02-08: Functions 1

1 - Purpose

- Create reusable code (a function)
- Use parameters in functions
- Use Boolean values as parameters
- Use return values in functions

2 - Questions about the material...

If you have any questions about the material in this lesson or your Class Project *feel free to email them to the instructor here*.

3 - The road to repeatable code (functions)

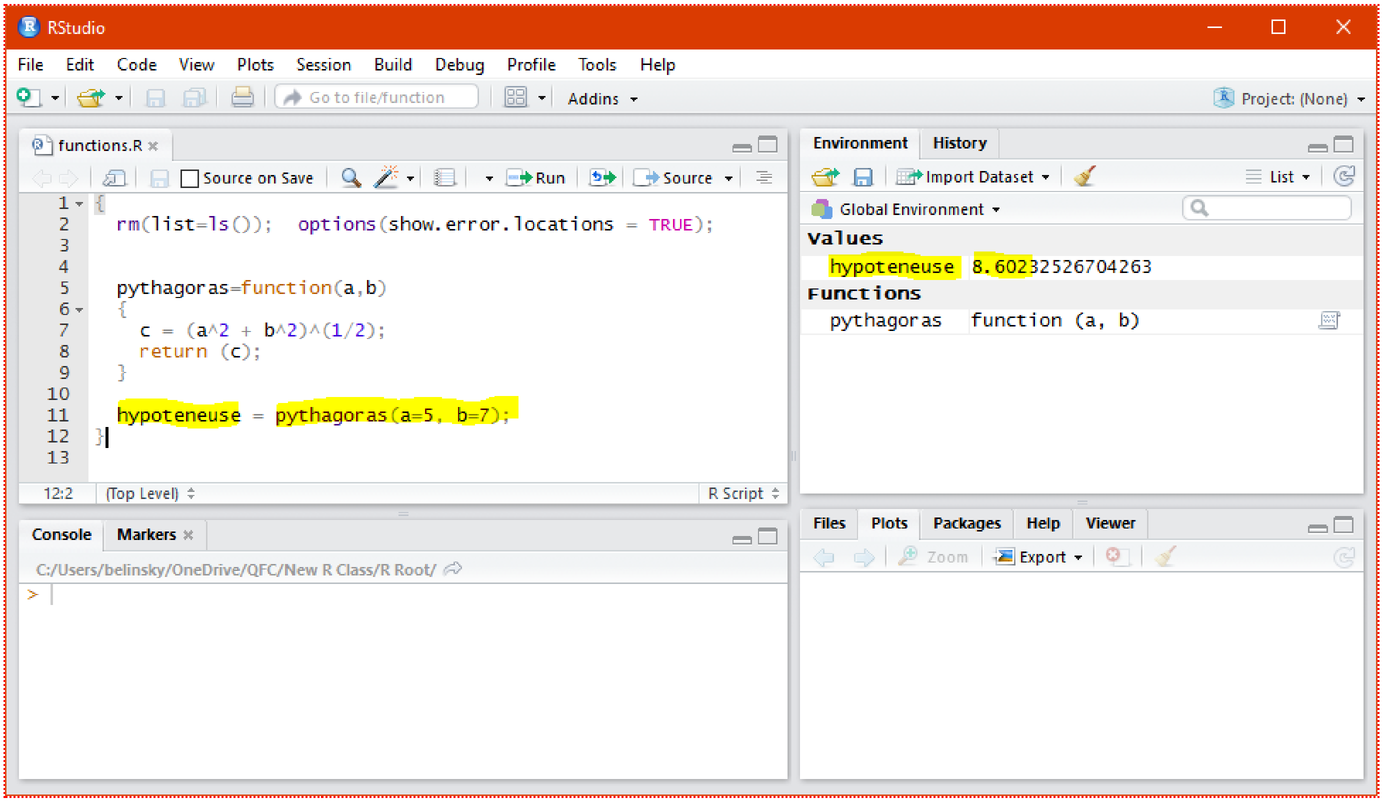
mean(), ***max()***, ***plot()*** are all examples of functions. Functions are reusable code that get executed from within a script -- it is sort of a script within a script. We use functions to avoid writing the same code over and over again. In the last lesson we used a function called ***plot()*** each time we wanted to produce a plot. ***plot()*** is a function built into R to handle the multitude of plotting situations that R programmers implement. We are going to create our own function that is a lot simpler but, like ***plot()***, can be used over and over again.

