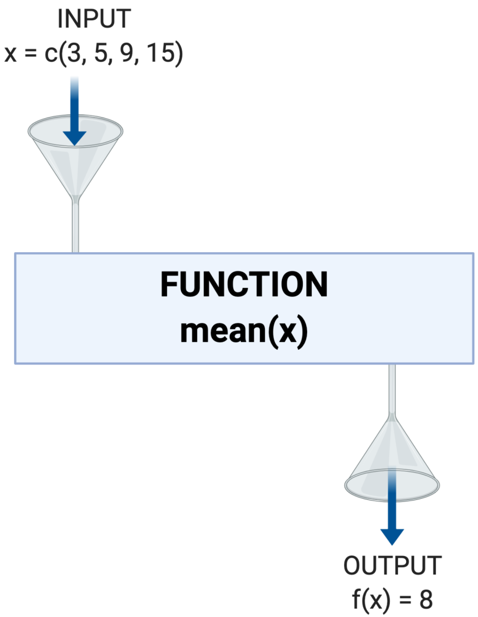


R has built in functions

- Schematic



INPUT
x = c(3, 5, 9, 15)

FUNCTION
mean(x)

OUTPUT
f(x) = 8

- R code

```
#input
x <- c(3,5,9,15)


#function
mean(x)
```

```
## [1] 8
```

Functions take arguments

- Function inputs are called arguments

- `mean()` has 3 arguments

- `?mean` to view arguments

- Arguments can be specified by *order* or *name*

```
x # a numeric vector

trim # fractions of outliers
     # you would like to
     # trim from each end

na.rm # option to remove
      # missing values
```

Packages also contain functions

```r
library(ggplot2)
ggplot(data = mtcars, aes(x = as.factor(cyl), y = mpg))+
  geom_boxplot()+
  xlab("cyl")
```

Function Syntax

A function is defined as follows:

```r
add_1 <- function(x){
  x + 1
}
```

We can break this down into:

- The signature (the user interface)

```r
add_1 <- function(x)
```

- The body (the code the function executes)

```r
{
  x + 1
}
```

3 Reasons to write functions

1. Code becomes easier to read & understand

Functions have evocative names e.g. mean(), sum(), sd()

