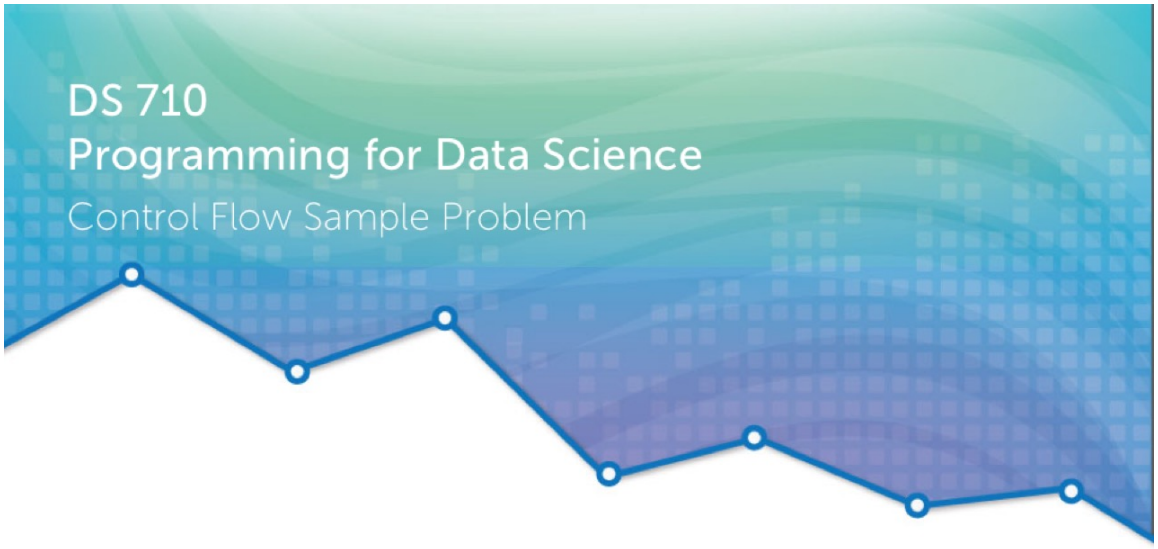
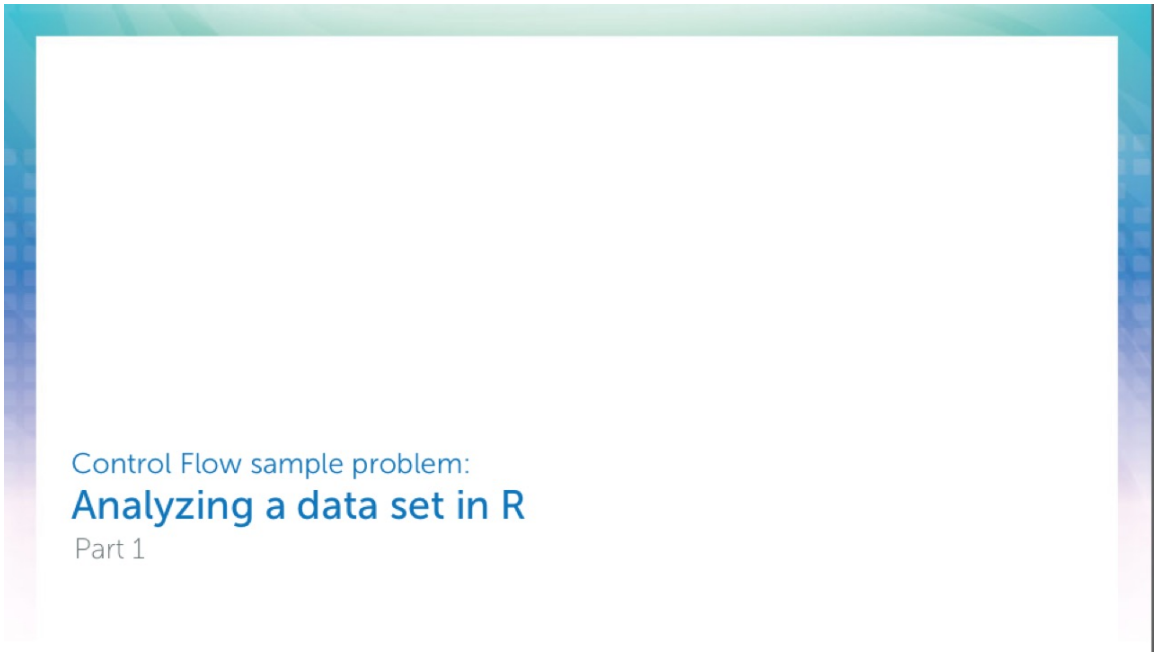
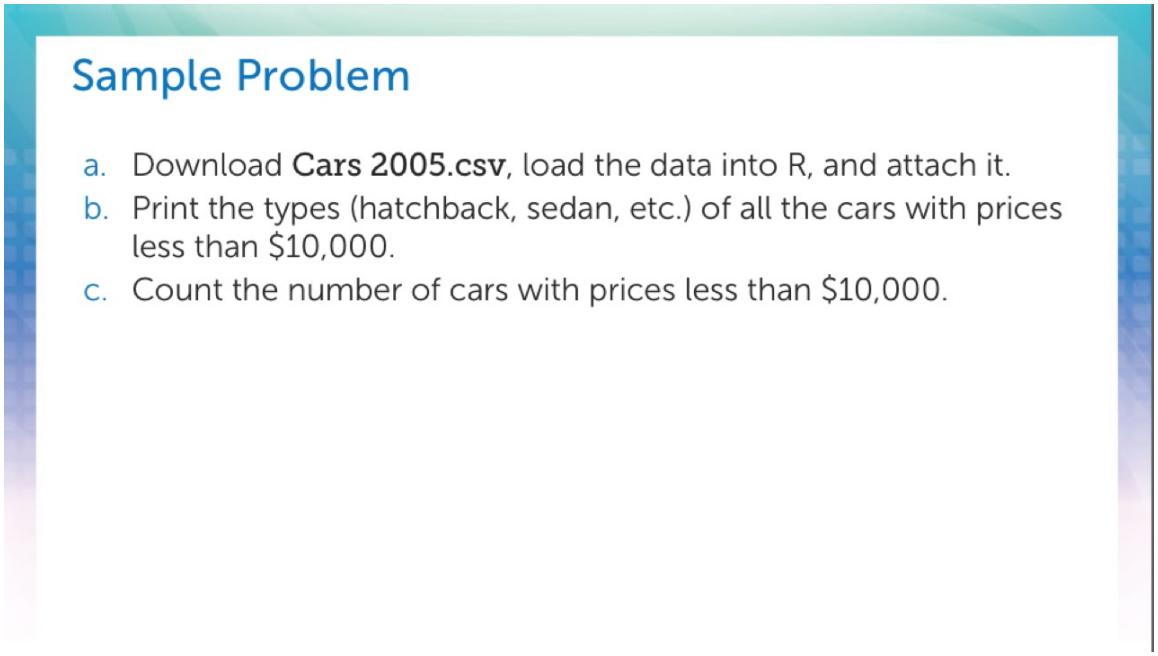


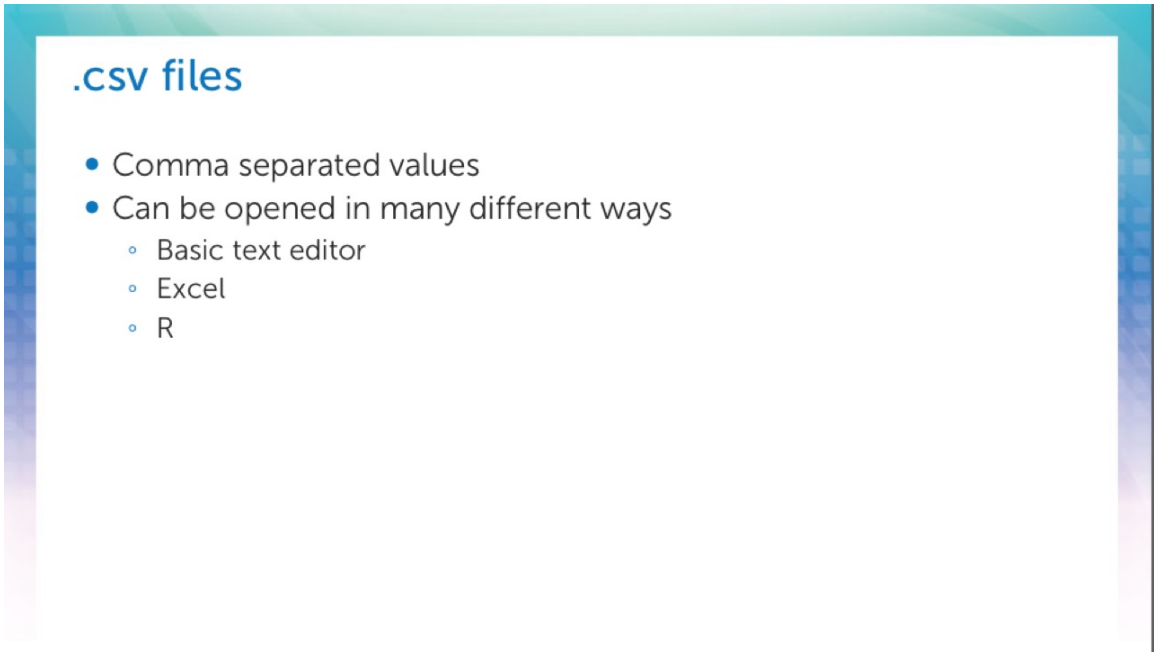
Analyzing a Data Set in R



Let's look at how to analyze a sample problem involving analyzing a data set using control flow in R.

