Q&A Vector-Subsetting-Iteration-Function

Question

Subsetting:

How can I subset a vector based on a condition that involves a function, like selecting all values greater than the mean of the vector?

If we have a vector `v`, we can calculate its mean using `mean(v)`. To find values in `v` that are greater than its mean, you can use `v[v > mean(v)]`.

Example:

Consider the vector `v` from 1 to 10. Its mean is 5.5.

```r
v <- c(1:10)
v[v > mean(v)]
```

```
[1]  6  7  8  9 10
```

Question

Subsetting

Names are so special, that there are special ways to create them and view them

```r
    x <- c(a = 1, b = 2, c = 3)
x
```

```
a b c
1 2 3
```

```r
names(x)
```

```
[1] "a" "b" "c"
```

Or we can create it as follow

```r
y <- 11:13
names(y) <- c("A", "B", "C")
y
```

```
 A  B  C 
11 12 13 
```

```r
names(y)
```

```
[1] "A" "B" "C"
```

- You can remove names with `unname()` function from {`base`} package.

```r
unname(x) ->z
z
```

```
[1] 1 2 3
```

```r
names(z)
```

```
NULL
```

- Names stay with single bracket `[]` subsetting

```r
x
```

```
a b c 
1 2 3 
```

```r
names(x[1])
```

```
[1] "a"
```

```r
names(x[1:2])
```

```
[1] "a" "b"
```

Not double bracket subsetting `[[]]`

```r
names(x[[1]])
```

```
NULL
```

- Names can be used for subsetting (more in Chapter 4)

```r
x[["a"]]
```

```
[1] 1
```

Difference betwen `[]`, `[[]]` and `$`

Sometimes you want just part of an object. In some cases you will use square `[ ]` brackets or double square `[[ ]]` brackets, and in other cases you will use a dollar sign `$`.

Extracting elements from a vector

```r
x <- seq(from = 5, to = 50, by = 5)

x
```

```
 [1]  5 10 15 20 25 30 35 40 45 50
```

we can, for example, extract the 2nd element,

```r
x[2]
```

```
[1] 10
```

we can also do it by

```r
x[[2]]
```

```
[1] 10
```

Elements 3 to 6,

```r
x[3:6]
```

```
[1] 15 20 25 30
```

Elements 2, 3, 5, 8

```r
x[c(2, 3, 5, 8)]
```

```
[1] 10 15 25 40
```

All elements but 7

```r
x[-7]
```

```
[1]  5 10 15 20 25 30 40 45 50
```

All values between 15 and 30, including 15

```r
x[x<30 & x>= 15]
```

```
[1] 15 20 25
```

You can extract elements of a vector by using logical.

```r
x[c(TRUE, TRUE, TRUE, FALSE, TRUE, FALSE, FALSE, TRUE, FALSE, FALSE)]
```

```
[1]  5 10 15 25 40
```

Extracting elements from a matrix or array

Similarly, we can extract elements from a matrix or array, but now we need *multiple indices* separated by *commas*. For example, given the following 2-dimensional matrix x,

```r
x <- matrix(c(10,12,31,14,51,60), nrow = 2, ncol = 3)
x
```

```
     [,1] [,2] [,3]
[1,]   10   31   51
[2,]   12   14   60
```

Extract the element in the 2nd row and 3rd column

```r
x[2, 3]
```

```
[1] 60
```

Extract the second row

```r
x[2,]
```

```
[1] 12 14 60
```

Extract the third

```r
x[, 3]
```

```
[1] 51 60
```

If you leave out the comma, you will get an answer not an error. For example:

```r
x[3]
```

```
[1] 31
```

But it is ambiguous to say "*the 3rd element of a matrix*" since you could go *down columns* or *across rows*. R has a default, but rather than try to remember what that is, just **do not forget the comma and then there is no ambiguity**.

- **ARRAY**

```r
z <- array(c(10,12,31,14,51,60, 7, 53), dim = c(2,2,2))
z
```

```
, , 1

     [,1] [,2]
[1,]   10   31
[2,]   12   14

, , 2

     [,1] [,2]
[1,]   51    7
[2,]   60   53
```

we can extract a single element,

```r
z[2,1,2]
```

```
[1] 60
```

A sub-vector,

```r
z[1,,2]
```

```
[1] 51  7
```

Or a sub-matrix,

```r
z[,2,] # Second columns of any row and any of two sub-matrices. Just remember by default it i
```

```
     [,1] [,2]
[1,]   31    7
[2,]   14   53
```

```r
z[,,2] # The Second sub-matrices
```

```
     [,1] [,2]
[1,]   51    7
[2,]   60   53
```

```
z[2,,] # The Second rows of any columns and any of two sub-matrices. Just remember by defaul
```

```
     [,1] [,2]
[1,]   12   60
[2,]   14   53
```

Extracting elements from a list

For a list, you can use single square `[ ]` brackets or double square `[[ ]]` brackets, depending on what you want to extract.

```
x <- list("5", c(1,2,3), factor(c("BMW", "FORD", "GM", "FORD", "JEEP", "BMW", "FORD")) )
x
```

```
[[1]]
[1] "5"

[[2]]
[1] 1 2 3

[[3]]
[1] BMW  FORD GM   FORD JEEP BMW  FORD
Levels: BMW FORD GM JEEP
```

- We can use `[ ]` to extract a sub-list containing only, for example, the second element,

```
x[1]
```

```
[[1]]
[1] "5"
```

```
class(x[1])
```

```
[1] "list"
```

```r
x[2]
```

```
[[1]]
[1] 1 2 3
```

```r
class(x[2])
```

```
[1] "list"
```

```r
x[3]
```

```
[[1]]
[1] BMW  FORD GM   FORD JEEP BMW  FORD
Levels: BMW FORD GM JEEP
```

```r
class(x[3])
```

```
[1] "list"
```

or multiple elements,

```r
x[c(1, 3)]
```

```
[[1]]
[1] "5"

[[2]]
[1] BMW  FORD GM   FORD JEEP BMW  FORD
Levels: BMW FORD GM JEEP
```

```r
class(x[c(1, 3)])
```

```
[1] "list"
```

- Or we can use `[[ ]]` to extract a single element, which will have the class of that element.

```r
x[[1]]
```

```
[1] "5"
```

```r
class(x[[1]])
```

```
[1] "character"
```

```r
x[[2]]
```

```
[1] 1 2 3
```

```r
class(x[[2]])
```

```
[1] "numeric"
```

```r
x[[3]]
```

```
[1] BMW  FORD GM   FORD JEEP BMW  FORD
Levels: BMW FORD GM JEEP
```

```r
class(x[[3]])
```

```
[1] "factor"
```

```r
x[[1]][1]
```

```
[1] "5"
```

```r
class(x[[1]][1])
```

```
[1] "character"
```

```r
x[[1]][2]
```

```
[1] NA
```

```r
class(x[[1]][2])
```

```
[1] "character"
```

```r
x[[2]][1]
```

```
[1] 1
```

```r
class(x[[2]][1])
```

```
[1] "numeric"
```

```r
x[[2]][2]
```

```
[1] 2
```

```r
x[[2]][3]
```

```
[1] 3
```

```r
x[[3]][1]
```

```
[1] BMW
Levels: BMW FORD GM JEEP
```

```r
class(x[[3]][1])
```

```
[1] "factor"
```

```r
x[[3]][2]
```

```
[1] FORD
Levels: BMW FORD GM JEEP
```

```r
x[[3]][3]
```

```
[1] GM
Levels: BMW FORD GM JEEP
```

```r
x[[3]][4]
```

```
[1] FORD
Levels: BMW FORD GM JEEP
```

```r
x[[3]][5]
```

```
[1] JEEP
Levels: BMW FORD GM JEEP
```

```r
class(x[[3]][5])
```

```
[1] "factor"
```

Extracting elements from a data frame

Recall that a data.frame is special type of list where each element is one of the columns. You can access the elements of a data.frame in a number of ways, including the $ method.

```r
df <- data.frame(outcome  = c(1, 0, 1, 1),
                 exposure = factor(c("yes", "yes", "no", "no"),
                                   levels = c("no", "yes"),
                                   labels = c("No", "Yes")),
                 age      = c(24, 55, 39, 18))
df
```

```
  outcome exposure age
1       1      Yes  24
2       0      Yes  55
3       1       No  39
4       1       No  18
```

- we can extract a data.frame made up of a subset of columns using `[ ]`,

```r
df[1:2]
```

```
  outcome exposure
1       1      Yes
2       0      Yes
3       1       No
4       1       No
```

```r
class(df[1:2])
```

```
[1] "data.frame"
```

```r
df[c("outcome", "exposure")]
```

```
  outcome exposure
1       1      Yes
2       0      Yes
3       1       No
4       1       No
```