The function we will create is called ***pythagoras()*** and it will take two input values representing the smaller sides of a right triangle. ***pythagoras()*** solves for the long side of the triangle, or the hypotenuse and returns the answer to the caller using an R function called ***return()***.

So ***pythagoras()*** executes the formula: $c^2 = a^2 + b^2$ or $c = \sqrt{a^2 + b^2}$.

```
1  {
2    rm(list=ls()); options(show.error.locations = TRUE);
3  
4    pythagoras=function(a,b)
5    {
6      c = (a^2 + b^2)^(1/2);
7      return (c);
8    }
9  
10   hypoteneuse = pythagoras(a=5, b=7);
11 }
```

It is useful to think of functions as having three components: parameters (inputs), code, and a return value (outputs). In the case of **pythagoras(),** the parameters are ***a*** and ***b***, the code is inside the curly brackets, and the return value is ***c***. On line 9, ***pythagoras()*** is called and the the parameters ***a*** and ***b*** are assigned the values ***5*** and ***7***. On line 5, ***c*** is calculated using ***a*** and ***b***. On line 6, ***pythagoras()*** uses the ***return()*** function to return the answer (***c*** = ***8.602***) and this value gets saved to the variable in line 9 named ***hypotenuse***.



```
1  {
2    rm(list=ls());  options(show.error.locations = TRUE);
3
4
5    pythagoras=function(a,b)
6    {
7      c = (a^2 + b^2)^(1/2);
8      return (c);
9    }
10
11   hypoteneuse = pythagoras(a=5, b=7);
12 }
13
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
> 
```

```
Values
  hypoteneuse    8.60232526704263
Functions
  pythagoras     function (a, b)
```

*Fig 1: Calling the **pythagoras()** function with two values (sides of a triangle) to solve the third value (**hypotenuse**)*

4 - Function Details

There is a whole lot going on here and we will take it step by step

```
1 pythagoras=function(a,b)
2 {
3   c = (a^2 + b^2)^(1/2);
4   return (c);
5 }
6
7 hypoteneuse = pythagoras(a=5, b=7);
```

pythagoras() is declared like a variable except there is the term ***function().*** *Variable are assigned values (e.g., x=4) and functions are assigned codeblocks.* The codeblock assigned to ***pythagoras()*** is designated by the curly brackets on lines 2 and 5 (***{ }***). This means that whenever ***pythagoras()*** is called in the script, the codeblock attached to ***pythagoras()*** will be executed.

```
1 pythagoras=function(a,b)
2 {
3   c = (a^2 + b^2)^(1/2);
4    return (c);
5  }
6
7  hypoteneuse = pythagoras(a=5, b=7);
```

Inside the parentheses following "function" are the parameters used by the function (***a*** and ***b***). ***a*** and ***b*** are variables used in ***pythagoras()*** and the values of ***a*** and ***b*** are assigned by the caller.

```
1  pythagoras=function(a,b)
2  {
3    c = (a^2 + b^2)^(1/2);
4    return (c);
5  }
6

7  hypoteneuse = pythagoras(a=5, b=7);
```

The variables (***a*** and ***b***) are assigned values by the user, in this case: ***a=5, b=7. pythagoras()*** uses the variables ***a*** and ***b*** to calculate the third side of the right triangle. The result of the calculation is assigned to the variable named ***c*** (line 4).

```
1  pythagoras=function(a,b)
2  {
3    c = (a^2 + b^2)^(1/2);
4    return (c);
5  }
6
7  hypoteneuse = pythagoras(a=5, b=7)
```

The ***return()*** function specifies the results of the function (***c***). In other words, ***pythagoras()*** is returning the answer, which is the value of ***c***, **8.507**, to the user.

```
1  pythagoras=function(a,b)

2  {
3    c = (a^2 + b^2)^(1/2);
4    return (c);
5  }
6
7  hypoteneuse = pythagoras(a=5, b=7);
```

To summarize: the function ***pythagoras()*** executes using input parameters ***a***=5, and ***b***=7, does its calculation, and assigns the answer to ***c***. The value of ***c***, which is ***8.602***, is returned to the caller and assigned to the variable ***hypotenuse***.