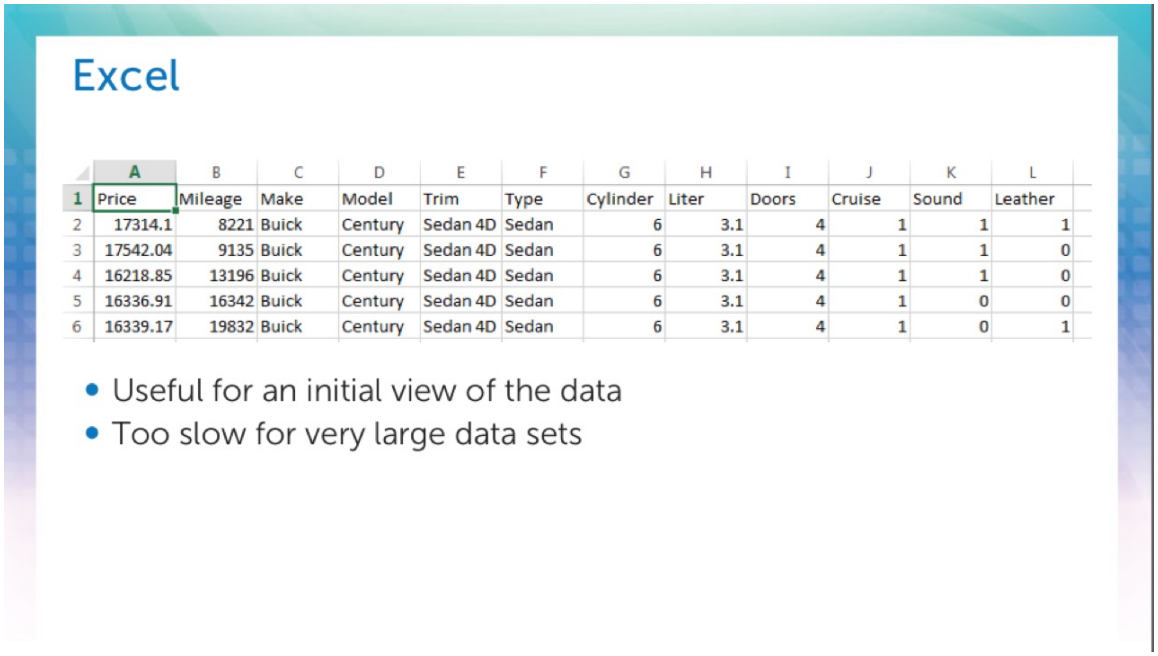


We'll analyze the data set cars2005.csv. First we'll need to load the data into R and attach it. Then we'll print the types of all the cars with prices less than $10,000. Finally we'll count how many cars have prices less and $10,000.

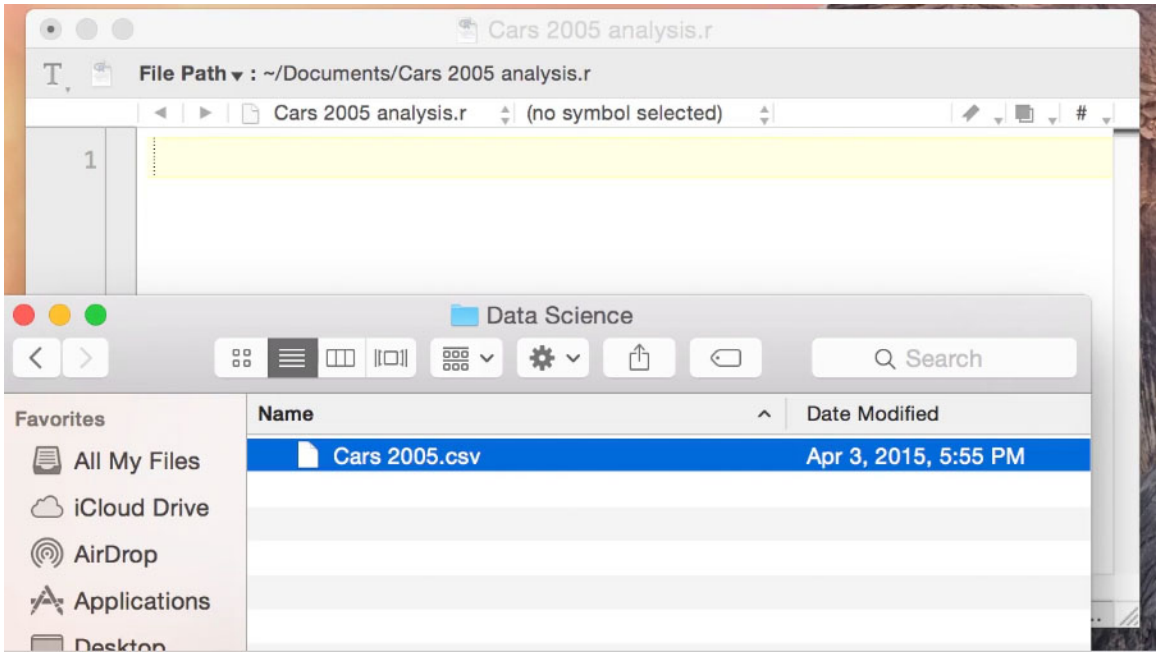


CSV stands for comma separated values. This is a nice file format, because it can be opened in many different ways. Using a basic text editor, Excel, or R.

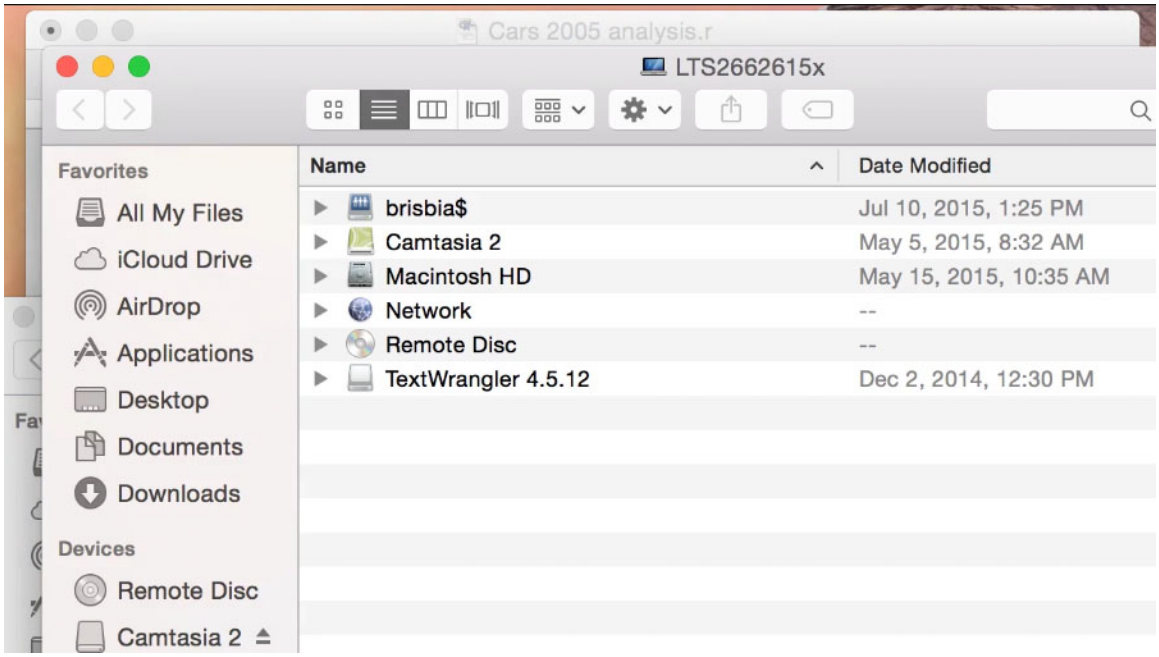
If we open the car's2005 data set in a basic text editor, such as notepad++ we can see that each of the entries in the data set is separated by commas. Hence, comma separated values.