- A single column of the data.frame, returned as the class of that column, using `[[ ]]` or `$`.

```r
df[3]
```

```
  age
1  24
2  55
3  39
4  18
```

```r
class(df[3])
```

```
[1] "data.frame"
```

```r
df[[3]]
```

```
[1] 24 55 39 18
```

```r
class(df[[3]])
```

```
[1] "numeric"
```

```r
df["age"]
```

```
  age
1  24
2  55
3  39
4  18
```

```r
class(df["age"])
```

```
[1] "data.frame"
```

```r
df[["age"]]
```

```
[1] 24 55 39 18
```

```r
class(df[["age"]])
```

```
[1] "numeric"
```

```r
df$age
```

```
[1] 24 55 39 18
```

```r
class(df$age)
```

```
[1] "numeric"
```

When using the `$` method, if the variable name has *spaces*, then enclose it in (not regular quotes) when extracting it. To illustrate, let's change the names of this data.frame by assigning a new value to its `names()`.

```r
names(df) <- c("Outcome Level", "Exposure", "Age")

df
```

```
  Outcome Level Exposure Age
1             1      Yes  24
2             0      Yes  55
3             1       No  39
4             1       No  18
```

```r
df$`Outcome Level`
```

```
[1] 1 0 1 1
```

The double and single quotation still is working. But R studio by default wrao the column names wit the `backticks`.

```r
df$"Outcome Level"
```

```
[1] 1 0 1 1
```

```r
df$'Outcome Level'
```

```
[1] 1 0 1 1
```

- You can also extract elements of a data.frame using matrix indexing.

```r
df[,1]
```

```
[1] 1 0 1 1
```

```r
class(df[,1])
```

```
[1] "numeric"
```

the first row of df, returning a data.frame with 1 row,

```r
df[1,]
```

```
  Outcome Level Exposure Age
1             1      Yes  24
```

```r
class(df[1,])
```

```
[1] "data.frame"
```

```r
df[2,]
```

```
  Outcome Level Exposure Age
2             0      Yes  55
```

or the first column of x, returning a vector of the class of that column,

```r
df[,1]
```

```
[1] 1 0 1 1
```

```r
class(df[,1])
```

```
[1] "numeric"
```

or a data.frame if you include `drop=F`.

```r
df[,1,drop=F]
```

```
  Outcome Level
1             1
2             0
3             1
4             1
```

```r
class(df[,1,drop=F])
```

```
[1] "data.frame"
```

If extracting more than 1 column, `drop=F` is not necessary to return a data.frame.

```
df[,2:3]
```

```
  Exposure Age
1      Yes  24
2      Yes  55
3       No  39
4       No  18
```

```
class(df[,2:3])
```

```
[1] "data.frame"
```

In any of these column extraction via matrix-subsetting examples, you can use the column names.

```
df[, "Outcome Level", drop=F]
```

```
  Outcome Level
1             1
2             0
3             1
4             1
```

```
class(df[, "Outcome Level", drop=F])
```

```
[1] "data.frame"
```

- Some data.frame objects have `rownames`. By default, R just assigns numbers.

```
rownames(df)
```

```
[1] "1" "2" "3" "4"
```

But suppose we have a data.frame with, say, participant IDs as the row names.

```
rownames(df) <- c("B239", "B211", "B101", "B439")
df
```

```
     Outcome Level Exposure Age
B239             1      Yes  24
B211             0      Yes  55
B101             1       No  39
B439             1       No  18
```

Then you can subset rows using row names.

```r
df[c("B211", "B439"),]
```

```
     Outcome Level Exposure Age
B211             0      Yes  55
B439             1       No  18
```

You can also subset rows of a data.frame using logical statements about the values in the data.frame.

```r
df[df$Exposure == "Yes",]
```

```
     Outcome Level Exposure Age
B239             1      Yes  24
B211             0      Yes  55
```

Question:

Apply Functions

Apply functions are a family of functions in base R which allow you to repetitively perform an action on multiple chunks of data. An apply function is essentially a loop, but run faster than loops and often require less code.

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

- `x` is the data that we will be performing the function
- `MARGIN` specifies whether you want to apply the function across *rows (1)* or *columns (2)*
- `FUN` is the function you want to use

```r
mpg |>
  select(cty, hwy, cyl, displ) |>
apply( 2, mean)
```

```
      cty       hwy       cyl     displ 
16.858974 23.440171  5.888889  3.471795 
```

```r
mpg |>
  select(cty, hwy, cyl, displ) |>
apply(1, mean)
```

```
  [1] 13.200 13.950 14.250 14.250 12.700 13.200 13.525 12.450 11.700 13.500
 [11] 13.000 12.200 12.700 12.775 12.275 11.950 12.775 12.800 11.825  9.825
 [21] 11.825 10.925 10.750 13.925 12.925 14.050 13.550 13.500 11.575  9.575
 [31]  9.925 11.375 13.100 14.600 13.275 14.125 13.150 12.100 12.500 11.825
 [41] 11.825 12.575 12.575  9.325 11.700 11.450 12.200 12.250 10.925 10.425
 [51]  9.975 10.225 11.425 11.425  8.425 10.300  9.800  9.975 10.675  8.425
 [61] 10.675 10.050 11.175  9.975 10.175  8.425 10.675 10.675 10.175  8.425
 [71]  9.800 10.050 10.925  9.975 10.150 10.350 10.850 10.250 11.000 10.250
 [81] 10.500 11.150 10.750 10.300 10.300 10.400 10.400 10.650  9.850 10.850
 [91] 13.450 13.200 13.250 12.500 12.150 12.400 12.650 12.400 11.850 16.650
[101] 15.400 15.650 14.400 15.400 16.450 16.700 16.450 14.000 12.600 12.850
[111] 14.350 14.600 13.125 13.125 14.075 12.750 13.500 13.500 13.250 12.425
[121] 12.175 12.425 12.000 10.925 11.250 10.925  8.425 11.425 11.175  9.775
[131]  9.500 10.550 10.600  9.650 10.350 10.100 10.850 10.250 10.500 11.150
[141] 10.750 14.100 13.100 15.125 15.375 13.875 13.625 13.250 13.250 13.375
[151] 10.075 10.325 11.000 10.900 13.275 12.950 13.450 13.950 13.575 12.375
[161] 12.125 13.375 12.625 13.125 11.875 13.300 12.800 12.875 12.875 12.875
[171] 13.375 12.625 13.375 10.425 10.675 10.850 10.350 11.500 10.925 14.050
[181] 13.550 14.600 14.600 13.250 13.250 14.125 13.550 14.050 14.600 14.850
[191] 13.250 13.250 13.575 14.950 15.700 16.700 17.700 16.700  9.675 11.175
[201] 10.425 10.675 11.425 10.350 10.850 10.750 11.500 14.000 12.750 14.000
[211] 14.250 12.450 20.725 14.000 12.750 14.250 14.000 14.375 14.375 11.950
[221] 12.450 21.225 18.975 14.000 12.750 13.875 14.125 13.950 13.200 13.250
[231] 14.000 12.700 13.200 13.150
```

There are 234 rows thus we will have the same number of mean for each row.

`_apply()`

`lapply`, `sapply`, and `vapply` are all functions that will loop a function through data in a *list* or *vector*.

Here are the agruments for the three functions:

- lapply(X, FUN, …)
- sapply(X, FUN, …, simplify = TRUE, USE.NAMES = TRUE)
- vapply(X, FUN, FUN.VALUE, …, USE.NAMES = TRUE)
    - `lapply()` First, try looking up `lapply` in the help section to see a description of all three function.

```
mpg |>
  select(cty, hwy, cyl, displ) |>
lapply(mean)
```

```
$cty
[1] 16.85897

$hwy
[1] 23.44017

$cyl
[1] 5.888889

$displ
[1] 3.471795
```

`lapply()` function did not return the output like `apply()` function because it treats the vector like list.

- `sapply()`

```
mpg |>
  select(cty, hwy, cyl, displ) |>
sapply(mean)
```

```
      cty       hwy       cyl     displ
16.858974 23.440171  5.888889  3.471795
```

`sapply()` works just like `lapply()`, but will simplify the output if possible. This means that instead of returning *a list* like `lapply()`, it will return *a vector* instead if the data is simplifiable.

- `vapply()`

`vapply()` is similar to `sapply()`, but it requires you to specify what type of data you are expecting.

I am expecting each item in the list to return a single numeric value, so `FUN.VALUE = numeric(1)`.

```
mpg |>
  select(cty, hwy, cyl, displ) |>
vapply(mean, FUN.VALUE = numeric(1))
```

```
      cty       hwy       cyl     displ
16.858974 23.440171  5.888889  3.471795
```

Which function should I use, lapply, sapply, or vapply?

If you are trying to decide which of these three functions to use, because it is the simplest, I would suggest to use sapply if possible. If you do not want your results to be simplified to a vector, lapply should be used.

