Programming with functions

Functions

A function has a form:

```
name <- function(argument_1, argument_2, ...) {
  expression_1
  expression_2
  ...
  return(output)
}
```

- `argument_1, arguments_2` are the names of variables.
- `name` is the name of function. You change `name` as you want.

To call or run the function we type:

```
name(x1, x2, ...)
```

the value of this expression is the value of output.

- A function may have more than one `return` statement, in which case it stops after executing the first one it reaches.
- If there is no statement '`return(output)` then the value returned by the function is the value of the last expression in the braces.
- A function always returns a value.
- For some functions the value returned is unimportant.
- In such cases one usually omits the return statement, or returns NULL.
- If the value returned by a function is not assigned to a variable, then it is printed.
- The most important advantage of using a function is that once it is loaded, it can be used again and again without having to reload it.
- The second most important use of functions is to break down a programming task into smaller logical units.

Example : Find zeros of `a2*x^2+a1*x+a0=0`

```
quad3 <- function(a0, a1, a2) {
  if(a2 == 0 && a1 == 0 && a0 == 0) {
    roots <- NA
  } else if (a2 == 0 && a1 == 0 ) {
      roots <- NULL
  } else if ( a2 == 0 ) {
    roots <- -a0/a1
  } else {
    discrim <- a1^2 - 4*a2*a0
    if (discrim > 0) {
      roots <- (-a1 +c(1,-1) * sqrt(a1^2-4*a2*a0))/(2*a2)
    } else if (discrim == 0) {
      roots <- -a1/(2*a2)
    } else {
```

```
      roots <- NULL
    }
  }
  return(roots)
}
```

Example : n choose r

The number of ways that you can choose r things from a set of n, ignoring the order, is

$$\frac{n!}{r!(n-r)!}$$

```
n_factorial <-function(n) {
  n_fact <- prod(1:n)
  return(n_fact)
}
n_choose_r <- function(n, r) {
  n_ch_r <- n_factorial(n)/n_factorial(r)/n_factorial(n-r)
  return(n_ch_r)
}
```

Example : Winsorised mean

k-th Winsorised mean of x={x1, . . . , xn} is defined as

$$w_k = \frac{(k+1)x_{k+1} + x_{k+2} + \cdots + x_{n-k+1} + (k+1)x_{n-k}}{n}$$

```
wmean <- function(x, k) {
    x <- sort(x)
    n <- length(x)
    x[1:k] <- x[k+1]
    x[(n-k+1):n] <- x[n-k]
    return(mean(x))
}
```

Exmple : Swap

swap values of `x[1]` and `x[2]`

```
f1  swap <- function(x){
f2    y <- x[2]
f3    x[2] <- x[1]
f4    x[1] <- y
f5    return(x)
f6  }
p1  x <- c(7, 8, 9)
p2  x[1:2] <- swap(x[1:2])
p3  x[2:3] <- swap(x[2:3])
```

Scope and its consequences

- Argument and variables defined within a function exist only within that function.
- If you define and use a variable x inside a function, it does not exist outside the function.
- If variables with the same name exist inside and outside a function, then they are separate and do not interact at all.
- The variable defined outside the function can be seen inside the function (provided there is not a variable with the same name defined inside).

```
test <- function(x) {
  y <- x+1
  return(y)
}
test(1)
```

```
## [1] 2
```

```
y
### Error : Object "y" not found
```

```
test2 <- function(x) {
  y <- x + z
  return(y)
}
z <- 1
test2(1)
```

```
## [1] 2
```

```
z<-2
test2(1)
```

```
## [1] 3
```

Optional argument and default value

- To give argument_1 the default value x1 we use argument_1 = x1 within the function definition.
- If an argument has a default then it may be omitted when calling the function, in which case the default is used.

```
test3 <- function(x=1, y=1, z=1) {
  return(x*100+y*10+z)
}
test3(2,2)
```

```
## [1] 221
```

```
test3(y=2, z=2)
```

```
## [1] 122
```

Vector-based programming

- Many R functions are vectorised.
- To further facilitate vector-based programming, R provides functions that enable the vectorisation of user-defined functions.
- `apply`, `sapply`, `lapply`, `tapply`, and `mapply`.