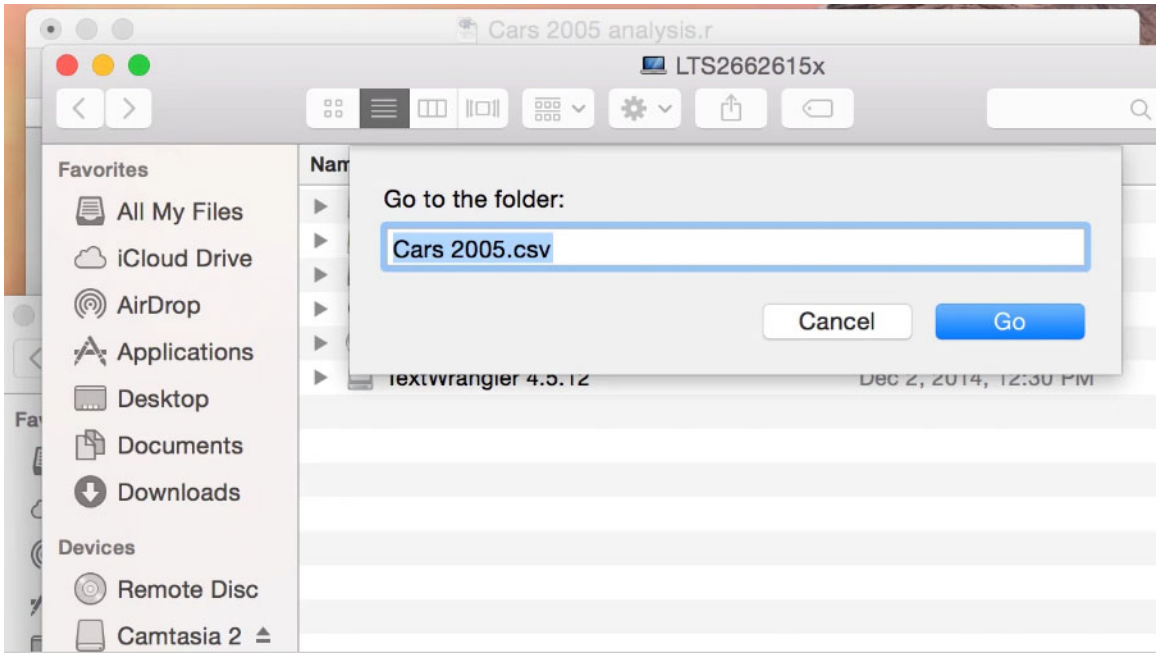
If we open it in Excel, we can see that each variable is separated into its own column. This is useful for getting an initial view of what's going on with the data set, at least if your data set isn't too large. In this case, we can see that the data contains information on used cars. If you're curious about the details of what each column contains, you can check out the metadata using the link below. We can also see that this data set contains an initial row that tells what each column contains, this is called a header row. Next, let's take a look at how to read this data set into R.



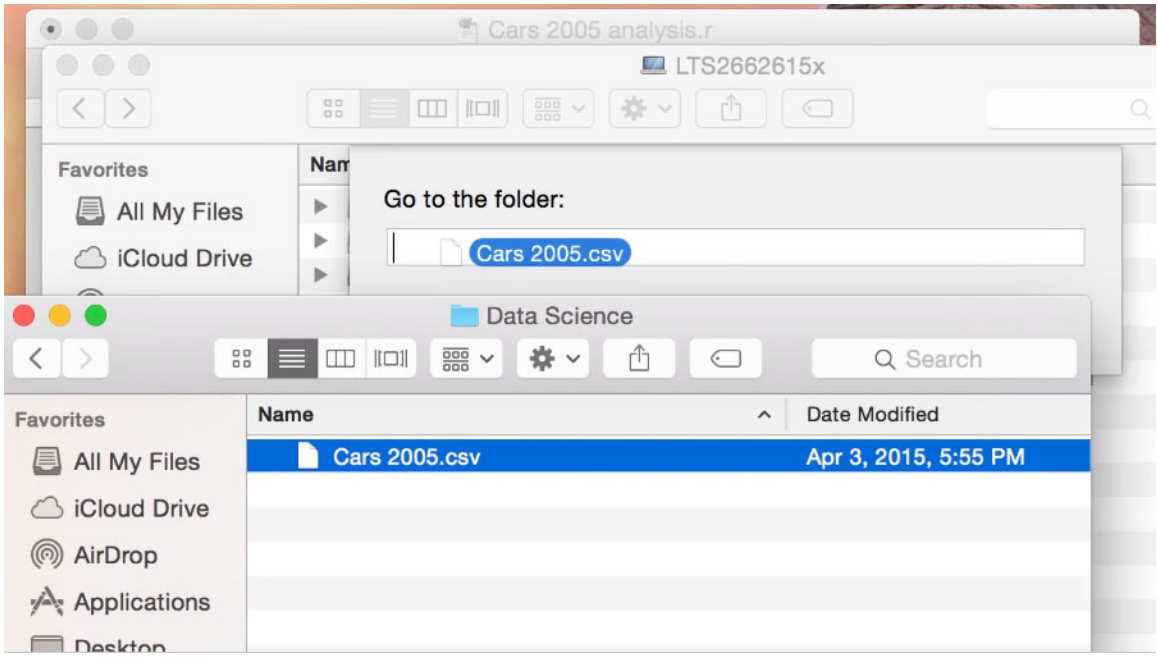
To open a CSV file in R, we need to make sure we know the full path of the directory where the file is saved. To find this on a Mac open the finder, and navigate to the file.



Then press Command N to open another finder window.

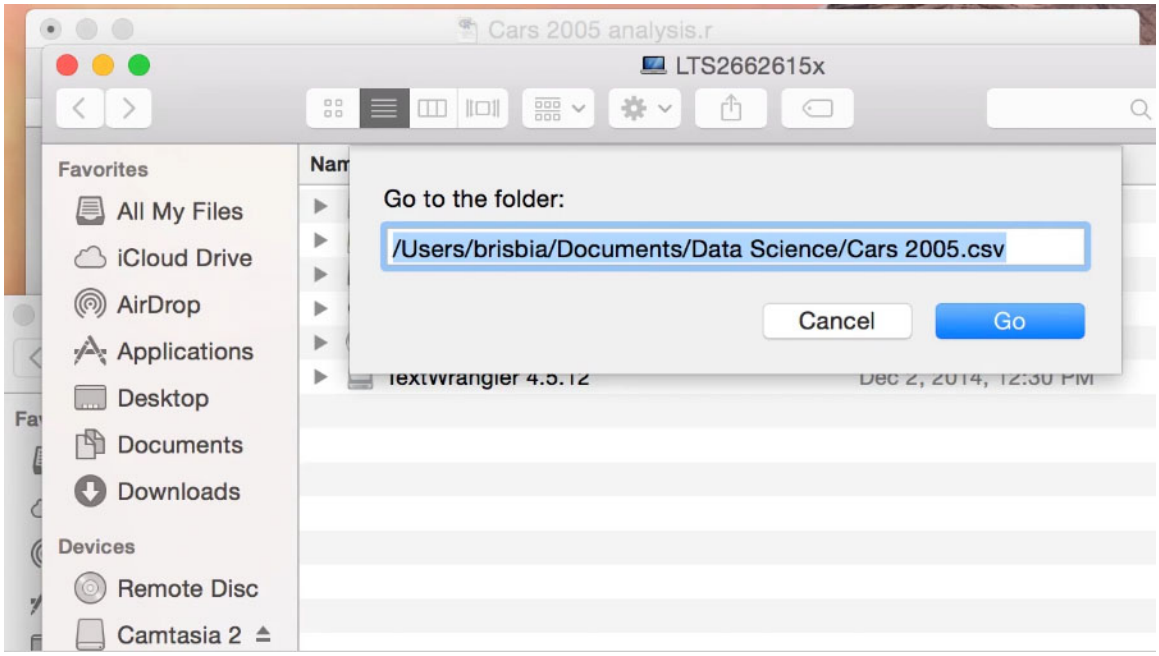


Then press Shift Command G to open the go to Window. Delete anything that's written on this line.

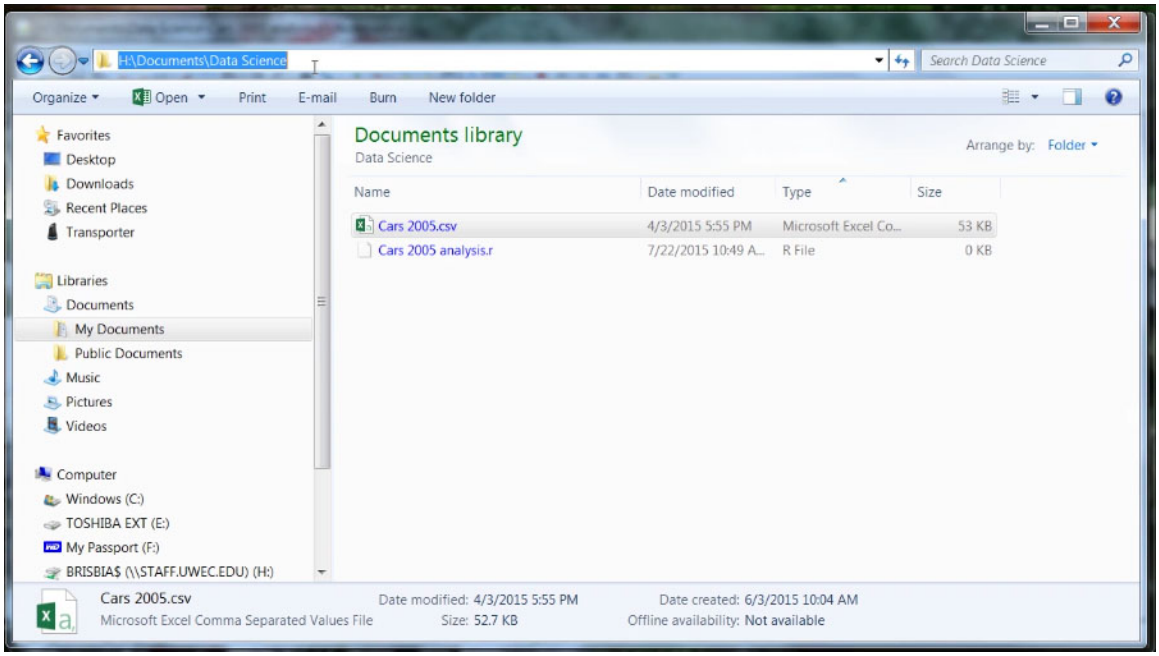


Then go back to our original finder window and click and drag that file into the go to Window. This shows you the full path of where the file is located.