`tapply()`, `mapply()`

To learn more go to https://ademos.people.uic.edu/Chapter4.html

Question

I have seen in other programming languages, like Matlab, that the compiler will automatically replace loops with vectorized code to be faster and more efficient. Is this also the case in R? With the map/apply functions, do they resolve to calling a lower level language that is faster?

- While I'm not familiar with all the technical specifics, I can share some insights based on my experience. In R, much like in Matlab, vectorized operations are generally more efficient than loops. This is because R is optimized for handling operations on vectors and matrices. (FreeMat is an open-source program similar to Matlab.)

Functions like apply, lapply, sapply from the {base} package, and the map family from the {purrr} package can indeed offer performance improvements over traditional loops. These functions are often implemented in lower-level languages like C or Fortran, which are optimized for speed.

When I transitioned from Matlab to R, I found that by using the right packages and vectorized functions, I could achieve comparable performance. For example, the {pracma} package in R provides many of the mathematical functions available in Matlab, making the transition smoother.

Question:

How to handle missing values?

In R, missing values are typically represented as NA. To check for missing values in variables, we use R's is.na() function. To find available values, we negate this function.

- **Question:**

Determine the number of missing values and the available items.

```
df <- tibble(
  C1 = c(1, 2, NA, 4, 5, 6),
  C2 = c(NA, 2, 3, NA, 5, 6),
  C3 = c(1, NA, 3, 4, NA, 6)
)
missing_values <- is.na(df)
sum(missing_values) -> n_miss
cat("The number of missing values are ", n_miss)
```

```
The number of missing values are  5
```

```
n_available_items <- nrow(df)*ncol(df) - n_miss
cat("\n \n The number of available items is determined by multiplying the observations by the
```

```



 The number of available items is determined by multiplying the observations by the number o
```

Handling missing values depends on the context and the nature of your data. Let's explore two common options:

1. **Removing Missing Values (Deletion):**
    - **Pros:**
        - Simple and straightforward.
        - Avoids imputing potentially incorrect values.
    - **Cons:**
        - Reduces the sample size.
        - May lead to biased results if missingness is not random.
    - **When to Use:**
        - If the proportion of missing values is small and randomly distributed.
        - If you can afford to lose some data.

- I. **Removes the rows that contain `NA`.**

```
dfn <- drop_na(df)
dfn
```

```
# A tibble: 1 x 3
     C1    C2    C3
  <dbl> <dbl> <dbl>
1     6     6     6
```

Using `drop_na()` Function of {`tidyr`} Package.

- II. **This will remove rows only if they have `NA` in C1**

```
drop_na(df,C1)
```

```
# A tibble: 5 x 3
     C1    C2    C3
  <dbl> <dbl> <dbl>
1     1    NA     1
2     2     2    NA
3     4    NA     4
4     5     5    NA
5     6     6     6
```

- III. This will remove rows only if they have `NA` in either C1 or C3. Rows with `NA` in C2 will be retained.

```
drop_na(df,C1, C3)
```

```
# A tibble: 3 x 3
     C1    C2    C3
  <dbl> <dbl> <dbl>
1     1    NA     1
2     4    NA     4
3     6     6     6
```

2. **Imputing with Mean (or Other Measures):**
   - **Pros:**
     - Retains the entire dataset.
     - Preserves statistical power.
   - **Cons:**
     - Assumes that missing values are missing at random.
     - May introduce bias if the mean is not representative.
   - **When to Use:**
     - If the proportion of missing values is significant.

```
df_1 <- tibble(A = c(2, 2, NA, 10, 20, NA, 3),
               B = c(1, NA, 5, NA, 8, 9, NA),
               C = c(NA, 4, 6, 7, NA, 2, 3)
)
missing_values <- is.na(df_1)
sum(missing_values) -> n_miss
cat("The number of missing values are ", n_miss)
```

```
The number of missing values are  7
```

```
n_available_items <- nrow(df)*ncol(df) - n_miss
cat("\n \n The number of available items is determined by multiplying the observations by the
```

```
 The number of available items is determined by multiplying the observations by the number o
```

Replacing mising value with mean of each column

```
df_1$A[is.na(df_1$A)] <- mean(df_1$A, na.rm = TRUE)
df_1$B[is.na(df_1$B)] <- mean(df_1$B, na.rm = TRUE)
df_1$C[is.na(df_1$C)] <- mean(df_1$C, na.rm = TRUE)

df_1
```

```
# A tibble: 7 x 3
      A     B     C
  <dbl> <dbl> <dbl>
1   2     1     4.4
2   2     5.75  4
3   7.4   5     6
4  10     5.75  7
5  20     8     4.4
6   7.4   9     2
7   3     5.75  3
```

Question:

How to handle mising values when using functions like `map()` and `apply()` from {`purr`} package?

In R, the `apply()` function belongs to the {`base`} package, but here we're utilizing functions from the {`purrr`} package. As you know, there are numerous approaches to writing code. In this course, we've opted to prioritize the `tidyverse` package. This choice is often more efficient and straightforward.

- The square root of `NA` comes as `NA`

```
v <- c( 1:3, NA, 2:5, NA)
map(v, sqrt)
```

```
[[1]]
[1] 1

[[2]]
[1] 1.414214

[[3]]
[1] 1.732051
```

```
[[4]]
[1] NA

[[5]]
[1] 1.414214

[[6]]
[1] 1.732051

[[7]]
[1] 2

[[8]]
[1] 2.236068

[[9]]
[1] NA
```

- Remove `NA` then compute square root

```r
v[!is.na(v)] ->
  v_n
```

```r
map(v_n, sqrt)
```

```
[[1]]
[1] 1

[[2]]
[1] 1.414214

[[3]]
[1] 1.732051

[[4]]
[1] 1.414214

[[5]]
[1] 1.732051

[[6]]
```

```
[1] 2

[[7]]
[1] 2.236068
```

Most functions in R include an `na.rm` argument, which, when set to `TRUE`, removes `NA` values before computation.

```r
l1 <- list(c(1, 2, NA, 4), c(6, NA, 3, NA))
map(l1, sum, na.rm = TRUE)
```

```
[[1]]
[1] 7

[[2]]
[1] 9
```

Find the mean

```r
map(l1, mean, na.rm = TRUE)
```

```
[[1]]
[1] 2.333333

[[2]]
[1] 4.5
```

Question

Anonymous functions

In R, functions are like objects themselves. They don't automatically come with a name attached. If you don't give it a name, it becomes an anonymous function.

Anonymous functions are used when you don't find it necessary to name them.

```r
df <- tibble(
  C1 = c(1, 2, 3, 4, 5),
  C2 = c( 6, 7, 8, 9, 10),
  C3 = c(11, 12, NA, 14,15)
)

df
```

```
# A tibble: 5 x 3
     C1    C2    C3
  <dbl> <dbl> <dbl>
1     1     6    11
2     2     7    12
3     3     8    NA
4     4     9    14
5     5    10    15
```

In the following code we use a function without selecting a name. The function square the values of `df`

```r
lapply(df, function(x) sqrt(x))
```

```
$C1
[1] 1.000000 1.414214 1.732051 2.000000 2.236068

$C2
[1] 2.449490 2.645751 2.828427 3.000000 3.162278

$C3
[1] 3.316625 3.464102       NA 3.741657 3.872983
```

The function read the data and returns the length of each column

```r
lapply(df, function(x) length(x))
```

```
$C1
[1] 5

$C2
[1] 5
```

```
$C3
[1] 5
```

In the next code we have a function that calculate the mean of each column

```
lapply(df, function(x) mean(x, na.rm = TRUE))
```

```
$C1
[1] 3

$C2
[1] 8

$C3
[1] 13
```

In the next code we show you we can do both by `map()` function.

```
map(df, sqrt)
```

```
$C1
[1] 1.000000 1.414214 1.732051 2.000000 2.236068

$C2
[1] 2.449490 2.645751 2.828427 3.000000 3.162278

$C3
[1] 3.316625 3.464102       NA 3.741657 3.872983
```

```
map(df, length)
```

```
$C1
[1] 5

$C2
[1] 5

$C3
[1] 5
```

```r
map(df, mean, na.rm = TRUE)
```

```
$C1
[1] 3

$C2
[1] 8

$C3
[1] 13
```

Question:

Factor and Subsetting

If I have a factor vector and I subset it, the levels are still there even if they are not in the subset. Why does this happen, and how can I avoid it?