5 - Reusing a function

The reason to create functions is to easily reuse a block of code. We don't have to create new code every time we want to solve for the third side in a right triangle, we just call ***pythagoras()*** and pass in the value of the two smaller sides of the right triangle.

```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  pythagoras=function(a,b)
  {
    c = (a^2 + b^2)^(1/2);
    return (c);
  }

  hypoteneuse1 = pythagoras(a=5, b=7);
  hypoteneuse2 = pythagoras(a=10, b=23);
  hypoteneuse3 = pythagoras(a=18, b=12);
  hypoteneuse4 = pythagoras(b=12, a=18);
  hypoteneuse5 = pythagoras(18, 12);
}
```

Note that you will often see code that skips the variable names as in:

```
hypoteneuse3 = pythagoras(18, 12);
```

This line of code works as long as the values are put in the correct order -- it is the equivalent of:

```
hypoteneuse3 = pythagoras(a=18, b=12);
```

You can also move the variables around and it will execute exactly the same:

```
hypoteneuse3 = pythagoras(b=12, a=18);
```

All three of these lines will call ***pythagoras()*** and assign ***a*** the value ***18*** and assign ***b*** the value ***12***

5.1 - Variable names do not matter... to R

Variable names are generally chosen to make it easier for the reader to understand the script. But the script could care less what variable names you use. The following script executes the exact same calculation and returns the exact same value as the script above -- it just uses variable and function names that are not intuitive to the user.

```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  doStuff=function(aValue, anotherValue)
  {
    answerToStuff = (aValue^2 + anotherValue^2)^(1/2);
    return (answerToStuff);
  }

  whatIGot = doStuff(aValue=5, anotherValue=7);
}
```

6 - Function for temperature conversion

We are going to do one more example-- a function that converts all temperature values in a vector from Fahrenheit to Celsius and from Celsius to Fahrenheit.

6.1 - Single value conversion

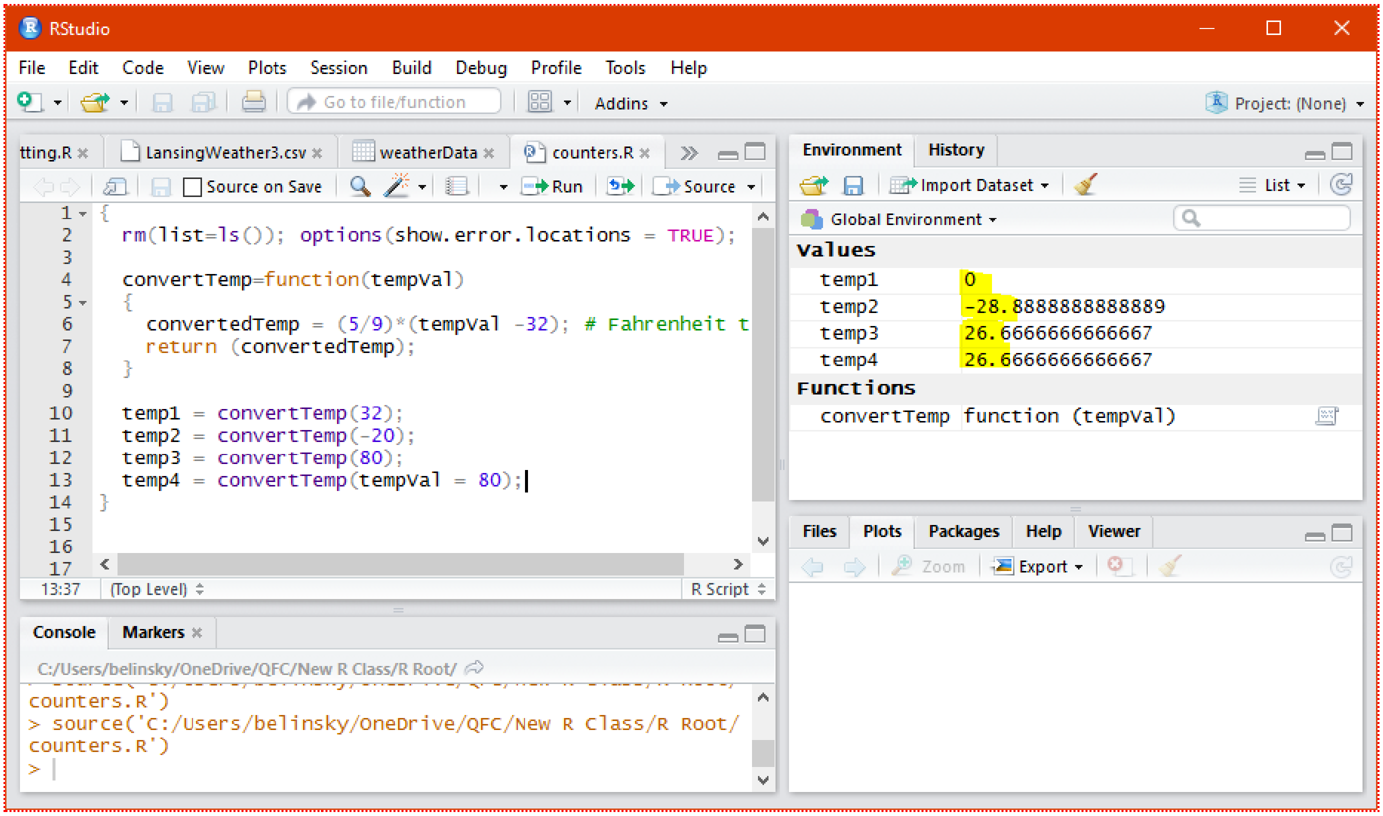
We will start with the conversion of a single value from Fahrenheit to Celsius

```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  convertTemp=function(tempVal)
  {
    convertedTemp = (5/9)*(tempVal -32); # Fahrenheit to Celsius conversion
    return (convertedTemp);
  }

  temp1 = convertTemp(32);
  temp2 = convertTemp(-20);
  temp3 = convertTemp(80);
  temp4 = convertTemp(tempVal = 80);
}
```