In my case you can see that I've saved the file in the data science folder, or directory, which in turn is in the Documents folder. The full path of a file on a Mac should always begin with a forward slash.

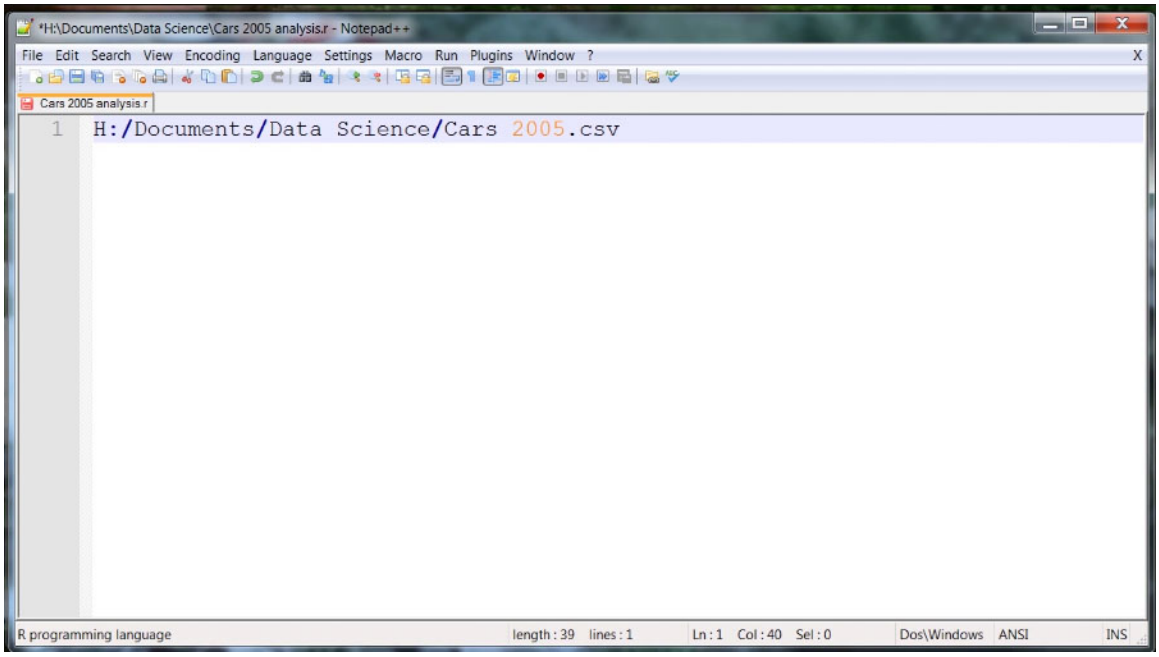


Highlight this path, and then press Command C to copy it, and switch over to your R script. Here I've saved my R script as a .R file in Text Wrangler. So everything I type will be color-coded. Press Command V to copy and paste our file name.



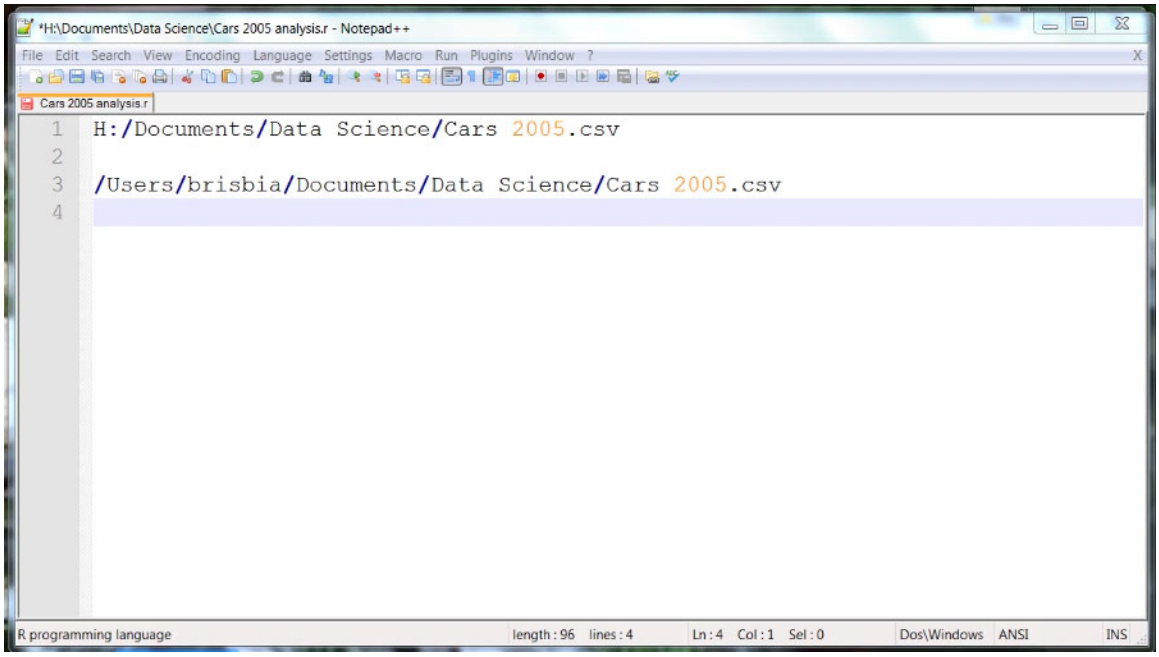
To open a CSV file in R we need to make sure we know the full path of the directory where the file is saved. To find this in windows open the file manager and navigate to where you can see the file. Then click on the address bar in the upper part of the window. Here you can see the full path of where the file is saved. In my case, I've saved it in the data science directory, or folder, which is in the documents directory, which is on the H drive.

In Windows, file paths should always start with a letter and a colon, that generally means that you don't want to save files directly to the desktop. Highlight the full file path and press Control C to copy it.

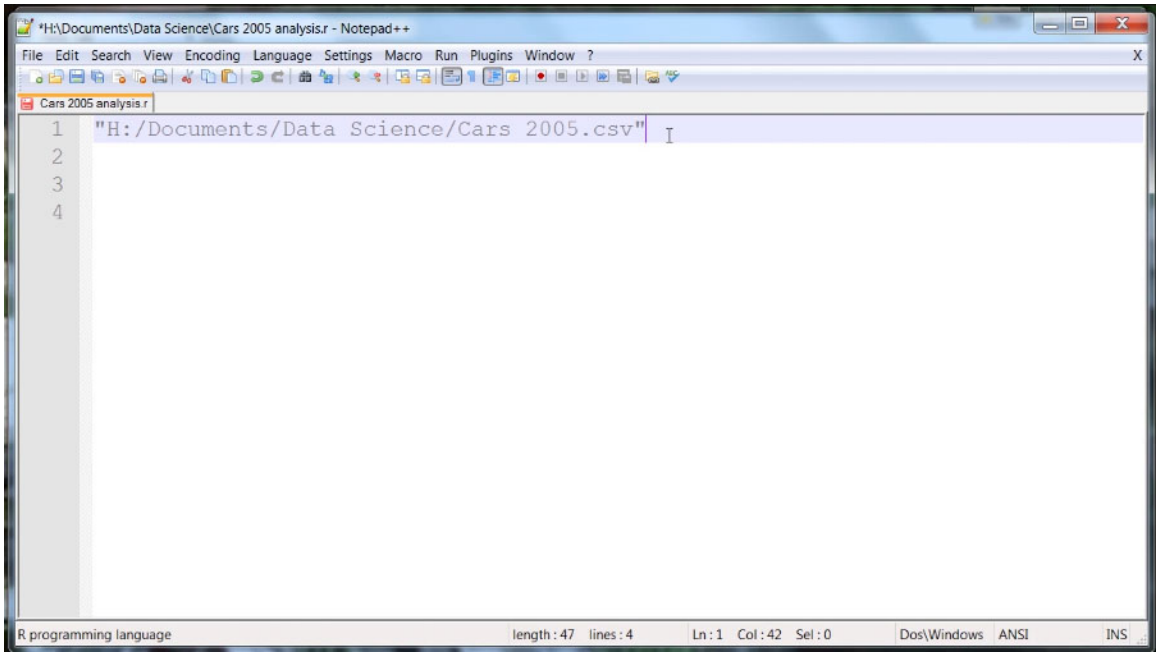


Then switch over to your R script. I've saved my R script as a .R file in Notepad++. That means that everything I type will be color-coded.