In summer 2024, one of my students, Chih-Chen Wang, explained it very well. Here what he wrote;

when you subset a factor vector in R, the underlying levels of the factor remain unchanged even if some of the levels are not present in the subset. This happens because factors are categorical data types with a predefined set of levels. We can remove any levels that are not actually present in the factor by "droplevels()"

Let us create a factor

```r
# Create a vector of names
names <- c("John", "Alice", "Bob", "Eve", "Michael")

# Create a factor vector with levels "male" and "female"
f <- factor(c("male", "female", "male", "female", "male"),
                 levels = c("male", "female"))

# Assign names to the factor vector
names(f) <- names

# Print the factor vector
print(f)
```

```
   John   Alice     Bob     Eve Michael 
   male  female    male  female    male 
Levels: male female
```

```r
f[-c(1,3,5)] ->
  f1
f1
```

```
 Alice    Eve 
female female 
Levels: male female
```

Or we may use the following code to get only females name.

```r
f[f=="female"]
```

```
 Alice    Eve 
female female 
Levels: male female
```

Now, if you use `droplevels()` function then level of male will be dropped since factor `f1` does not contain any male names.

```r
droplevels(f1)
```

```
 Alice    Eve 
female female 
Levels: female
```

Question

When to use the `set.seed()` function?

- As you know, the random generation function isn't truly random. It's deterministic based on its input, known as a seed. When we all use the same seed, we get identical results. We often use the seed function to validate our code. If we're debugging, we don't want different outputs each time we run the code. Another reason to use it is to compare our work with others, like team members.

Question:

How to generate a sequence of dates and use them in a for loop?

- There are three main classes for date/time data:
  - `Date` for just the date.
  - `POSIXct` for both the date and the time. "POSIXct" stands for "Portable Operating System Interface Calendar Time"
  - `hms` stands for "hours, minutes, and seconds."
- `today()` will give you the current date in the `Date` class, `now()` gives you in addition the time.

```
now(tzone = "UTC") # Universal Coordinated Time
```

```
[1] "2024-07-19 16:49:32 UTC"
```

- `Sys.time()` and `Sys.Date()` are from {`base`} package
- current time

```
    hms::as_hms(now())
```

```
12:49:32.744094
```

```
    class(hms::as_hms(now()))
```

```
[1] "hms"      "difftime"
```

The functions `as_date()`, `as.Date()`, and `ymd()` are all used to work with date data in R, but they come from different packages and have slightly different purposes and behaviors. Here's an overview of each:

1. `as_date()` from {`lubridate`}
   - Convert an object to a date or date-time

```
as.Date("2024-07-17")
```

```
[1] "2024-07-17"
```

```r
as_date(0)
```

```
[1] "1970-01-01"
```

```r
as_date(365)
```

```
[1] "1971-01-01"
```

2. **`ymd()`** from {`lubridate`}

   - **Purpose**: A convenience function to parse dates in the year-month-day format. It automatically recognizes and converts a variety of common date string formats to Date objects.

```r
ymd("2024-07-16")
```

```
[1] "2024-07-16"
```

```r
ymd("20240716")
```

```
[1] "2024-07-16"
```

3. **`as.Date()`**: {`base`}

   - Convert between character representations and objects of class "Date" representing calendar dates.

```r
as.Date("2024-07-17")
```

```
[1] "2024-07-17"
```

```r
as.Date("17-07-2024", format = "%d-%m-%Y")
```

```
[1] "2024-07-17"
```

```r
as.Date("07-17-24", format = "%m-%d-%y")
```

```
[1] "2024-07-17"
```

We will use {lubridate} package

- Only the order of year, month, and day matters

```
ymd(c("2024/07-16", "2024-07/16", "20240716"))
```

```
[1] "2024-07-16" "2024-07-16" "2024-07-16"
```

Note: - Note that `ms()`, `hm()`, and `hms()` won't recognize "-" as a separator because it treats it as negative time. So use `parse_time()` here.

```
ms("10-10")
```

```
[1] "10M -10S"
```

```
ms("10:10")
```

```
[1] "10M 10S"
```

_ You can order them and it reads only date and time

```
parse_date_time("23, 22, 01 Read only what it needed to read to display the time 07/16/20
```

```
[1] "2024-07-16 23:22:01 UTC"
```

- **Parsing Dates**

```
x <- parse_date("17/07/2024", format = "%d/%m/%Y")
x
```

```
[1] "2024-07-17"
```

```
class(x)
```

```
[1] "Date"
```

```r
y <- parse_datetime("07/17/2040 11:59:20", format = "%m/%d/%Y %H:%M:%S")
y
```

```
[1] "2040-07-17 11:59:20 UTC"
```

```r
class(y)
```

```
[1] "POSIXct" "POSIXt"
```

```r
z <- parse_time("11:59:20", "%H:%M:%S")
z
```

```
11:59:20
```

```r
class(z)
```

```
[1] "hms"      "difftime"
```

How to to create dates and date-times?

```r
make_date(year = 2024, month = 7, day = 16)
```

```
[1] "2024-07-16"
```

```r
make_datetime(year = 2024, month = 8, day = 17, hour = 23, min = 59, sec = 59)
```

```
[1] "2024-08-17 23:59:59 UTC"
```

What happen if we use `as_date()` function to convert a vector of numeral value to `date` class?

- This function will try to coerce an object to a date.
- `as_datetime()` tries to coerce an object to a `POSIXct` object.

```r
year <- c(2000, 2001, 2010)
(as_date(year) ->
  year)
```

```
[1] "1975-06-24" "1975-06-25" "1975-07-04"
```

It creates a a vector of dates in the format "YYYY-MM-DD". The first entry is year 2000 days after year 1970-01-01

`nycflights13` example:

```r
library(nycflights13)
flights |>
  select(c(year, month, day, hour, minute)) |>
  glimpse()
```

```
Rows: 336,776
Columns: 5
$ year   <int> 2013, 2013, 2013, 2013, 2013, 2013, 2013, 2013, 2013, 2013, 201~
$ month  <int> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ~
$ day    <int> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ~
$ hour   <dbl> 5, 5, 5, 5, 6, 5, 6, 6, 6, 6, 6, 6, 6, 6, 6, 5, 6, 6, 6, 6, 6, ~
$ minute <dbl> 15, 29, 40, 45, 0, 58, 0, 0, 0, 0, 0, 0, 0, 0, 0, 59, 0, 0, 0, ~
```

Create a column that show s the the date and time of the flights

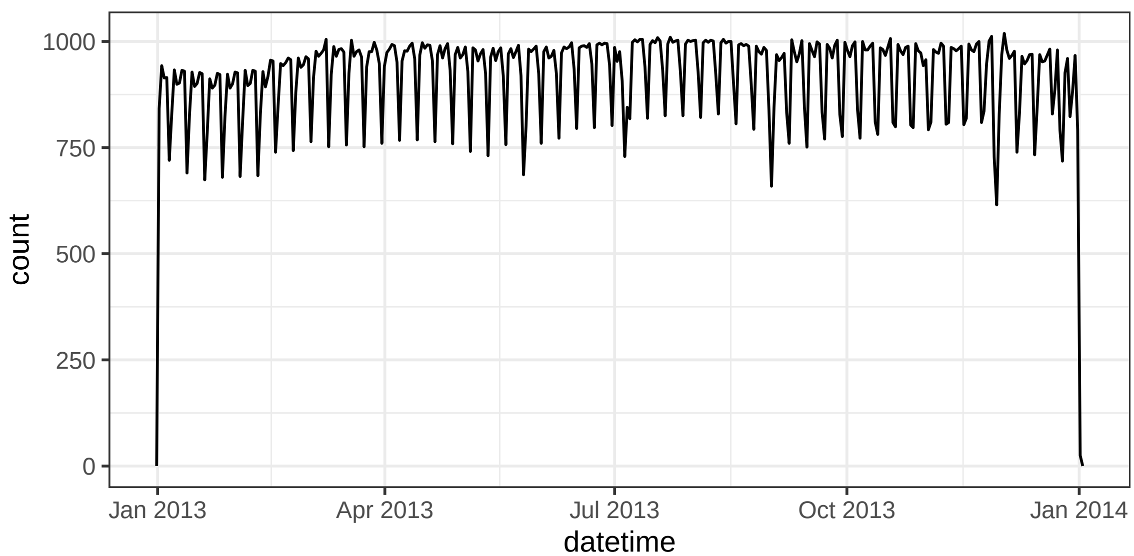
```r
    data("flights")
    flights %>%
      mutate(datetime = make_datetime(year    = year,
                                      month   = month,
                                      day     = day,
                                      hour    = hour,
                                      min = minute)) ->
      flights
      select(flights, datetime)
```

```
# A tibble: 336,776 x 1
   datetime
   <dttm>
```

```
 1 2013-01-01 05:15:00
 2 2013-01-01 05:29:00
 3 2013-01-01 05:40:00
 4 2013-01-01 05:45:00
 5 2013-01-01 06:00:00
 6 2013-01-01 05:58:00
 7 2013-01-01 06:00:00
 8 2013-01-01 06:00:00
 9 2013-01-01 06:00:00
10 2013-01-01 06:00:00
# i 336,766 more rows
```

