

# Class 06: R Functions

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## R Functions

In this session you will work through the process of developing your own function for calculating average grades for fictional students in a fictional class.

We will start with a simplified version of the problem. Grade some vectors of student scores. We want to drop the lowest score and get the average.

```
# Example input vectors to start with
student1 <- c(100, 100, 100, 100, 100, 100, 100, 90)
student2 <- c(100, NA, 90, 90, 90, 90, 97, 80)
student3 <- c(90, NA, NA, NA, NA, NA, NA, NA)
```

We can use the `mean()` function to get the average:

```
mean(student1)
```

```
[1] 98.75
```

We can find the smallest value with the `min()` function

```
min(student1)
```

```
[1] 90
```

There is also the `which.min()` function. Let's see if this can help:

```
student1
```

```
[1] 100 100 100 100 100 100 100 90
```

```
which.min(student1)
```

```
[1] 8
```

```
#returns the value of the lowest score  
#not very helpful  
student1[which.min(student1)]
```

```
[1] 90
```

```
x <- 1:5  
x
```

```
[1] 1 2 3 4 5
```

```
x[-4]
```

```
[1] 1 2 3 5
```

Let's put this together to drop the lowest value and find the mean:

```
s1 <- student1[-which.min(student1)] #s1 is the vector without the lowest score  
s1
```

```
[1] 100 100 100 100 100 100 100
```

```
mean(s1)
```

```
[1] 100
```

```
#putting it all together  
mean(student1[-which.min(student1)])
```

```
[1] 100
```

Now for student2

```
student2
```

```
[1] 100 NA 90 90 90 90 97 80
```

```
mean(student2[-which.min(student2)])
```

```
[1] NA
```

```
which.min(student2)
```

```
[1] 8
```

```
student2[-which.min(student2)]
```

```
[1] 100 NA 90 90 90 90 97
```

```
mean(c(5, 5, 5, NA), na.rm=TRUE)
```

```
[1] 5
```

```
mean(student2[-which.min(student2)], na.rm=TRUE)
```

```
[1] 92.83333
```

What about student 3?

```
student3
```

```
[1] 90 NA NA NA NA NA NA NA
```

```
mean(student3, na.rm=TRUE)
```

```
[1] 90
```

Not good, inflates grades as it drops all the NAs before determining the mean...

How does the function `is.na()` work?

```
student3
```

```
[1] 90 NA NA NA NA NA NA NA
```

```
is.na(student3)
```

```
[1] FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
```

```
student2
```

```
[1] 100 NA 90 90 90 90 97 80
```

```
is.na(student2)
```

```
[1] FALSE TRUE FALSE FALSE FALSE FALSE FALSE FALSE
```

I can use a logical vector to index another vector.

```
x <- 1:5  
x[x>3]
```

```
[1] 4 5
```

```
student2[is.na(student2)] <- 0 #assigns 0 to NA  
student2
```

```
[1] 100 0 90 90 90 90 97 80
```

```
x <- student3  
x[is.na(x)] <- 0  
mean(x[-which.min(x)])
```

```
[1] 12.85714
```

We now have our working snippet of code! This is now going to be the body of our function.

All functions in R have at least three things:

- A name (that we pick)
- input arguments
- a body (the code that does the work)

```
grade <- function(x) {  
  # mask NA to zero  
  x[is.na(x)] <- 0  
  # drop lowest value and get the mean  
  mean(x[-which.min(x)])  
}
```

Let's try it out

```
grade(student1)
```

```
[1] 100
```

```
grade(student2)
```

```
[1] 91
```

```
grade(student3)
```

```
[1] 12.85714
```

Grading an example class gradebook:

Q1. Write a function `grade()` to determine an overall grade from a vector of student homework assignment scores dropping the lowest single score. If a student misses a homework (i.e. has an NA value) this can be used as a score to be potentially dropped. Your final function should be adequately explained with code comments and be able to work on an example class gradebook such as this one in CSV format: “<https://tinyurl.com/gradeinput>” [3pts]

```
gradebook <- read.csv("https://tinyurl.com/gradeinput", row.names = 1)
head(gradebook)
```

```
      hw1 hw2 hw3 hw4 hw5
student-1 100 73 100 88 79
student-2 85 64 78 89 78
student-3 83 69 77 100 77
student-4 88 NA 73 100 76
student-5 88 100 75 86 79
student-6 89 78 100 89 77
```

```
View(gradebook)
```

We can use an `apply()` function to use existing `grade()` function on the whole class gradebook.