Next I'll press Control V to paste the file path. There's one more thing that we need to fix, and that is that Windows uses backslashes in its file paths, but R interprets backslashes as a signal to ignore whatever letter comes next. We don't want that, so we need to change the backslashes to forward slashes. Finally, add another forward slash and type the name of the file.

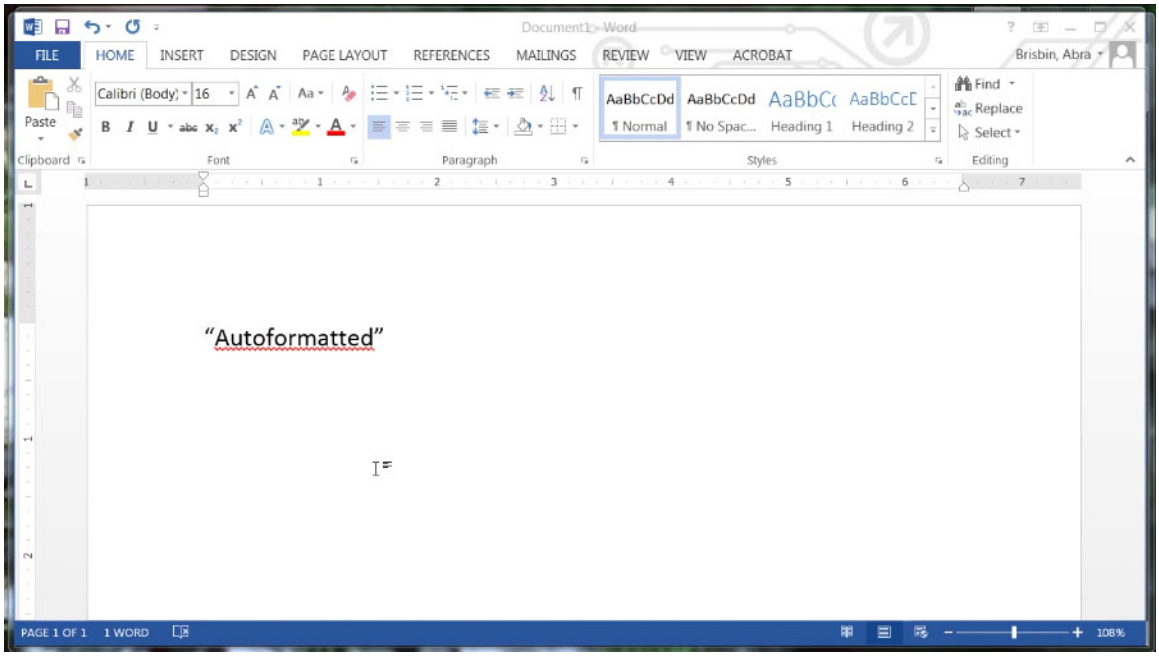


Now we have the full path of the file we want to read into R, written in an R script in either Notepad++ in Windows or Text Wrangler in Mac. This will look a little different depending on whether you're working on a Windows machine or on a Mac, but the rest of what we're going to do will be the same regardless of what kind of operating system you're using.

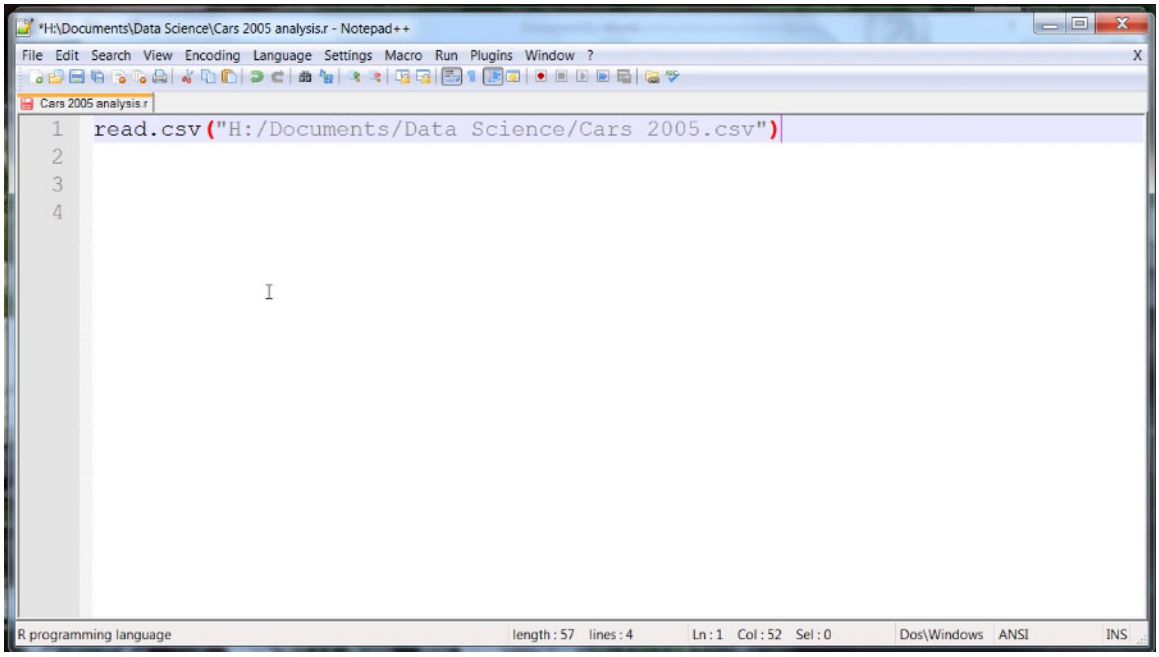


I'm using a Windows computer, so I'll delete the file path on Mac, and work with the file path in Windows, and I've already made sure that all of my slashes are forward slashes not back slashes.

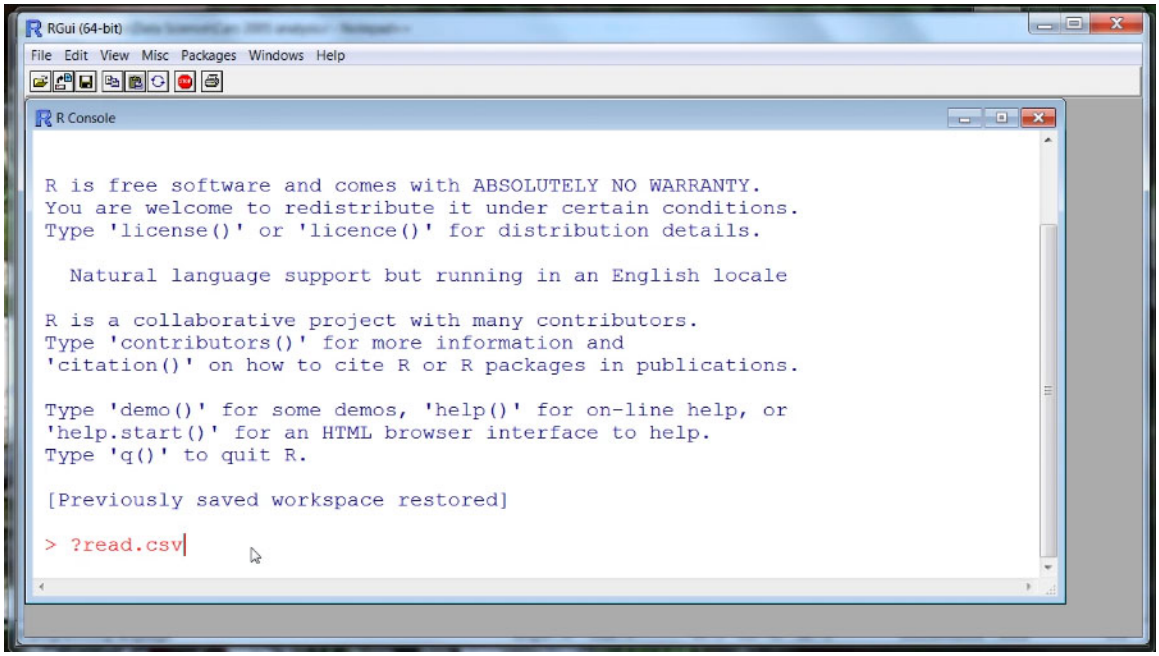
You want to start by enclosing the file path in quotation marks. This tells R that the file path is a string, or basically a series of words. It's not the name of a variable. You want to make sure that your quotation marks are straight vertical quotation marks, not auto formatted to indicate a difference between the quotation marks at the start, versus the end of the quote.



For example, the quotation marks in a Word document are auto formatted, and R doesn't understand how to interpret those. This won't be an issue if you're using Notepad++ or Text Wrangler, but it can be a problem if you're trying to copy code from a Word document. On a Mac if you're using text edit instead of Text Wrangler hold down the Control key when you're typing the quote mark, that will prevent auto formatting.