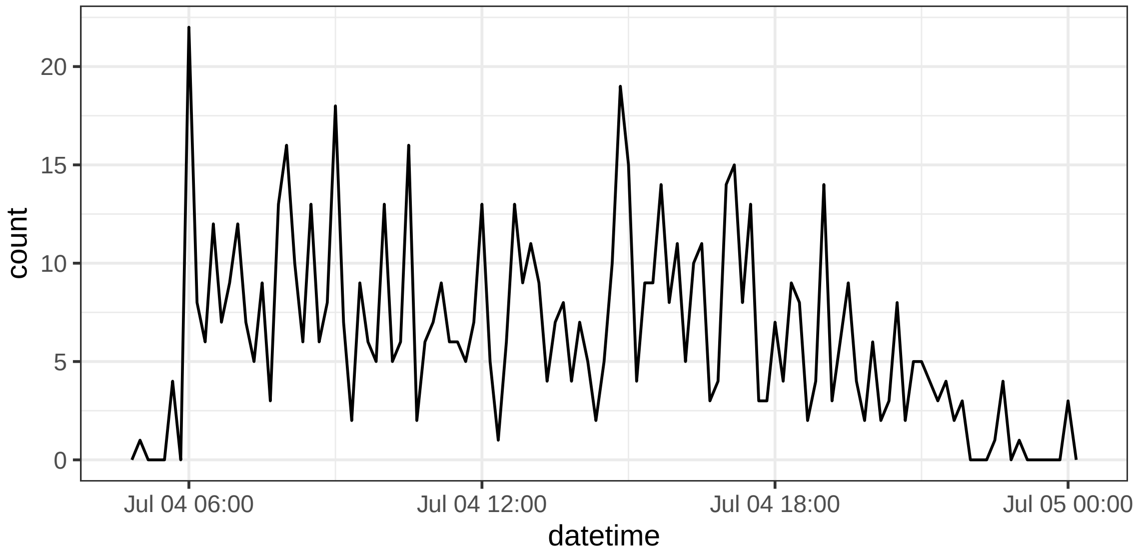
- Having it in the date-time format makes it easier to plot.

```r
ggplot(flights, aes(x = datetime)) +
  geom_freqpoly(bins = 365)
```



- It makes it easier to filter by date

```r
flights %>%
  filter(as_date(datetime) == ymd(20130704)) %>%
  ggplot(aes(x = datetime)) +
  geom_freqpoly(binwidth = 600)
```



Extracting Components

```
ddat <- mdy_hms("07/16/2024 03:51:44")
ddat
```

```
[1] "2024-07-16 03:51:44 UTC"
```

- `year()` extracts the year.
- `month()` extracts the month.
- `week()` extracts the week.
- `mday()` extracts the day of the month (1, 2, 3, …).
- `wday()` extracts the day of the week (Saturday, Sunday, Monday …).
- `yday()` extracts the day of the year (1, 2, 3, …)
- `hour()` extracts the hour.
- `minute()` extract the minute.
- `second()` extracts the second.

```
year(ddat)
```

```
[1] 2024
```

```
month(ddat, label = TRUE)
```

```
[1] Jul
12 Levels: Jan < Feb < Mar < Apr < May < Jun < Jul < Aug < Sep < ... < Dec
```

```r
week(ddat)
```

```
[1] 29
```

```r
mday(ddat)
```

```
[1] 16
```

```r
wday(ddat, label = TRUE)
```

```
[1] Tue
Levels: Sun < Mon < Tue < Wed < Thu < Fri < Sat
```

```r
yday(ddat)
```

```
[1] 198
```

```r
hour(ddat)
```

```
[1] 3
```

```r
minute(ddat)
```

```
[1] 51
```

```r
second(ddat)
```

```
[1] 44
```

- Let us generate a sequence of dates starting from today to the end of semester

```r
l_day <- ymd("2024-08-17")
t_day <- today()

# Create sequence of dates from today until last day
sequence_day <- seq(t_day, l_day, by = "day")

# Create the dataframe
df <- tibble(
  date = sequence_day,
  days_left = as.numeric(l_day - sequence_day)
)


print(df)
```

```
# A tibble: 30 x 2
   date       days_left
   <date>         <dbl>
 1 2024-07-19        29
 2 2024-07-20        28
 3 2024-07-21        27
 4 2024-07-22        26
 5 2024-07-23        25
 6 2024-07-24        24
 7 2024-07-25        23
 8 2024-07-26        22
 9 2024-07-27        21
10 2024-07-28        20
# i 20 more rows
```

- The following code generates the weekends

```r
l_day <- ymd("2024-08-17")
t_day <- today()

# Create sequence of dates from today until last day
sequence_day <- seq(t_day, l_day, by = "day")


weekends <- sequence_day[wday(sequence_day) %in% c(1, 7)] # 1 = Sunday, 7 = Saturday
```

```r
print(weekends)
```

```
[1] "2024-07-20" "2024-07-21" "2024-07-27" "2024-07-28" "2024-08-03"
[6] "2024-08-04" "2024-08-10" "2024-08-11" "2024-08-17"
```

The output is a dataframe

```r
l_day <- ymd("2024-08-17")
t_day <- today()

# Create sequence of dates from today until last day
sequence_day <- seq(t_day, l_day, by = "day")


weekends <- sequence_day[wday(sequence_day) %in% c(1, 7)]
df <- tibble(Weekend = weekends)


print(df)
```

```
# A tibble: 9 x 1
  Weekend
  <date>
1 2024-07-20
2 2024-07-21
3 2024-07-27
4 2024-07-28
5 2024-08-03
6 2024-08-04
7 2024-08-10
8 2024-08-11
9 2024-08-17
```

_ By For Loop

```r
l_day <- ymd("2024-08-17")
t_day <- today()


sequence_day <- seq(t_day, l_day, by = "day")
```

```r
# Initiate a vector for loop
weekends <- c() # or vector()

# Loop through each date from today to last day
for (dates in sequence_day) {
  d <- as_date(dates)
  if (wday(d) %in% c(1, 7)){
    weekends <- c(weekends, d) # append the date to the weekends vector.
    w <- as_date(weekends)
  }
  }

# Print the weekends
print(w)
```

```
[1] "2024-07-20" "2024-07-21" "2024-07-27" "2024-07-28" "2024-08-03"
[6] "2024-08-04" "2024-08-10" "2024-08-11" "2024-08-17"
```

```r
l_day <- ymd("2024-08-17")
t_day <- today()


sequence_day <- seq(t_day, l_day, by = "day")


weekends_df <- tibble(weekend = as_date(character()))

# Loop through each date from today to last day
for (dates in sequence_day) {
  d <- as_date(dates)
  if (wday(d) %in% c(1, 7)){
    weekends_df <- rbind(weekends_df, tibble(weekend = d)) # append the date to the datafram
  }
}

# Print the weekends data frame
print(weekends_df)
```

```
# A tibble: 9 x 1
  weekend
```

```
  <date>
1 2024-07-20
2 2024-07-21
3 2024-07-27
4 2024-07-28
5 2024-08-03
6 2024-08-04
7 2024-08-10
8 2024-08-11
9 2024-08-17
```

Question

Mixed data Types

In R, a vector must have elements of the same type, so if we try to create a vector with mixed types, R will **coerce** them.

- Consider following vectors. These are mixed vectors and R coreced them to the most flexible type.

```r
v1 <- c(1, 3.14, "a", TRUE)
v1
```

```
[1] "1"    "3.14" "a"    "TRUE"
```

```r
typeof(v1)
```

```
[1] "character"
```

```r
map(v1, typeof)
```

```
[[1]]
[1] "character"

[[2]]
[1] "character"

[[3]]
```

```
[1] "character"

[[4]]
[1] "character"
```

```r
v2 <- c(FALSE, exp(1),- 21, pi, TRUE)
v2
```

```
[1]   0.000000   2.718282 -21.000000   3.141593   1.000000
```

```r
typeof(v2)
```

```
[1] "double"
```

```r
map(v2, typeof)
```

```
[[1]]
[1] "double"

[[2]]
[1] "double"

[[3]]
[1] "double"

[[4]]
[1] "double"

[[5]]
[1] "double"
```

We can use a list to store elements of mixed types without coercion.

```r
l1 <-list(1, 3.14, "a", TRUE)
```

```r
typeof(l1)
```

```
[1] "list"
```

```r
map(l1, typeof)
```

```
[[1]]
[1] "double"

[[2]]
[1] "double"

[[3]]
[1] "character"

[[4]]
[1] "logical"
```

**We can use `sapply()` from {`base`} package to find type of objects

```r
sapply(l1, typeof)
```

```
[1] "double"    "double"    "character" "logical"
```

```r
sapply(v2, typeof)
```

```
[1] "double" "double" "double" "double" "double"
```

```r
sapply(v1, typeof)
```

```
          1        3.14           a        TRUE 
"character" "character" "character" "character" 
```