Notice that ***temp4*** explicitly sets the function parameter ***tempVal = 80,*** whereas ***temp3*** does not. But ***temp3*** and ***temp4*** still evaluate to the same value.



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  convertTemp=function(tempVal)
  {
    convertedTemp = (5/9)*(tempVal -32);  # Fahrenheit t
    return (convertedTemp);
  }

  temp1 = convertTemp(32);
  temp2 = convertTemp(-20);
  temp3 = convertTemp(80);
  temp4 = convertTemp(tempVal = 80);
}
```

```
Values
  temp1          0
  temp2          -28.8888888888889
  temp3          26.6666666666667
  temp4          26.6666666666667
Functions
  convertTemp    function (tempVal)
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
counters.R')
> 
```

Fig 2: Converting single temperature values from Fahrenheit to Celsius

6.2 - Converting in both directions: Boolean Variable

In the previous unit we generated ***TRUE*** and ***FALSE*** statements by performing conditional operations on a variable like:

```
if( yourAge > 20 && yourAge < 50) # yourAge betwen 20 and 50
```

or

```
# checking two spellings of Muenster
if(favCheese == "Muenster" || favCheese == "Meunster")
```

TRUE and ***FALSE*** are predefined words in R and can be used as values for a variable. A variable that has ***TRUE*** or ***FALSE*** as a value is called a *Boolean Variable*. In the next example we will use a Boolean variables as a function parameter (***toCelsius***) to check how the user wants to convert the temperature values:

if the parameter ***toCelsius*** is set to ***TRUE***: convert from Fahrenheit to Celsius
if the parameter ***toCelsius*** is set to ***FALSE***: convert from Celsius to Fahrenheit

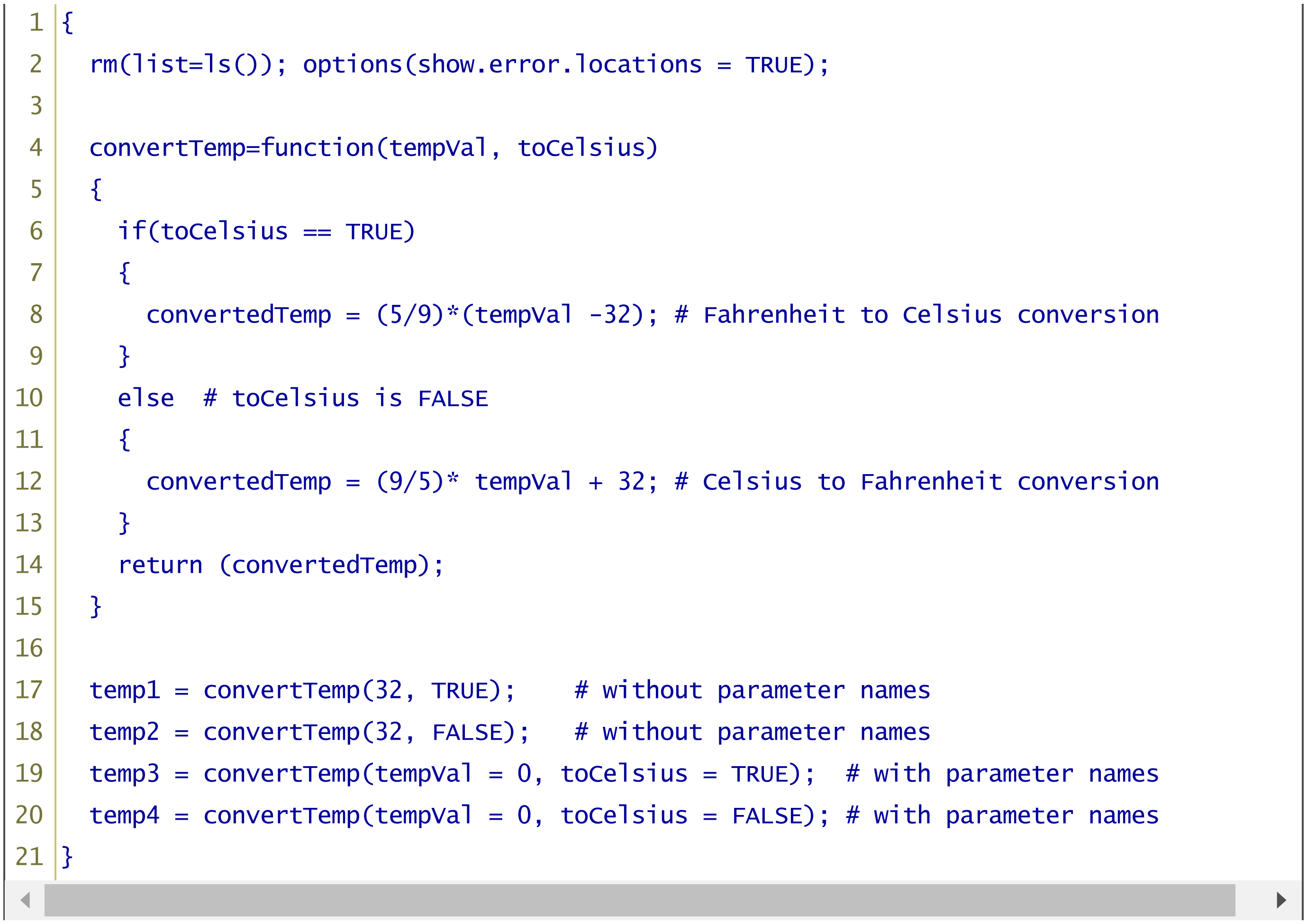
Boolean variables can only be set to ***TRUE*** or ***FALSE*** so they are convenient when you have a scenario with exclusively two options.

6.3 - Conditional statements inside a function

Now we want a function that can do temperature conversions in two directions: **Fahrenheit (F) -> Celsius (C)** and **Celsius (C) -> Fahrenheit (F)**. The function needs to differentiate between an **F -> C** conversion and a **C**

-> **F** conversion. Since there are exclusively two possibilities we can use a ***TRUE***/***FALSE*** scenario. In the script below, the function has two parameters that the user needs to set: ***tempVal*** and ***toCelsius***.

toCelsius *can only have two values:* ***TRUE*** *and* ***FALSE****.*
If ***toCelsius*** is ***TRUE***, we will use the **F -> C** conversion, if ***toCelsius*** is ***FALSE***, we will use the **C -> F** conversion.

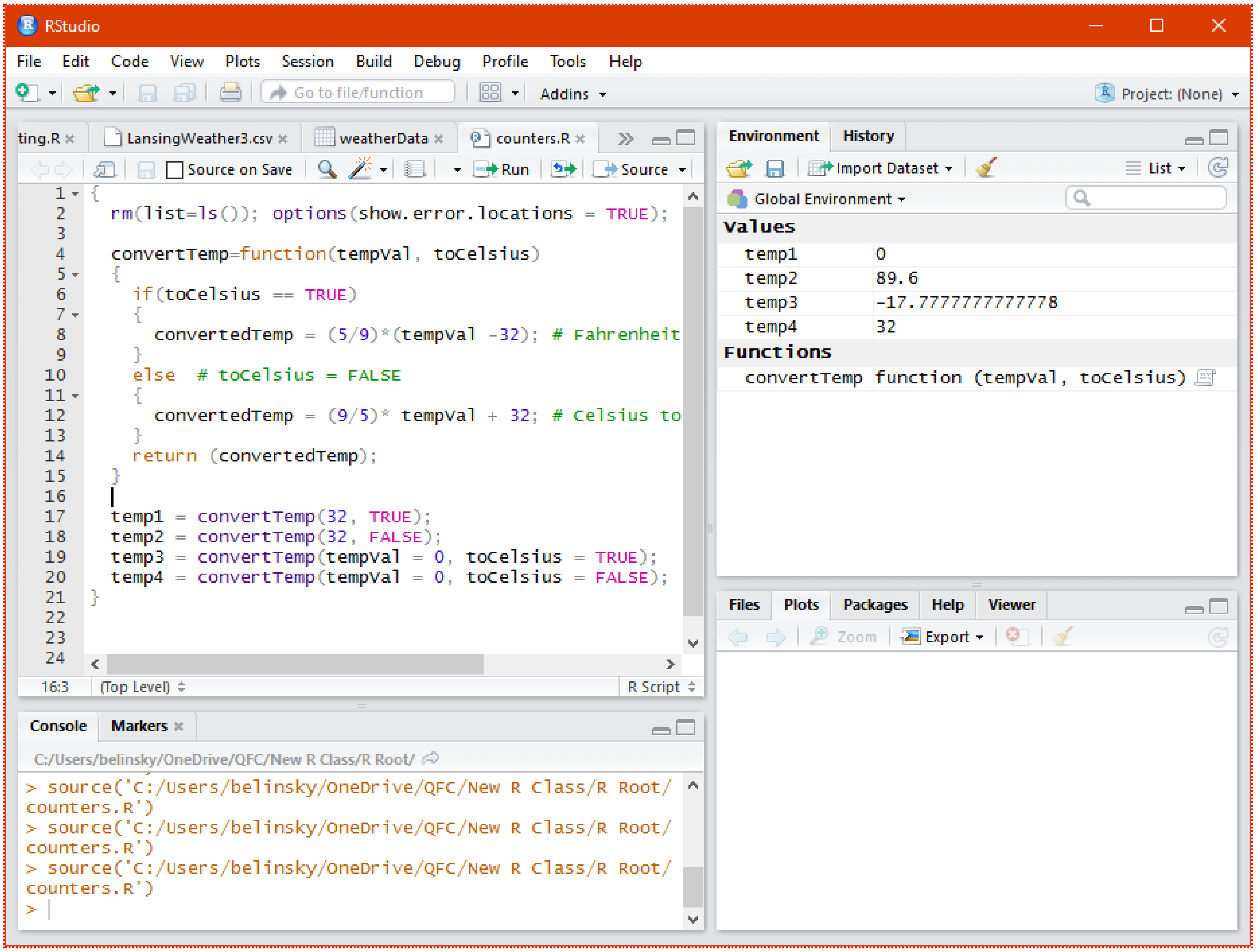