2. Code becomes easier to change

add_1 <- function(x){x + 1} can easily become add_2 <- function(x){x + 2}

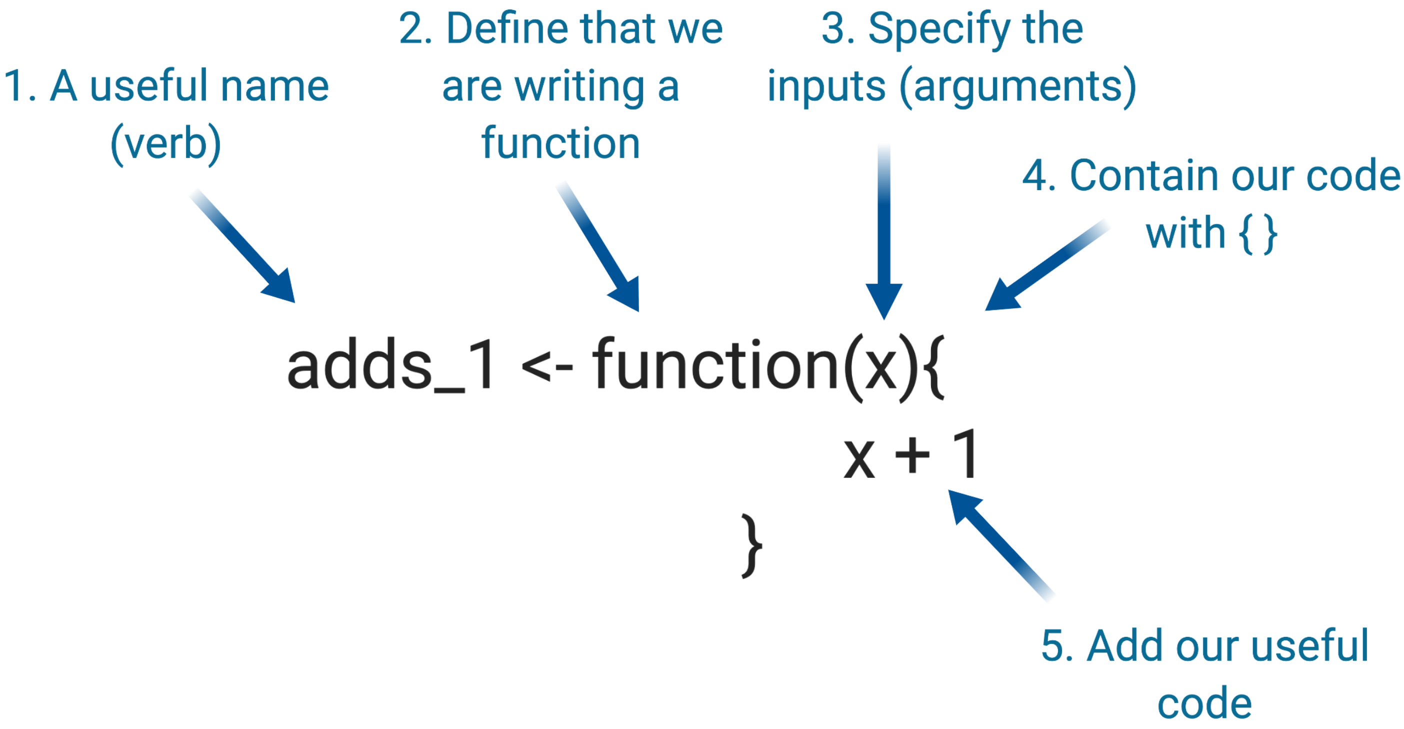
3. Less mistakes

No copy and pasting chunks of code

"You should consider writing a function whenever you've copied and pasted a block of code more than twice"

Hadley Wickham

Writing your own function (Step by Step)



1. A useful name (verb)

2. Define that we are writing a function

3. Specify the inputs (arguments)

4. Contain our code with { }

```
adds_1 <- function(x){
                  x + 1
              }
```

5. Add our useful code

Embedding Functions

This code:

```r
exp_1 <- read.csv("exp_1_data.csv") #import
exp_1_filtered <- filter(exp1, value < 10) #filter
```

Can be wrapped into a function:

```r
#write a function to import and filter data
import_and_filter <- function(path_to_file){

  x <- read.csv(path_to_file) #import
  x <- filter(x, value < 10) #filter
  return(x)
}
```

Now we can repeat for lots of experiments:

```r
#Use function
exp_1 <- import_and_filter("exp_1_data.csv")
exp_2 <- import_and_filter("exp_2_data.csv")
exp_3 <- import_and_filter("exp_3_data.csv")
```

Exercise 1

- Write your own function that multiplies the input by 10

- Answer

```
times10 <- function(x){
  10*x
}
```

Documentation

- Documentation is essential, even if the only person reading your code will be you in the future
- Check help for any function for the best examples (?mean)

```r
#multiplies the input by ten
#input must be numeric
times10 <- function(x){
  10*x
}
```

Exercise 2

- Embed the following functions in your own function

```r
my_data <- read.csv("my_csv_file.csv")
my_processed_data <- mutate(my_data, total = sum)
```

- Answer

```r
input_and_process <- function(my_csv_file){
  my_data <- read.csv(my_csv_file)
  my_processed_data <- mutate(my_data, total = sum(my_column))
  return(my_processed_data)
}
```

Iteration and Loop Functions

Iteration

Like functions, iteration is another tool to *reduce duplication* in your code, resulting in code that is *easier to read* with *reducing mistakes*.

Some main tools to iterate in R are:

- Loops (a good way to learn iteration)
- Loop functions - (more efficient) like *apply family statements* (behind-the-scenes looping in base) OR the *purrr package* (behind-the-scenes looping using the Tidyverse)

Here we will focus on Looping and apply statements. Take a look at the Purr package from Hadley Wickham in your own time.

For Loops

Say we want to calculate the mean of every column in a dataframe (we will use the mtcars dataframe as an example:)

```
head(mtcars, 3)
```

```
##                mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4     21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag 21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710    22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
```

We could calculate each mean one by one, like this:

```
mean(mtcars$mpg) #20.09062
mean(mtcars$cyl) #6.1875
mean(mtcars$disp) #230.7219
# ...etc ...
```

For Loops

A better (think *less errors* and *easier to read*) approach is to use a *For Loop*

```
mtcars_means <- vector(length = ncol(mtcars))  # 1. Define Output

for (i in seq_along(mtcars)) {                 # 2. Define Sequence
  mtcars_means[[i]] <- mean(mtcars[[i]])       # 3. Define Body
}

mtcars_means
```

```
##  [1]  20.090625   6.187500 230.721875 146.687500   3.596563   3.217250
##  [7]  17.848750   0.437500   0.406250   3.687500   2.812500
```

Loops have 3 parts:

- Before you start the loop, you must define a container for the output. An good way to do this is to create an empty vector the same length as our dataframe we want to iterate through:

```r
mtcars_means <- vector(length = ncol(mtcars))  # 1. Define Output
```

- We then define what to iterate/loop through. Each pass of the loop will assign *i* to a different value from seq_along(mtcars) - in this case each value of *i* is a column of mtcars:

```r
for (i in seq_along(mtcars)) # 2. Define sequence
```