DataFrame

Having a column with mixed data types (like column 3 in the example) indicates that the data is not `tidy`. In `tidy` data, each column should contain only one type of data (e.g., all numbers, all characters, etc.).

```r
df <- tibble::tibble(
  Var1 = c(T, TRUE, F),
  Var2 = c("Jim", "Steve", "Mary"),
  Var3 = c(4.5, FALSE, -pi)  # This column has mixed data types
)
df
```

```
# A tibble: 3 x 3
  Var1  Var2   Var3
  <lgl> <chr> <dbl>
1 TRUE  Jim    4.5
2 TRUE  Steve  0
3 FALSE Mary  -3.14
```

When a column contains mixed types, R often coerces the entire column to the most flexible type (in this case, dbl) to accommodate all values.

```r
typeof(df)
```

```
[1] "list"
```

```r
class(df)
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

```r
map(df, typeof)
```

```
$Var1
[1] "logical"

$Var2
[1] "character"

$Var3
[1] "double"
```

```r
sapply(df, typeof)
```

```
       Var1        Var2        Var3
  "logical" "character"    "double"
```

Question

Is the "Special For Loop Method" a good method to be adapted as a function to determine values like median or standard deviation for any given dataframe?

- We can find the numerical summaries of a data set as follow

```
mpg |>
  summarise(median(cty), mean(cty), sd(cty), sum(cty))
```

```
# A tibble: 1 x 4
  `median(cty)` `mean(cty)` `sd(cty)` `sum(cty)`
          <dbl>       <dbl>     <dbl>      <int>
1            17        16.9      4.26       3945
```

- Or we can get the numerical summaries based on `class` of the cars

```
mpg |>
  group_by(class) |>
  summarise(median(cty), mean(cty), sd(cty), sum(cty), n())
```

```
# A tibble: 7 x 6
  class      `median(cty)` `mean(cty)` `sd(cty)` `sum(cty)` `n()`
  <chr>              <dbl>       <dbl>     <dbl>      <int> <int>
1 2seater               15        15.4     0.548         77     5
2 compact               20        20.1     3.39         946    47
3 midsize               18        18.8     1.95         769    41
4 minivan               16        15.8     1.83         174    11
5 pickup                13        13       2.05         429    33
6 subcompact              19        20.4     4.60         713    35
7 suv                   13        13.5     2.42         837    62
```

- The summaries of all variables can be obtained by

```
mpg |>
  summary()
```

```
 manufacturer          model               displ            year     
 Length:234         Length:234         Min.   :1.600   Min.   :1999  
 Class :character   Class :character   1st Qu.:2.400   1st Qu.:1999  
 Mode  :character   Mode  :character   Median :3.300   Median :2004  
                                       Mean   :3.472   Mean   :2004  
                                       3rd Qu.:4.600   3rd Qu.:2008  
                                       Max.   :7.000   Max.   :2008  
      cyl           trans               drv                 cty       
 Min.   :4.000   Length:234         Length:234         Min.   : 9.00  
 1st Qu.:4.000   Class :character   Class :character   1st Qu.:14.00  
 Median :6.000   Mode  :character   Mode  :character   Median :17.00  
 Mean   :5.889                                         Mean   :16.86  
 3rd Qu.:8.000                                         3rd Qu.:19.00  
 Max.   :8.000                                         Max.   :35.00  
      hwy             fl               class          
 Min.   :12.00   Length:234         Length:234        
 1st Qu.:18.00   Class :character   Class :character  
 Median :24.00   Mode  :character   Mode  :character  
 Mean   :23.44                                        
 3rd Qu.:27.00                                        
 Max.   :44.00                                        
```

Create by For Loop

```
mean_vec <- vector(mode = "numeric", length = length(mpg))
for (i in seq_along(mpg)) {
mean_vec[[i]] <- mean(mpg[[i]], na.rm = TRUE)
}
```

```
Warning in mean.default(mpg[[i]], na.rm = TRUE): argument is not numeric or
logical: returning NA
Warning in mean.default(mpg[[i]], na.rm = TRUE): argument is not numeric or
logical: returning NA
Warning in mean.default(mpg[[i]], na.rm = TRUE): argument is not numeric or
logical: returning NA
Warning in mean.default(mpg[[i]], na.rm = TRUE): argument is not numeric or
logical: returning NA
Warning in mean.default(mpg[[i]], na.rm = TRUE): argument is not numeric or
logical: returning NA
Warning in mean.default(mpg[[i]], na.rm = TRUE): argument is not numeric or
logical: returning NA
```

```
mean_vec
```

```
 [1]          NA          NA    3.471795 2003.500000    5.888889          NA
 [7]          NA   16.858974   23.440171          NA          NA
```

For non_numerical variables you get NA*.*

- Let select all numerical variables of `mpg` data.

```
mpg |>
  select(c(displ, year, cyl, cty, hwy)) ->
  mpg_num
mpg_num
```

```
# A tibble: 234 x 5
   displ  year   cyl   cty   hwy
   <dbl> <int> <int> <int> <int>
 1   1.8  1999     4    18    29
 2   1.8  1999     4    21    29
 3   2    2008     4    20    31
 4   2    2008     4    21    30
 5   2.8  1999     6    16    26
 6   2.8  1999     6    18    26
 7   3.1  2008     6    18    27
 8   1.8  1999     4    18    26
 9   1.8  1999     4    16    25
10   2    2008     4    20    28
# i 224 more rows
```

```
mean_vec <- vector(mode = "numeric", length = length(mpg_num)) # Initiate a vector for loop
for (i in seq_along(mpg_num)) {
mean_vec[[i]] <- mean(mpg_num[[i]], na.rm = TRUE)
}
mean_vec
```

```
[1]    3.471795 2003.500000    5.888889   16.858974   23.440171
```

Let's find the standard deviation of each column

```
sd_vec <- vector()
for (i in seq_along(mpg_num)) {
sd_vec[[i]] <- sd(mpg_num[[i]], na.rm = TRUE)
}
sd_vec
```

```
[1] 1.291959 4.509646 1.611534 4.255946 5.954643
```

Create by functions from {base} package

- *We can use `colMeans()` function from {`base`} package.

```
colMeans(mpg_num)
```

```
      displ        year         cyl         cty         hwy 
   3.471795 2003.500000    5.888889   16.858974   23.440171 
```

There are other functions `rowMeans()`, `colSums()` and `rowSums()`. Unfortunately, there is no "colSDs()" function

```
colSums(mpg_num)
```

```
   displ     year      cyl      cty      hwy 
   812.4 468819.0   1378.0   3945.0   5485.0 
```

There are 234 rows. Thus there are 234. We use `head()` to show only the first 3 outputs

```
rowSums(mpg_num)
```

```
  [1] 2051.8 2054.8 2065.0 2065.0 2049.8 2051.8 2062.1 2048.8 2045.8 2062.0
 [11] 2060.0 2047.8 2049.8 2059.1 2057.1 2046.8 2059.1 2059.2 2055.3 2047.3
 [21] 2055.3 2042.7 2051.0 2054.7 2050.7 2064.2 2062.2 2062.0 2054.3 2046.3
 [31] 2038.7 2044.5 2051.4 2066.4 2052.1 2064.5 2060.6 2047.4 2049.0 2046.3
 [41] 2046.3 2058.3 2058.3 2045.3 2045.8 2044.8 2056.8 2057.0 2051.7 2049.7
 [51] 2038.9 2039.9 2053.7 2053.7 2041.7 2040.2 2038.2 2038.9 2050.7 2041.7
 [61] 2050.7 2039.2 2052.7 2038.9 2048.7 2041.7 2050.7 2050.7 2048.7 2041.7
 [71] 2038.2 2039.2 2051.7 2038.9 2039.6 2040.4 2051.4 2040.0 2043.0 2040.0
 [81] 2050.0 2052.6 2042.0 2040.2 2040.2 2040.6 2040.6 2050.6 2038.4 2051.4
 [91] 2052.8 2051.8 2061.0 2058.0 2047.6 2048.6 2058.6 2057.6 2055.4 2065.6
```