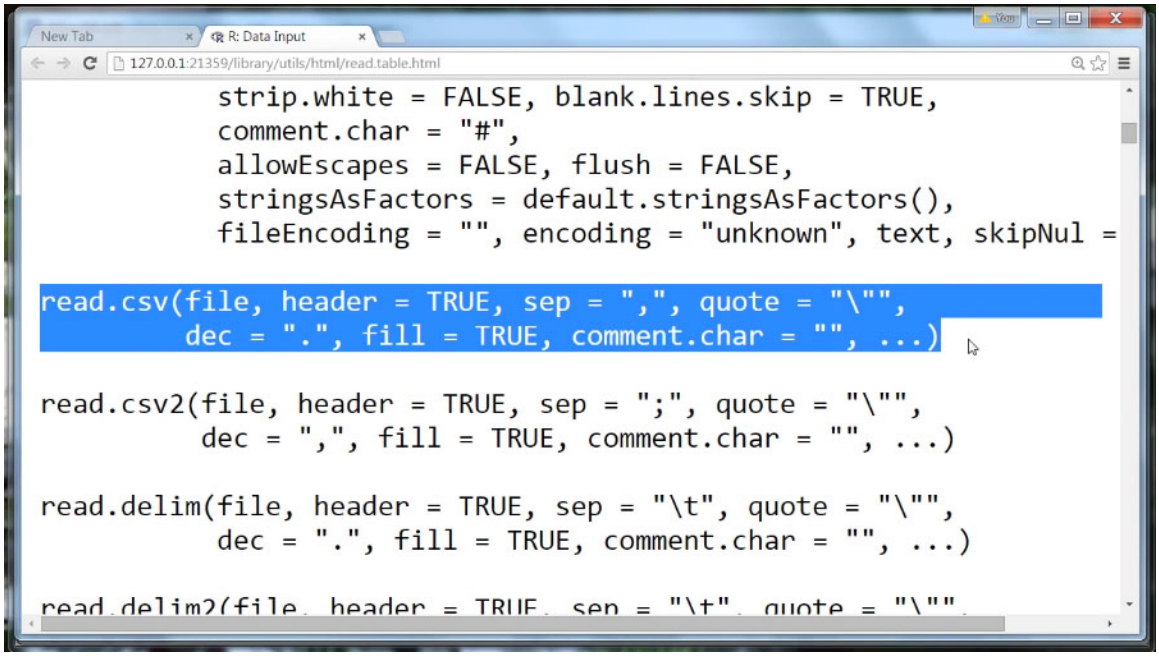


All right, to read the CSV file into R we want to use the read.csv function. That's read.csv, not cvs. Remember CSV stands for comma separated values, and for most functions in R we enclose the arguments in parentheses.

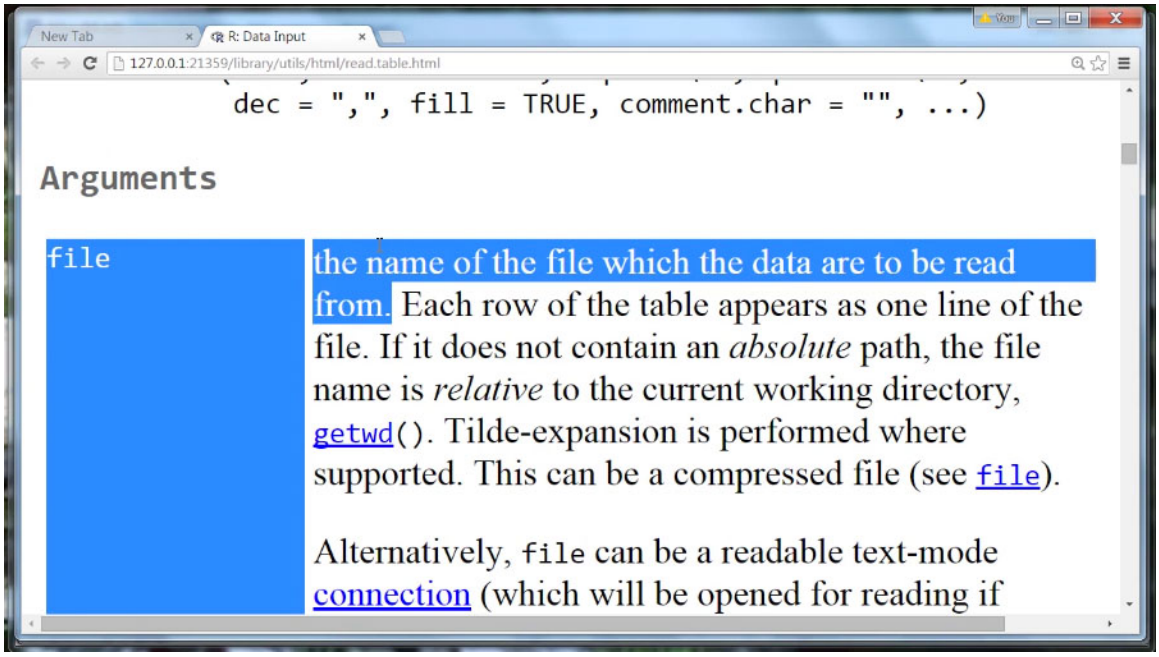


If you don't remember what a particular function does, you can always look it up by going to the R console, and typing a question mark and then the name of the function.

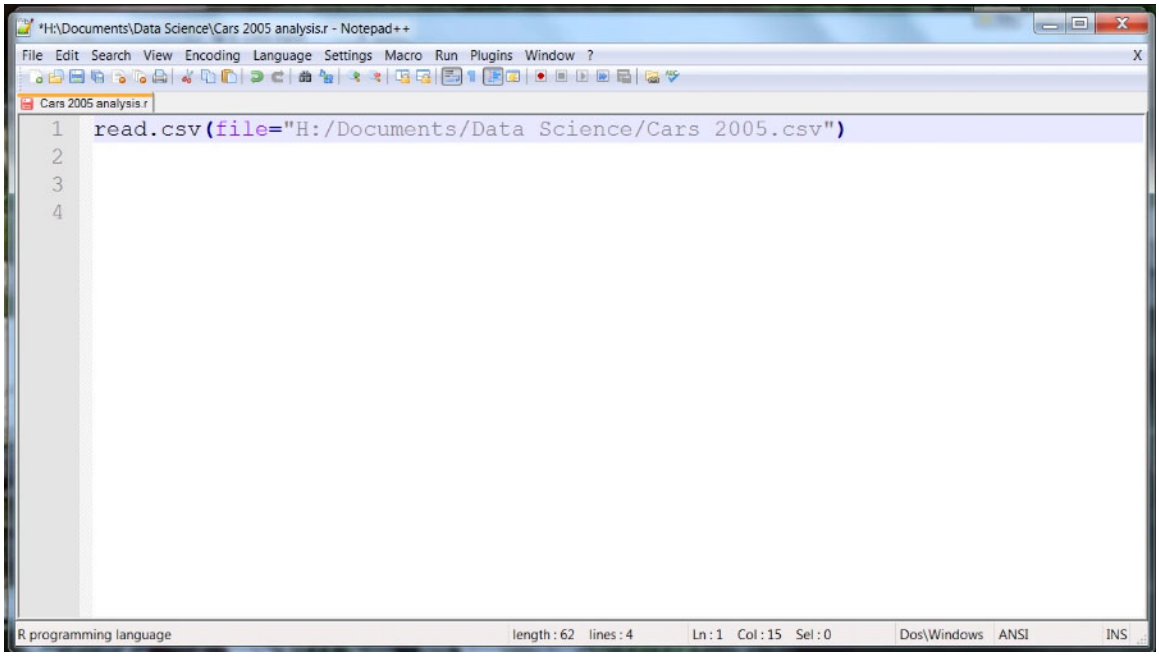
We press Enter, and this brings us to the manual page for this function. I'll make it a little bigger so it's easier to read.