```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  convertTemp=function(tempVal, toCelsius)
  {
    if(toCelsius == TRUE)
    {
      convertedTemp = (5/9)*(tempVal -32); # Fahrenheit to Celsius conversion
    }
    else  # toCelsius is FALSE
    {
      convertedTemp = (9/5)* tempVal + 32; # Celsius to Fahrenheit conversion
    }
    return (convertedTemp);
  }

  temp1 = convertTemp(32, TRUE);    # without parameter names
  temp2 = convertTemp(32, FALSE);   # without parameter names
  temp3 = convertTemp(tempVal = 0, toCelsius = TRUE);  # with parameter names
  temp4 = convertTemp(tempVal = 0, toCelsius = FALSE); # with parameter names
}
```

Notice that ***TRUE*** and ***FALSE*** are not in quotes. ***TRUE*** and ***FALSE*** are reserved keywords in R. This means ***TRUE*** and ***FALSE*** cannot be assigned a value (i.e., ***TRUE*** = **5** will return an error).



```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  convertTemp=function(tempVal, toCelsius)
  {
    if(toCelsius == TRUE)
    {
      convertedTemp = (5/9)*(tempVal -32); # Fahrenheit
    }
    else  # toCelsius = FALSE
    {
      convertedTemp = (9/5)* tempVal + 32; # Celsius to
    }
    return (convertedTemp);
  }

  temp1 = convertTemp(32, TRUE);
  temp2 = convertTemp(32, FALSE);
  temp3 = convertTemp(tempVal = 0, toCelsius = TRUE);
  temp4 = convertTemp(tempVal = 0, toCelsius = FALSE);
}
```

```
Values
  temp1         0
  temp2         89.6
  temp3         -17.7777777777778
  temp4         32
Functions
  convertTemp   function (tempVal, toCelsius)
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