```
[101] 2060.6 2061.6 2056.6 2060.6 2073.8 2074.8 2073.8 2064.0 2049.4 2050.4
[111] 2065.4 2066.4 2051.5 2051.5 2064.3 2050.0 2053.0 2062.0 2061.0 2057.7
[121] 2056.7 2057.7 2056.0 2051.7 2044.0 2042.7 2041.7 2053.7 2052.7 2047.1
[131] 2037.0 2050.2 2050.4 2037.6 2040.4 2039.4 2051.4 2040.0 2050.0 2052.6
[141] 2042.0 2055.4 2051.4 2068.5 2069.5 2063.5 2062.5 2052.0 2052.0 2061.5
[151] 2039.3 2040.3 2052.0 2051.6 2052.1 2050.8 2052.8 2063.8 2062.3 2048.5
[161] 2047.5 2061.5 2058.5 2060.5 2055.5 2052.2 2050.2 2050.5 2050.5 2059.5
[171] 2061.5 2058.5 2061.5 2040.7 2041.7 2042.4 2040.4 2054.0 2051.7 2055.2
[181] 2053.2 2066.4 2066.4 2052.0 2052.0 2064.5 2053.2 2055.2 2066.4 2067.4
[191] 2052.0 2052.0 2062.3 2058.8 2061.8 2065.8 2078.8 2074.8 2037.7 2052.7
[201] 2040.7 2041.7 2053.7 2040.4 2042.4 2051.0 2054.0 2055.0 2050.0 2064.0
[211] 2065.0 2048.8 2081.9 2055.0 2050.0 2065.0 2064.0 2065.5 2065.5 2046.8
[221] 2048.8 2083.9 2074.9 2055.0 2050.0 2063.5 2064.5 2054.8 2051.8 2061.0
[231] 2064.0 2049.8 2051.8 2060.6
```

```r
rowMeans(mpg_num) |>
  head(n = 3)
```

```
[1] 410.36 410.96 413.00
```

Create by `map()` from {purr} package

`map_*()` takes a vector (or list or data frame) as input, applies a provided function on each element of that vector, and outputs a vector of the same length.

```
-   `map()` returns a list.
-   `map_lgl()` returns a logical vector.
-   `map_int()` returns an integer vector.
-   `map_dbl()` returns a double vector.
-   `map_chr()` returns a character vector.
```

```r
    map_dbl(mpg_num, mean)
```

```r
map(mpg,summary)
```

```
$manufacturer
   Length     Class      Mode 
      234 character character 

$model
```

```
   Length     Class      Mode 
      234 character character 

$displ
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  1.600   2.400   3.300   3.472   4.600   7.000 

$year
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
   1999    1999    2004    2004    2008    2008 

$cyl
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  4.000   4.000   6.000   5.889   8.000   8.000 

$trans
   Length     Class      Mode 
      234 character character 

$drv
   Length     Class      Mode 
      234 character character 

$cty
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
   9.00   14.00   17.00   16.86   19.00   35.00 

$hwy
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  12.00   18.00   24.00   23.44   27.00   44.00 

$fl
   Length     Class      Mode 
      234 character character 

$class
   Length     Class      Mode 
      234 character character 
```

```
map_chr(mpg, typeof)
```

```
manufacturer        model        displ         year          cyl        trans
```

```
 "character"  "character"     "double"    "integer"    "integer"  "character"
         drv          cty          hwy           fl        class
 "character"    "integer"    "integer"  "character"  "character"
```

```
map_chr(mpg, class)
```

```
manufacturer        model        displ         year          cyl        trans
 "character"  "character"    "numeric"    "integer"    "integer"  "character"
         drv          cty          hwy           fl        class
 "character"    "integer"    "integer"  "character"  "character"
```

Find the number of unique value in each column

```
map_int(mpg, function(x) length(unique(x)))
```

```
manufacturer        model        displ         year          cyl        trans
          15           38           35            2            4           10
         drv          cty          hwy           fl        class
           3           21           27            5            7
```

Generate 7 random normals for each of $\mu = -10, 0, 10, \dots, 100$.

1. **Create by loop**

```
set.seed(123)
df <- tibble(row=1:7)
for (i in seq(-10, 100, by =10)){
  df <- cbind(df, tibble(rnorm(mean = i, n=7)))
               }
df
```

```
  row rnorm(mean = i, n = 7) rnorm(mean = i, n = 7) rnorm(mean = i, n = 7)
1   1             -10.560476             -1.2650612               9.444159
2   2             -10.230177             -0.6868529              11.786913
3   3              -8.441292             -0.4456620              10.497850
4   4              -9.929492              1.2240818               8.033383
5   5              -9.870712              0.3598138              10.701356
6   6              -8.284935              0.4007715               9.527209
7   7              -9.539084              0.1106827               8.932176
  rnorm(mean = i, n = 7) rnorm(mean = i, n = 7) rnorm(mean = i, n = 7)
```

```
1                 19.78203              28.86186              40.68864
2                 18.97400              31.25381              40.55392
3                 19.27111              30.42646              39.93809
4                 19.37496              29.70493              39.69404
5                 18.31331              30.89513              39.61953
6                 20.83779              30.87813              39.30529
7                 20.15337              30.82158              39.79208
  rnorm(mean = i, n = 7) rnorm(mean = i, n = 7) rnorm(mean = i, n = 7)
1                 48.73460              59.91663              68.45125
2                 52.16896              60.25332              70.58461
3                 51.20796              59.97145              70.12385
4                 48.87689              59.95713              70.21594
5                 49.59712              61.36860              70.37964
6                 49.53334              59.77423              69.49768
7                 50.77997              61.51647              69.66679
  rnorm(mean = i, n = 7) rnorm(mean = i, n = 7) rnorm(mean = i, n = 7)
1                 78.98142              89.50897              98.77928
2                 78.92821              87.69083             100.18130
3                 80.30353              91.00574              99.86111
4                 80.44821              89.29080             100.00576
5                 80.05300              89.31199             100.38528
6                 80.92227              91.02557              99.62934
7                 82.05008              89.71523             100.64438
```

- The above has three issues
  - I. We used `cbind()` from `base` package. we want to use bind_cols()`from`dplyr‘
  - II. We do not need the first row. We need to remove it.
  - III. The column names are not very good. So we can give it a better name. I use `names(df)` function

```
set.seed(123)
df <- tibble(row=1:7)
for (i in seq(-10, 100, by =10)){
  df <- bind_cols(df, tibble(rnorm(mean = i, n=7)))
                }
```

```
New names:
New names:
New names:
New names:
New names:
```

```
New names:
New names:
New names:
New names:
New names:
New names:
* `rnorm(mean = i, n = 7)` -> `rnorm(mean = i, n = 7)...2`
* `rnorm(mean = i, n = 7)` -> `rnorm(mean = i, n = 7)...3`
```

```
df |>
  select(-1) ->
  df_new
df_new
```

```
# A tibble: 7 x 12
  `rnorm(mean = i, n = 7)...2` rnorm(mean = i, n = 7)..~1 rnorm(mean = i, n = ~2
                         <dbl>                      <dbl>                  <dbl>
1                       -10.6                      -1.27                    9.44
2                       -10.2                      -0.687                  11.8
3                        -8.44                     -0.446                  10.5
4                        -9.93                      1.22                    8.03
5                        -9.87                      0.360                  10.7
6                        -8.28                      0.401                   9.53
7                        -9.54                      0.111                   8.93
# i abbreviated names: 1: `rnorm(mean = i, n = 7)...3`,
#   2: `rnorm(mean = i, n = 7)...4`
# i 9 more variables: `rnorm(mean = i, n = 7)...5` <dbl>,
#   `rnorm(mean = i, n = 7)...6` <dbl>, `rnorm(mean = i, n = 7)...7` <dbl>,
#   `rnorm(mean = i, n = 7)...8` <dbl>, `rnorm(mean = i, n = 7)...9` <dbl>,
#   `rnorm(mean = i, n = 7)...10` <dbl>, `rnorm(mean = i, n = 7)...11` <dbl>,
#   `rnorm(mean = i, n = 7)...12` <dbl>, ...
```

```
names(df_new) <- LETTERS[1:12]
df_new
```

```
# A tibble: 7 x 12
       A      B     C     D     E     F     G     H     I     J     K     L
   <dbl>  <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 -10.6  -1.27   9.44  19.8  28.9  40.7  48.7  59.9  68.5  79.0  89.5  98.8
2 -10.2  -0.687 11.8   19.0  31.3  40.6  52.2  60.3  70.6  78.9  87.7 100.
3  -8.44 -0.446 10.5   19.3  30.4  39.9  51.2  60.0  70.1  80.3  91.0  99.9
```

```
4  -9.93  1.22   8.03  19.4  29.7  39.7  48.9  60.0  70.2  80.4  89.3 100.
5  -9.87  0.360 10.7   18.3  30.9  39.6  49.6  61.4  70.4  80.1  89.3 100.
6  -8.28  0.401  9.53  20.8  30.9  39.3  49.5  59.8  69.5  80.9  91.0  99.6
7  -9.54  0.111  8.93  20.2  30.8  39.8  50.8  61.5  69.7  82.1  89.7 101.
```

2. **CReate by `map_`**