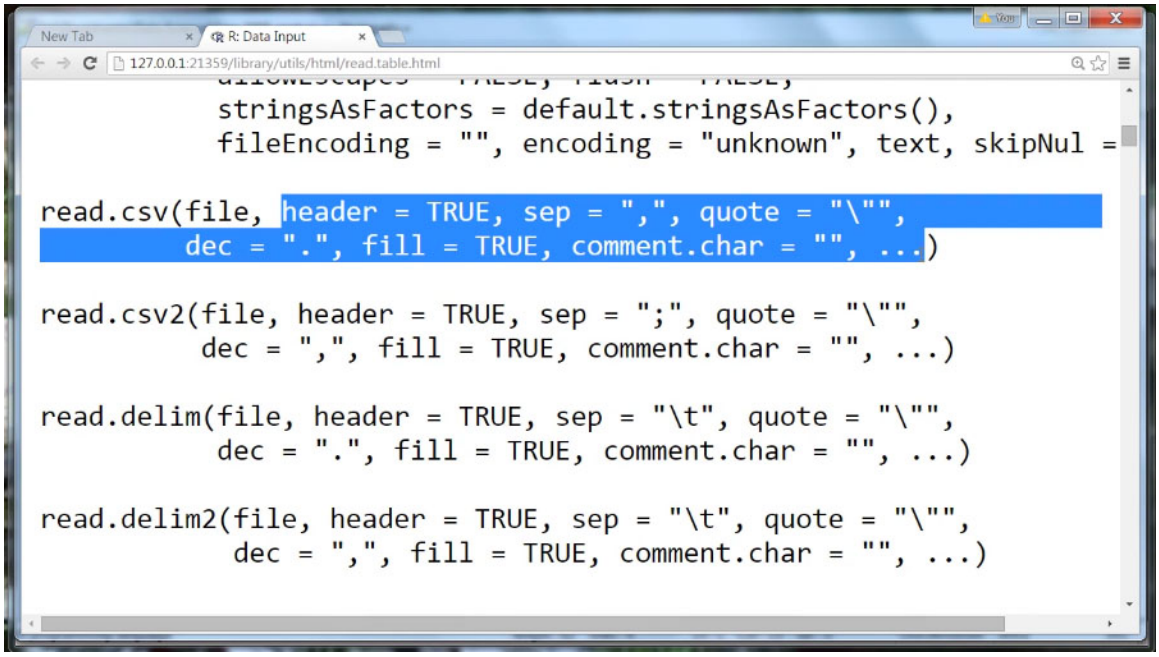
Here you can see the syntax that you use to use the function read.csv, and the first argument is file.



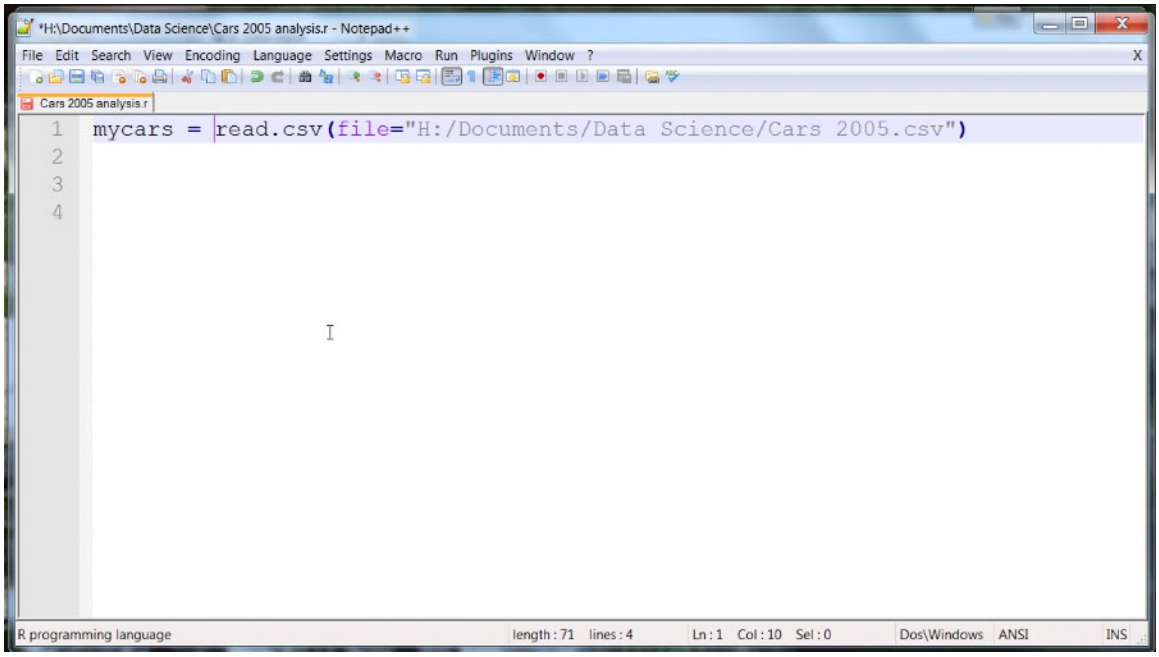
If we scroll down, we can read the description of that argument, and see that it's the name of the file from which the data are to be read from. That's what we want. So our file path is listed correctly as the first argument of read.csv.



If we want we can be specific by typing file equals, and then the file name. But this is optional.

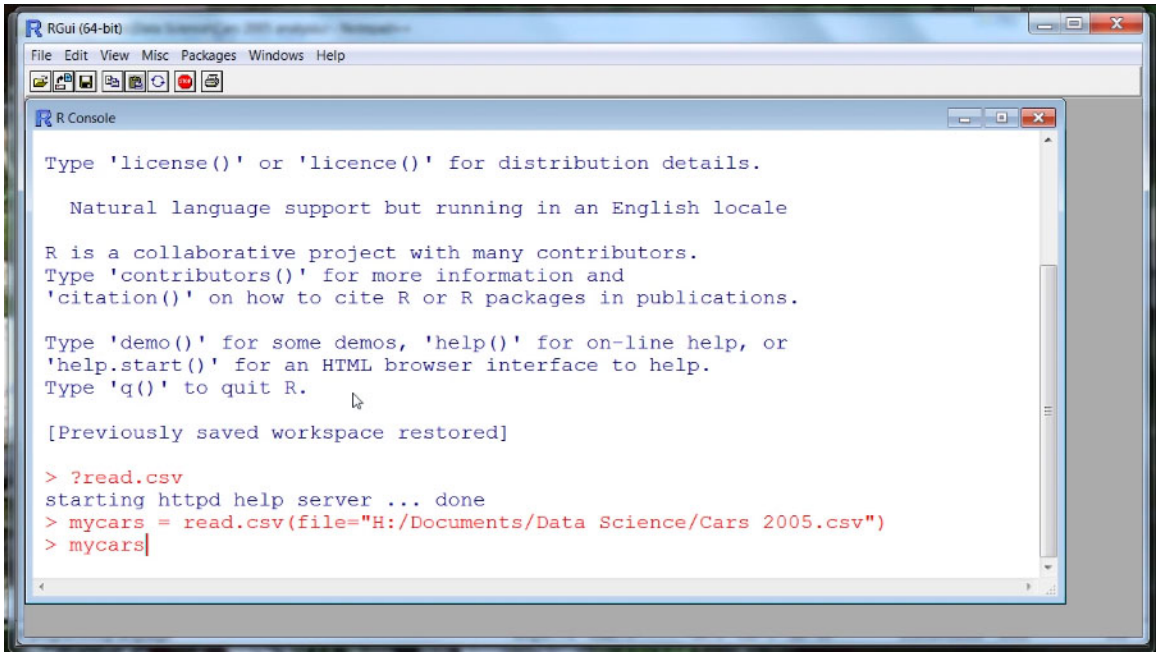


You'll notice that read.csv takes several other possible arguments, but all of them have equals something after the argument. Those are the default values that R will use if you don't type that argument in the function call. For our purposes, the default values are fine, so we don't have to type anything else.



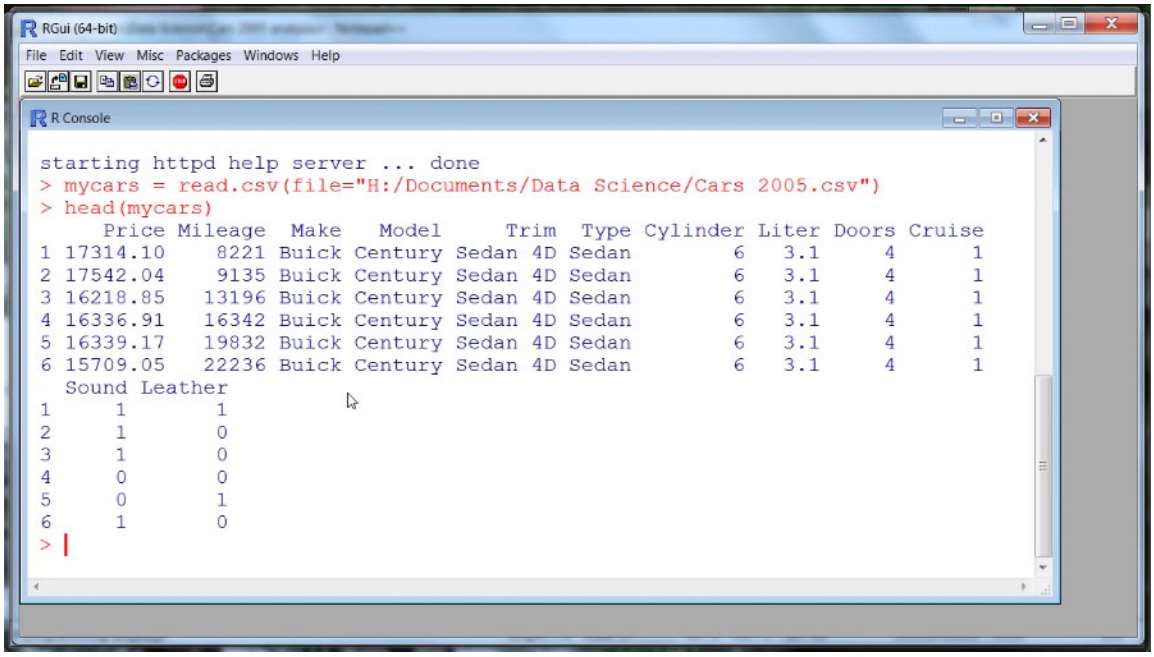
This is now a perfectly valid line of R code. But if we tried entering this into the R console, R would read in the data and print it right back out to the screen without storing it anywhere in memory.