counters.R')
> 
```

*Fig 3: Using a Boolean (**TRUE/FALSE**) value to determine the direction of the temperature conversion.*

6.4 - Using a vector instead of a single value

The function ***convertTemp***() works with a vector of temperature values without any modification because R is flexible enough to treat operations on an entire vector the same way it treats operations involving single values.

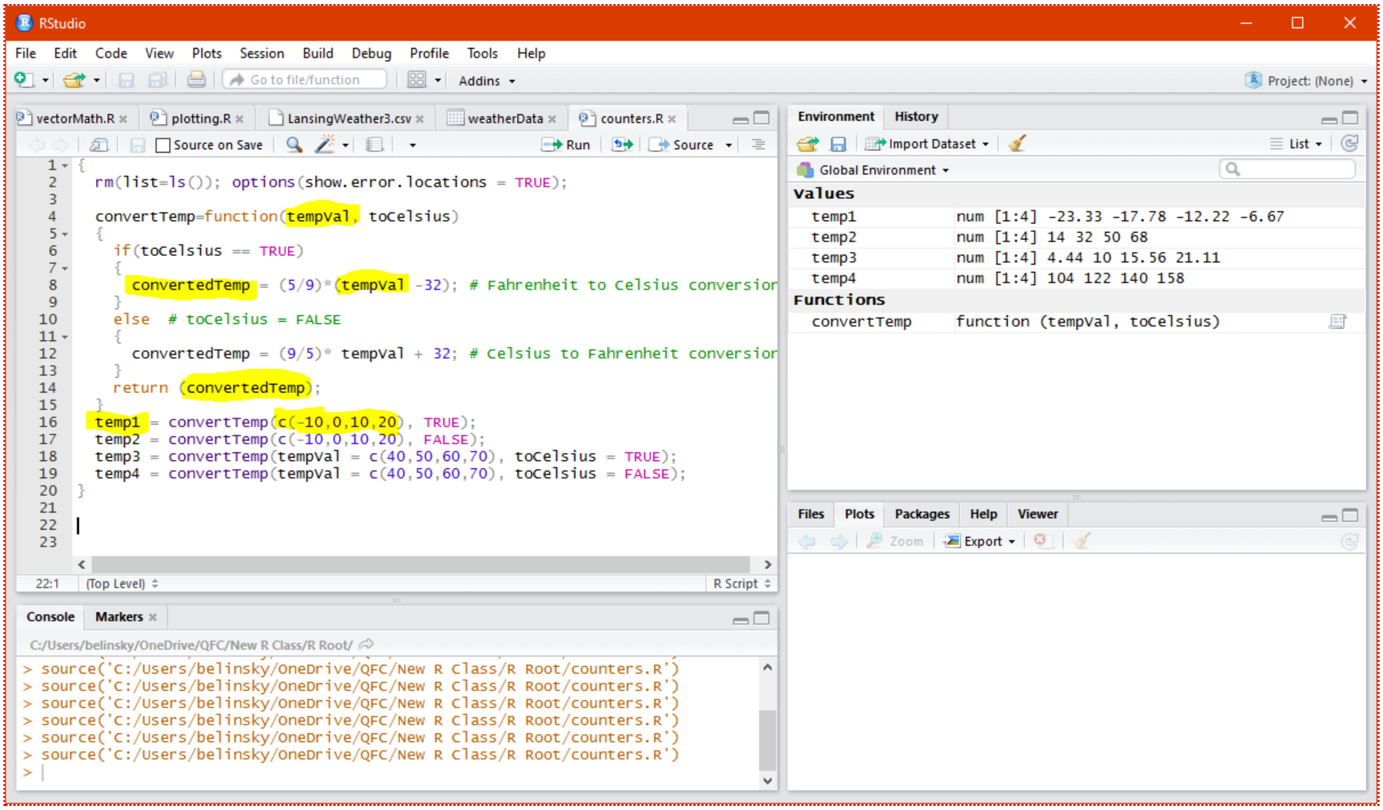
```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  convertTemp=function(tempVal, toCelsius)
  {
    if(toCelsius == TRUE)
    {
      convertedTemp = (5/9)*(tempVal -32); # Fahrenheit to Celsius conversion
    }
    else  # toCelsius = FALSE
    {
      convertedTemp = (9/5)* tempVal + 32; # Celsius to Fahrenheit conversion
13      }
14      return (convertedTemp);
15    }
16
17    temp1 = convertTemp(c(-10,0,10,20), TRUE);
18    temp2 = convertTemp(c(-10,0,10,20), FALSE);
19    temp3 = convertTemp(tempVal = c(40,50,60,70), toCelsius = TRUE);
20    temp4 = convertTemp(tempVal = c(40,50,60,70), toCelsius = FALSE);
21  }
```

When ***convertTemp()*** is called in lines 16-19:

- a vector with four values is assigned to ***tempVal***.
- ***tempVal*** gets used to calculate ***convertedTemp*** (lines 7 and 11)
- ***convertedTemp*** will be a vector with the same number of values as ***tempVal***

convertedTemp, a vector, is returned to the caller (line 13). The value of ***convertedTemp*** is saved into the variables named ***temp1***, ***temp2***, ***temp3***, and ***temp4***, which will also be vectors.