```r
set.seed(123)
    map_dfc(seq(-10, 100, by = 10), rnorm, n = 7)
```

```
New names:
* `` -> `...1`
* `` -> `...2`
* `` -> `...3`
* `` -> `...4`
* `` -> `...5`
* `` -> `...6`
* `` -> `...7`
* `` -> `...8`
* `` -> `...9`
* `` -> `...10`
* `` -> `...11`
* `` -> `...12`
```

```
# A tibble: 7 x 12
    ...1   ...2  ...3  ...4  ...5  ...6  ...7  ...8  ...9 ...10 ...11 ...12
   <dbl>  <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 -10.6  -1.27   9.44  19.8  28.9  40.7  48.7  59.9  68.5  79.0  89.5  98.8
2 -10.2  -0.687 11.8   19.0  31.3  40.6  52.2  60.3  70.6  78.9  87.7 100.
3  -8.44 -0.446 10.5   19.3  30.4  39.9  51.2  60.0  70.1  80.3  91.0  99.9
4  -9.93  1.22   8.03  19.4  29.7  39.7  48.9  60.0  70.2  80.4  89.3 100.
5  -9.87  0.360 10.7   18.3  30.9  39.6  49.6  61.4  70.4  80.1  89.3 100.
6  -8.28  0.401  9.53  20.8  30.9  39.3  49.5  59.8  69.5  80.9  91.0  99.6
7  -9.54  0.111  8.93  20.2  30.8  39.8  50.8  61.5  69.7  82.1  89.7 101.
```

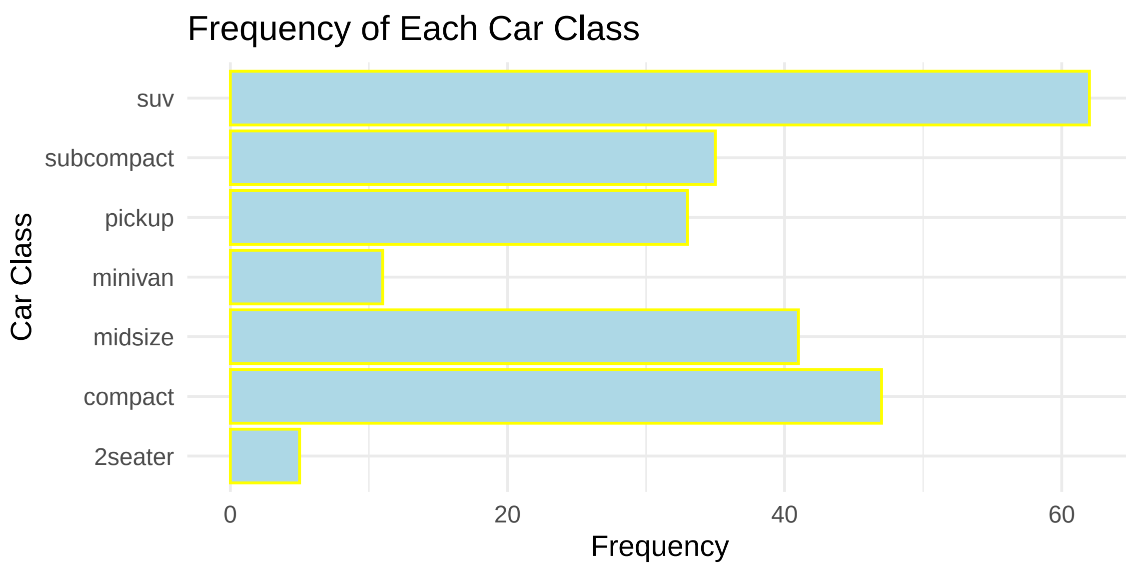
Table

- To create a frequency table of categorical variables, such as class, and its graph, follow these steps:

```
  table(mpg$class) ->
  t1

as.data.frame(t1) ->
  df

colnames(df) <- c("Class", "Count")

df
```

```
       Class Count
1    2seater     5
2    compact    47
3    midsize    41
4    minivan    11
5     pickup    33
6 subcompact    35
7        suv    62
```

```
df |>
  ggplot(aes(  y =Class, x= Count)) +
  geom_bar(stat = "identity", color = "yellow", fill = "lightblue") +
  theme_minimal() +
  labs(title = "Frequency of Each Car Class",
       y = "Car Class",
       x = "Frequency")
```

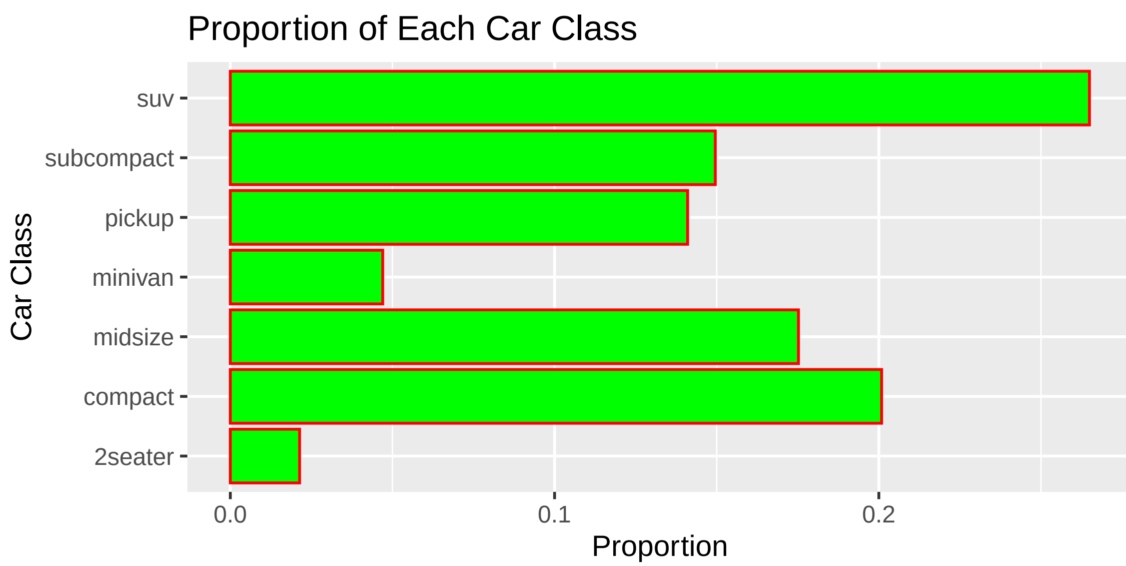


- Now calculate proportion of each class and draw its bargraph

```
df |>
  mutate(Prop = Count/sum(Count)) ->
  df_p
df_p
```

```
       Class Count       Prop
1    2seater     5 0.02136752
2    compact    47 0.20085470
3    midsize    41 0.17521368
4    minivan    11 0.04700855
5     pickup    33 0.14102564
6 subcompact    35 0.14957265
7        suv    62 0.26495726
```

```
df_p |>
  ggplot(aes(  y =Class, x= Prop)) +
  geom_bar(stat = "identity", color = "red", fill = "green") +
  theme_grey() +
  labs(title = "Proportion of Each Car Class",
       y = "Car Class",
       x = "Proportion")
```



Question

vectorization in R to duplicate, mutate (Create a new column)

- Go to https://biodash.github.io/codeclub/12_loops/ for "Vectorization and loops in R"

Consider the following data

```
 table(mpg$class) ->
  t1

as.data.frame(t1) ->
  df

colnames(df) <- c("Class", "Count")

df
```

```
       Class Count
1    2seater     5
2    compact    47
3    midsize    41
4    minivan    11
5     pickup    33
```

```
6 subcompact    35
7        suv    62
```

We want to create a new column called Proportion with `mutate()` and without mutate (vectorization)

`mutate()` function from `dplyr` package

```r
df |>
  mutate(Proportion = Count/sum(Count)) ->
  df_prop
df_prop
```

```
       Class Count Proportion
1    2seater     5 0.02136752
2    compact    47 0.20085470
3    midsize    41 0.17521368
4    minivan    11 0.04700855
5     pickup    33 0.14102564
6 subcompact    35 0.14957265
7        suv    62 0.26495726
```

Create by $

```r
df$Proportion <- (df$Count/sum(df$Count))
df
```

```
       Class Count Proportion
1    2seater     5 0.02136752
2    compact    47 0.20085470
3    midsize    41 0.17521368
4    minivan    11 0.04700855
5     pickup    33 0.14102564
6 subcompact    35 0.14957265
7        suv    62 0.26495726
```

Create by Subsetting

```r
df["Percentage"] <- df["Proportion"]*100
df
```

```
       Class Count Proportion Percentage
1    2seater     5 0.02136752   2.136752
2    compact    47 0.20085470  20.085470
3    midsize    41 0.17521368  17.521368
4    minivan    11 0.04700855   4.700855
5     pickup    33 0.14102564  14.102564
6 subcompact    35 0.14957265  14.957265
7        suv    62 0.26495726  26.495726
```