- The body is the code that we want to execute for every value of *i*. It is run repeatedly, in this case for each column of mtcars:

```r
mtcars_means[[i]] <- mean(mtcars[[i]]) # 3. Define body
```

Exercise 3

- Write a for loop to calculate the median of every column in the USArrests dataset

- Answer

```
USArrests_medians <- vector(length = ncol(USArrests))# 1. Define Output

for (i in seq_along(USArrests)) {                    # 2. Define Sequen
  USArrests_medians[[i]] <- median(USArrests[[i]])   # 3. Define Body
}

USArrests_medians
```

```
## [1]   7.25 159.00  66.00  20.10
```

Loop Functions

- Apply functions are more efficient than for loops, particularly when working with big data.
- The apply family contains lots of functions - *apply(), sapply(), lapply(), tapply() and mapply()*
- They loop over different structures in R and generate a different structured outputs.
- Here, we will look at apply() which loops over arrays/matrixes and lapply, which loops over lists.

apply()

```
apply(X, MARGIN, FUN, ...)
```

- Loops over an array or matrix (X). 1 = rows and 2 = columns
- Can loop over columns or rows with the MARGIN argument
- Specify a function (FUN) that you want to apply to the data. It can be any function in R (like mean()) or a user definied function.

We can use apply to calculate the mean of all columns in the mtcars dataframe like this:

```
my_means <- apply(mtcars, 2, mean)
my_means
```

```
##        mpg        cyl       disp         hp       drat         wt
##  20.090625   6.187500 230.721875 146.687500   3.596563   3.217250
##       qsec         vs         am       gear       carb
##  17.848750   0.437500   0.406250   3.687500   2.812500
```

lapply()

```
lapply(X, FUN, ...)
```

- loops over elements in a list (X) and return a list
- Specify a function (FUN) that you want to apply to the data. It can be any function in R (like mean()) or a user defined function.
- Returns a list of length X which is the result of the function applied to each element of X

```
mtcars_list <- as.list(mtcars) # turn mtcars into a list for demonstrat

my_means <- lapply(mtcars_list, mean)
head(my_means, 2)
```

```
## $mpg
## [1] 20.09062
##
## $cyl
## [1] 6.1875
```

Exercise 4

- Use an apply family function to calculate the sum of each of the columns in the mtcars dataset

- Answer

```
mtcars_sums <- apply(mtcars, 2, sum)
mtcars_sums
```

```
##      mpg      cyl     disp       hp     drat       wt     qsec       vs
##  642.900  198.000 7383.100 4694.000  115.090  102.952  571.160   14.000
##       am     gear     carb
##   13.000  118.000   90.000
```

Conditional Statements

If Statements

If Statements are conditional statements in R. In an If Statement, we define code to be executed if certain conditions are met

```r
x <- 5

if(x > 0){                          # 1. Define Condition
    print("Positive Number")        # 2. Define Body
}
```

```
## [1] "Positive Number"
```

If…Else Statements

But what if x < 0

```r
x <- -4

if(x > 0){                      # 1. Define Condition
    print("Positive Number")    # 2. Define Body
}
```

- Nothing happens… unless we add else

```r
x <- -4

if(x > 0){                      # 1. Define Condition
    print("Positive Number")    # 2. Define Body
} else {
  print("Negative Number")
}
```

```
## [1] "Negative Number"
```

Side Note: ifelse() is a fast alternative

- For simple cases, we can use the base R function ifelse() instead

```r
x <- 5

my_test <- ifelse(test = x>0,
                  yes = print("Positive Number"),
                  no = print("Negative Number"))
```

```
## [1] "Positive Number"
```

```r
#This means: if x > 0 ,
#             then print "Positive Number",
#             or if not print "Negative Number"

my_test
```

```
## [1] "Positive Number"
```

Exercise 5

```r
x <- 10
y <- 5
```

- Define an condition statement that prints "x times y is big" if x*y > 10

- Answer

```r
if(x*y > 10){
  print("x times y is big")
}
```

```
## [1] "x times y is big"
```

Exercise 5

- Redefine x and y as follows:

```
x <- 0.8
y <- 2
```

- Add a useful else... condition to our if else statement from before
- Answer

```
if(x*y > 10){
  print("x times y is big")
} else {
  print("x times y is small")
}
```

```
## [1] "x times y is small"
```

Exercise 6

```r
x <- c(3,-4,6,-9)
```

- Using a For Loop, iterate through the vector x and print whether each value is positive or negative

- Answer

```r
my_answers <- vector(mode = "character", length = length(x))

for (i in seq_along(x)){

  if(x[i] > 0){
    my_answers[i] = "X is positive"
  } else {
    my_answers[i] = "X is negative"
  }
}

my_answers
```

```
## [1] "X is positive" "X is negative" "X is positive" "X is negative"
```

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