1 Functions

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Section 1

Functions
R offers a wide range of useful functions. Here are some examples:

- **Statistics**: min, max, mean, median, quantile, sd, var, cor, round
- **Sorting**: sort, order, rev, rank
- **Random numbers**: runif, rnorm, ...

```r
x <- runif(10)
x
## [1] 0.1137 0.6223 0.6093 0.6234 0.8609 0.6403 0.0095 0.2326 0.6661 0.5143
summary(x)
##       Min. 1st Qu.  Median    Mean 3rd Qu.   Max.  
##  0.010 0.300 0.620 0.489   0.640 0.860
sort(x)
## [1] 0.0095 0.1137 0.2326 0.5143 0.6093 0.6223 0.6234 0.6403 0.6661 0.8609
## [10] 0.0095
sort(x, decreasing = TRUE)
## [1] 0.8609 0.6661 0.6403 0.6234 0.6223 0.6093 0.5143 0.2326 0.1137 0.0095
```
User defined functions

R is a functional programming language. Functions are objects of mode “function”.

```r
# defining a function
inc <- function(x) { x + 1 }
inc
## function(x) { x + 1 }
mode(inc)
## [1] "function"
# calling the function
inc(5)
## [1] 6
# functions that use only vectorized operators (e.g., +)
# are automatically vectorized.
inc(1:10)
## [1] 2 3 4 5 6 7 8 9 10 11

Note
Functions return the value of the last expression or can be specified via return(value).
```
Named arguments and default values

```r
inc <- function(x, by = 1) { x + by }

inc(5) # using a default value
## [1] 6

inc(1:5, 10) # using order
## [1] 11 12 13 14 15

inc(1:5, by=10) # using order+names
## [1] 11 12 13 14 15

inc(by=10, x=1:5) # using names
## [1] 11 12 13 14 15

inc(matrix(1:4, nrow=2), 10)
## [,1] [,2]
## [1,] 11 13
## [2,] 12 14
```

Advanced Knowledge

Since functions are regular (first class) objects they can be passed on as arguments and returned by functions.
Many functions in R (e.g., `print`, `plot`) look at the supplied object and then choose automatically an appropriate behavior. These functions are called **generic** functions.

The **implementations** have the object type in the name after a dot. Example:

```
print is generic and print.data.frame prints data frames.
```

**Hint**

Type the function name and hit *Tab* for auto-completion.
Section 2

Conditions and Loops
The if Statement

```r
x <- 12
if(x>10) { # result of condition needs length 1
    print("x is >10")
} else {
    print("x is <=10")
}
## [1] "x is >10"

Using vectors to make decisions

```r
x <- c(12, 16, 3)
if(all(x > 10)) print("All values in x are >10")
if(any(x > 10)) print("There is at least one value >10")
## [1] "There is at least one value >10"

```r
c(FALSE, TRUE, TRUE) | c(FALSE, TRUE, FALSE) # element-wise OR (see &)
## [1] FALSE TRUE TRUE
c(FALSE, TRUE, TRUE) || c(FALSE, TRUE, FALSE) # only eval. the 1. elements
## [1] FALSE
```
The for loop

```r
# calculate the sum of the integers 1 to 5
x <- 0
for(i in 1:5) {
  x <- x + i
}

x
## [1] 15

# we can also use lists (R recycles values!)
l <- list(a = 2, b = 1:2, c = 4)
x <- 0; for(i in l) { x <- x + i }
x
## [1] 7 8
```
The while loop

```r
# calculate the sum of the integers 1 to 5
x <- 0
i <- 1
while(i <= 5) { x <- x + i; i <- i + 1 }
x
```

```r
## [1] 15
```

```r
# in R we would rather use a vectorized function
sum(1:5)
```

```r
## [1] 15
```

Note

Loops are not frequently used in R since most problems can be solved more efficiently using functions and vectorization.
Section 3

apply, lapply, sapply, ...
apply – apply functions to a matrix

```r
m <- matrix(1:9, nrow=3)
m

## [,1] [,2] [,3]
## [1,] 1  4  7
## [2,] 2  5  8
## [3,] 3  6  9

apply(m, MARGIN=1, sum) # apply sum to rows

## [1] 12 15 18

apply(m, MARGIN=2, sum) # apply sum to cols

## [1]  6 15 24

# same as
rowSums(m); colSums(m)

## [1] 12 15 18
## [1]  6 15 24
```
lapply/sapply – apply functions to each element in a list

```r
l <- list(1:3, 6, 7:3)
# apply rev to all elements
lapply(l, FUN=function(x) { rev(x) })
## [[1]]
## [1] 3 2 1
##
## [[2]]
## [1] 6
##
## [[3]]
## [1] 3 4 5 6 7

# apply automatically "simplifies" the result. Here into a vector.
sapply(l, length)
## [1] 3 1 5
```
Section 4

Exercises
Exercises

1. Create \( x \) by \( x \leftarrow \text{runif}(100) \). Write a function with the name \( \text{avg_gt} \) with two formal arguments: a vector \( x \) and a value \( gt \). The functions computes the average of the values greater than \( gt \) in \( x \). Write a version with a loop and if and one version without loops and if statements.

2. Create a list with 5 numeric vectors (lengths and values of your choice). Sort all vectors in the list. Hint: see \( \text{sort()} \).

3. Write a function which computes the smallest value in each column of a given matrix. Create a random \( 5 \times 5 \) matrix to test the function.