```
1  {
2    rm(list=ls()); options(show.error.locations = TRUE);
3
4    convertTemp=function(tempVal, toCelsius)
5    {
6      if(toCelsius == TRUE)
7      {
8        convertedTemp = (5/9)*(tempVal -32); # Fahrenheit to Celsius conversion
9      }
10     else  # toCelsius = FALSE
11     {
12       convertedTemp = (9/5)* tempVal + 32; # Celsius to Fahrenheit conversion
13     }
14     return (convertedTemp);
15   }
16   temp1 = convertTemp(c(-10,0,10,20), TRUE);
17   temp2 = convertTemp(c(-10,0,10,20), FALSE);
18   temp3 = convertTemp(tempVal = c(40,50,60,70), toCelsius = TRUE);
19   temp4 = convertTemp(tempVal = c(40,50,60,70), toCelsius = FALSE);
20 }
21
22
23
```

```
Values
  temp1         num [1:4] -23.33 -17.78 -12.22 -6.67
  temp2         num [1:4] 14 32 50 68
  temp3         num [1:4] 4.44 10 15.56 21.11
  temp4         num [1:4] 104 122 140 158
Functions
  convertTemp   function (tempVal, toCelsius)
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/counters.R')
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/counters.R')
> 
```

Fig 4: Converting multiple values in a vector.

Extension: Using a for() to iterate through the vector values

7 - Application

If you have any questions regarding this application or your Class Project, feel free to email them to the instructor here. You can attach the whole Root Folder as a zipped file.

1) Create ***one function*** that does all of the following weight conversions:

a) kg -> g
b) g -> kg
c) lb -> g
d) g --> lb
e) lb -> kg
f) kg -> lb

Hint: One way to think about this is that the function has an if-else structure with six possibilities (one for each conversion) and the parameter for the functions determines which of the six gets executed.

2) Create a function that finds the *difference in temperatures* between consecutive days and returns the temperature differences as a vector (i.e., take the application for lesson 2-5 and turn it into a function)

So if you have four high temperatures: **40, 45, 35, 42**:
the temperature difference returned by the function would be: **5, -10, 7**

Note: *the return vector has one less value* than the vector given to the function.

*Save you script file as **app2-8.r** in the **scripts** folder of your RStudio Project for the class.*

8 - Extension: Using a for() to iterate through vector values

The following example functionally does the same thing as *Fig.4* except with a ***for().*** While it takes more code to do it this way, it also opens up the possibility of doing more processing on the values (e.g., checking for invalid values).

```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  convertTemp=function(tempVal, toCelsius)
  {
    convertedTemp = c();  # declare convertedTemp as a vector

    for(i in 1:length(tempVal))  # go through each value in the vector
    {
      if(toCelsius == TRUE)
      {
        convertedTemp[i] = (5/9)*(tempVal[i] -32); # F to C conversion
      }
      else  # toCelsius = FALSE
      {
        convertedTemp[i] = (9/5)* tempVal[i] + 32; # C to F conversion
      }
    }
    return (convertedTemp);
  }
  temp1 = convertTemp(c(-10,0,10,20), TRUE);
  temp2 = convertTemp(c(-10,0,10,20), FALSE);
  temp3 = convertTemp(tempVal = c(40,50,60,70), toCelsius = TRUE);
  temp4 = convertTemp(tempVal = c(40,50,60,70), toCelsius = FALSE);
}
```