

# Class 06: R Functions

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## R functions

In this class we will work through the process of developing our 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
```

```
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 average

```
mean(student1[-which.min(student1)])
```

```
[1] 100
```

Now what about student 2

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

```
[1] NA
```

```
mean(c(5,5,5,NA))
```

```
[1] NA
```

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

```
[1] 5
```

Can I use this 'na.rm=TRUE' argument to help here?

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

```
[1] 92.83333
```

Hmmm... ok what about student 3

```
student3
```

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

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

```
[1] 90
```

So this sucks! It inflates grades as it drops all the NAs before determining the mean...

How does function 'is.na()' how does it 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
```

I can use a logical vector to index another vector

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

```
[1] 4 5
```

```
student2[is.na(student2)] <- 0  
student2
```

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

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

```
[1] 90 0 0 0 0 0 0 0
```

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

```
[1] 12.85714
```

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

All function in R have at least 3 things:

- A name (we pick that)
- 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 mean
  mean(x[-which.min(x)])
}
```

Let's try it out

```
grade(student1)
```

```
[1] 100
```

```
grade(student2)
```

```
[1] 91
```

```
grade(student3)
```

```
[1] 12.85714
```

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

I can use the super useful but a bit more complicated ‘apply()’ function to use our existing ‘grade()’ function on the whole class gradebook.

How does this ‘apply()’ function work?

```
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]

```
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	

```
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]

```
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
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	NA	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	NA
student-16	92	100	74	89	77
student-17	88	63	100	86	78
student-18	91	NA	100	87	100
student-19	91	68	75	86	79
student-20	91	68	76	88	76

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

```
hw2
2
```

```
# not a way way
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 homeworks) to zero first:

```
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
```

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 entire gradebook.

```
apply(mask, 2, cor, y=results)
```

hw1	hw2	hw3	hw4	hw5
0.4250204	0.1767780	0.3042561	0.3810884	0.6325982

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