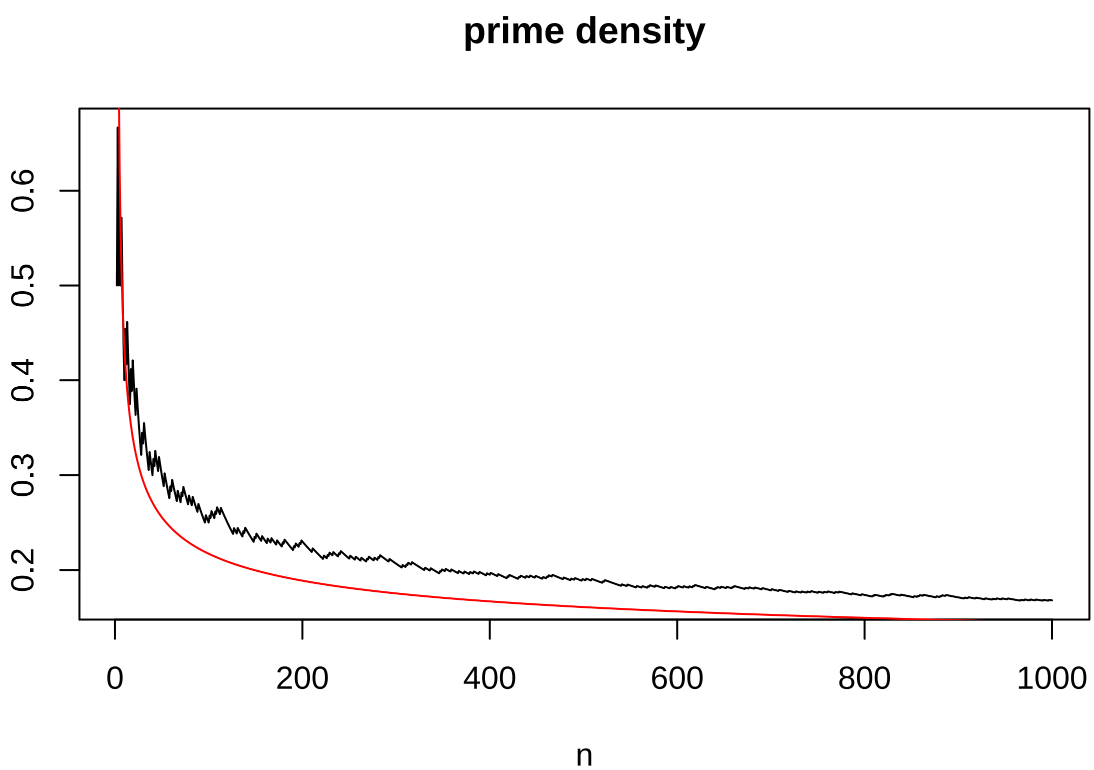
- `sapply(X, FUN)`
- apply function `FUN` to every element of vector `X`.

Example : Density of primes – sapply

- Let $\rho(n)$ be the number of primes less than or equal to n
- Then
$$\lim_{n\to\infty} \frac{\rho(n)\log(n)}{n} \to 1.$$
- To check this, first we define a function `prime` that tests if a given integer is prime.
- We then use `sapply` to apply `prime` to the vector `2:n`.

```
prime <- function(n) {
  if ( n==1 ) {
    is.prime <- FALSE
  } else if ( n==2) {
    is.prime <- TRUE
  } else {
    is.prime <- TRUE
    for ( m in 2:(n/2) ) {
            if ( n%%m == 0 ) is.prime <- FALSE
    }
  }
  return(is.prime)
}
```

```
n <- 1000
m.vec <- 2:n
primes <- sapply(m.vec, prime)
num.primes <- cumsum(primes)
plot(m.vec, num.primes/m.vec, type = "l", main = "prime density", xlab = "n", ylab = "")
lines(m.vec, 1/log(m.vec), col= "red")
```



Recursive programing

- A recursive program is one that calls itself.
- This is useful because many algorithms are recursive in nature.

n factorial

```
nfact2 <- function(n) {
  if (n==1) {
    cat("called nfact2(1)\n")
    return(1)
  } else {
    cat("called nfact2(", n, ")\n", sep="")
    return(n*nfact2(n-1))
  }
}
```

Sieve of Eratosthenes

The Sieve of Eratosthenes is an algorithm for finding all of the primes less than or equal to a given number n.

1. Start with the list $2, 3, \cdots, n$ and $p = 2$.
2. Remove from the list all elements that are multiples of p (but keep p itself).
3. Increase p to the smallest element of the remaining list that is larger than the current p.
4. If p is larger than $\sqrt{n}$ then stop, otherwise go back to step 2.

```
primesieve <- function(sieved, unsieved) {
  p <- unsieved[1]
  n <- unsieved[length(unsieved)]
```

```
  if ( p^2 > n ) {
    return(c(sieved, unsieved))
  } else {
    unsieved <- unsieved[unsieved %% p != 0]
    sieved <- c(sieved, p)
    return(primesieve(sieved, unsieved))
  }
}
```