How does this `apply()` function work?

```
#apply the function grade over gradebook (input for function) with margin 1 (for the rows)
results <- apply(gradebook, 1, grade)
results
```

```
student-1 student-2 student-3 student-4 student-5 student-6 student-7
91.75      82.50      84.25      84.25      88.25      89.00      94.00
student-8 student-9 student-10 student-11 student-12 student-13 student-14
93.75      87.75      79.00      86.00      91.75      92.25      87.75
student-15 student-16 student-17 student-18 student-19 student-20
78.75      89.50      88.00      94.50      82.75      82.75
```

Q2. Using your `grade()` function and the supplied gradebook, Who is the top scoring student overall in the gradebook? [3pts]

```
which.max(results)
```

```
student-18
18
```

Q3. From your analysis of the gradebook, which homework was toughest on students (i.e. obtained the lowest scores overall? [2pts]

```
which.min(apply(gradebook, 2, sum, na.rm=TRUE))
```

hw2

2

```
#not a good way; does not use NA, so not a representative mean  
which.min(apply(gradebook, 2, mean, na.rm=TRUE))
```

hw3

3

If I want to use the mean approach, I will need to mask the NA (missing homework) as zero.

```
mask <- gradebook  
mask[is.na(mask)] <- 0  
mask
```

	hw1	hw2	hw3	hw4	hw5
student-1	100	73	100	88	79
student-2	85	64	78	89	78
student-3	83	69	77	100	77
student-4	88	0	73	100	76
student-5	88	100	75	86	79
student-6	89	78	100	89	77
student-7	89	100	74	87	100
student-8	89	100	76	86	100
student-9	86	100	77	88	77
student-10	89	72	79	0	76
student-11	82	66	78	84	100
student-12	100	70	75	92	100
student-13	89	100	76	100	80
student-14	85	100	77	89	76
student-15	85	65	76	89	0
student-16	92	100	74	89	77
student-17	88	63	100	86	78
student-18	91	0	100	87	100
student-19	91	68	75	86	79
student-20	91	68	76	88	76

```
which.min(apply(mask, 2, mean, na.rm = TRUE))
```

```
hw2  
2
```

Most people did not do well on homework 2.

Q4. Optional Extension: From your analysis of the gradebook, which homework was most predictive of overall score (i.e. highest correlation with average grade score)? [1pt]

Here we are going to look at the correlation of each homework results (i.e. the columns in the gradebook) with the overall grade of students from the course (in the `results` object obtained from using our `grade()` function).

```
results
```

student-1	student-2	student-3	student-4	student-5	student-6	student-7
91.75	82.50	84.25	84.25	88.25	89.00	94.00
student-8	student-9	student-10	student-11	student-12	student-13	student-14
93.75	87.75	79.00	86.00	91.75	92.25	87.75
student-15	student-16	student-17	student-18	student-19	student-20	
78.75	89.50	88.00	94.50	82.75	82.75	

```
mask$hw4
```

```
[1] 88 89 100 100 86 89 87 86 88 0 84 92 100 89 89 89 86 87 86  
[20] 88
```

I am going to use `cor()` function:

```
cor(results, mask$hw4)
```

```
[1] 0.3810884
```

```
cor(results, mask$hw5)
```

```
[1] 0.6325982
```

I want to use the `apply()` function to do this over the entire gradebook.



```
#can add extra arguments after function - in this case, "results"  
apply(mask, 2, cor, y=results)
```

hw1	hw2	hw3	hw4	hw5
0.4250204	0.1767780	0.3042561	0.3810884	0.6325982

Homework 5 has the most predictive overall score

Q5. Make sure you save your Quarto document and can click the “Render” (or Rmarkdown”Knit”) button to generate a PDF foramt report without errors. Finally, submit your PDF to gradescope. [1pt]