We'd like to store R data in memory, so we need to give this a variable name. Say mycars equals read.csv. You can get any valid variable name you like, but to avoid confusion later, it's good to choose a variable name that's not the same as any of the column headers in the data set.

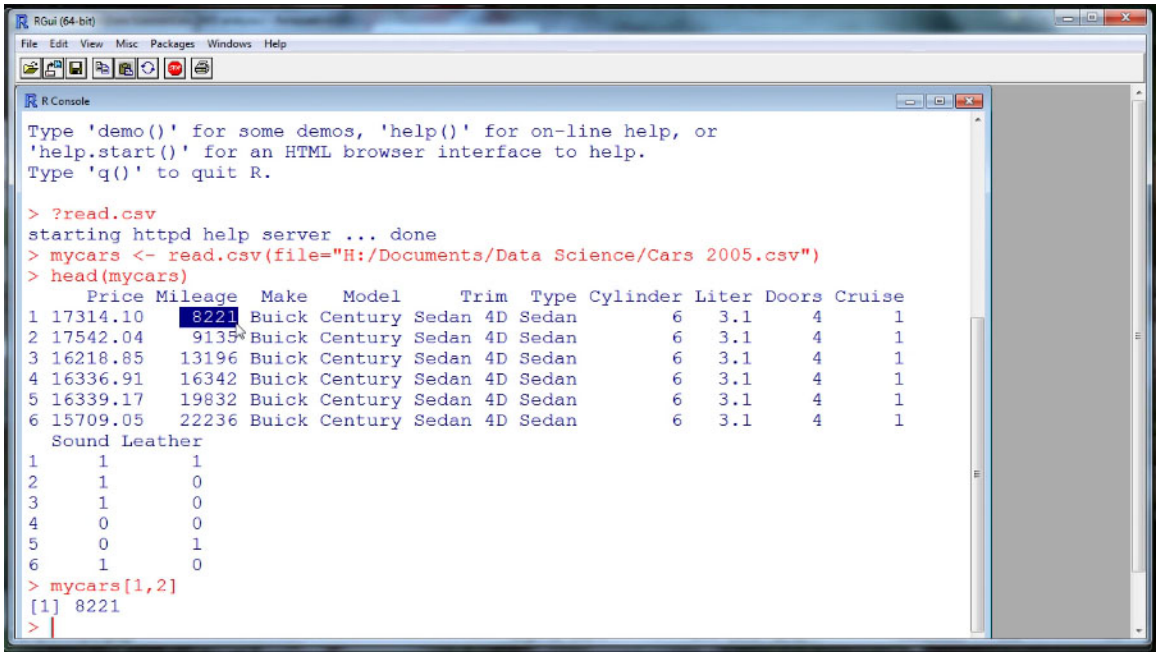


To run this code, we can copy it by pressing Control C, or Command C, and then paste it into the R console using Control V or Command V, and press Enter.

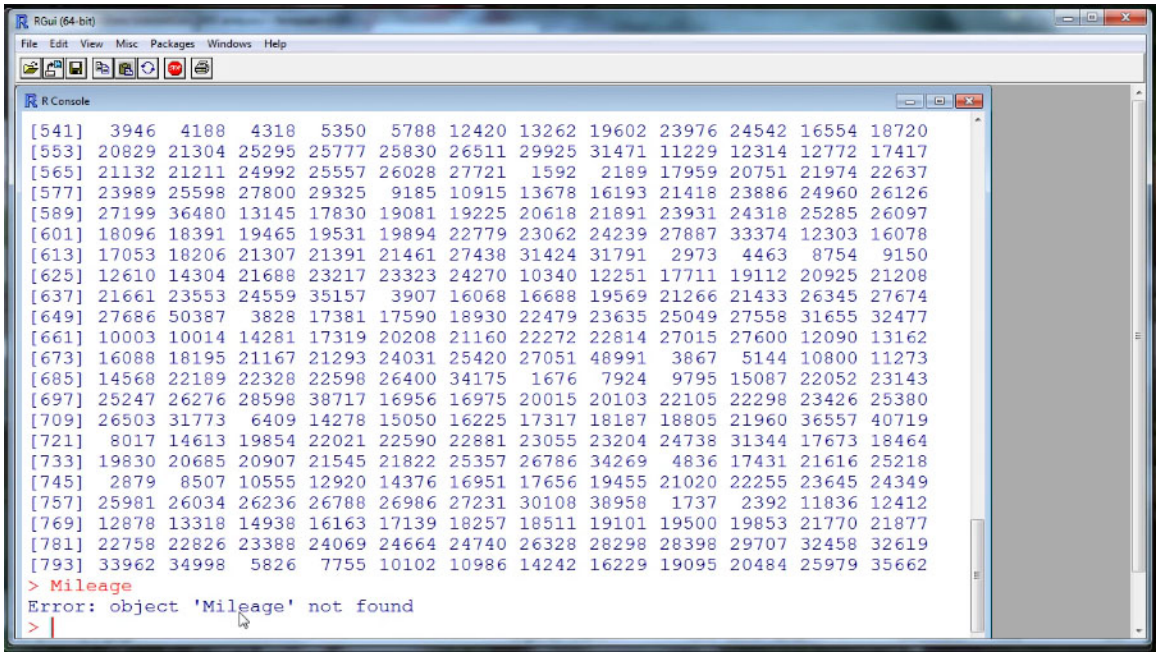
You'll notice that nothing happens on the screen. In order to see the data that we've just read in, we need to type the name of the variable where we sort it, and press Enter. But this is a fairly large data set, so it's more convenient just to look at the first few lines of code.



We can do that using the head function, and press Enter. Here you can see the first six rows of data in all of the columns. In this case my window wasn't quite wide enough so the last two columns wrapped around and they're listed below the first two columns.

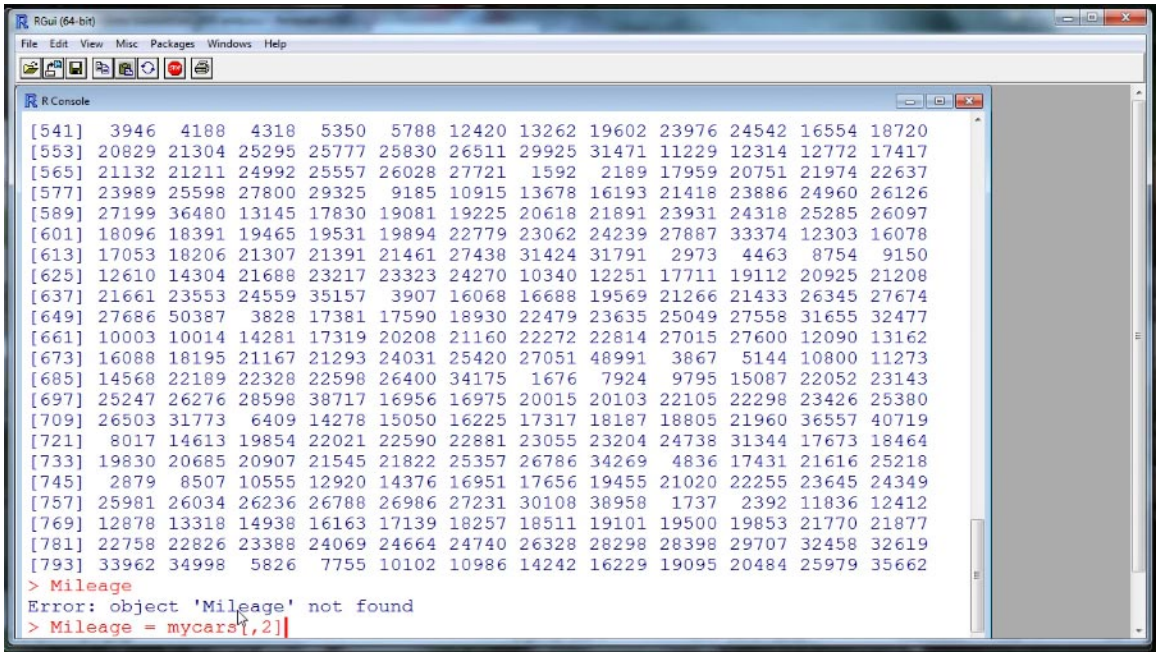


Our data set is now stored as a matrix. We can refer to particular elements of the matrix using square bracket notation. For example, mycars, square bracket, 1 comma 2 will give the value in the first row and second column. For example, 8,221 we can see was in the first row and second column when we looked at the first few lines of data. This means that we could look at the whole second column by typing mycars, square bracket, comma 2. When we don't put anything in the rows section of the square bracket notation, then we look at all the rows.

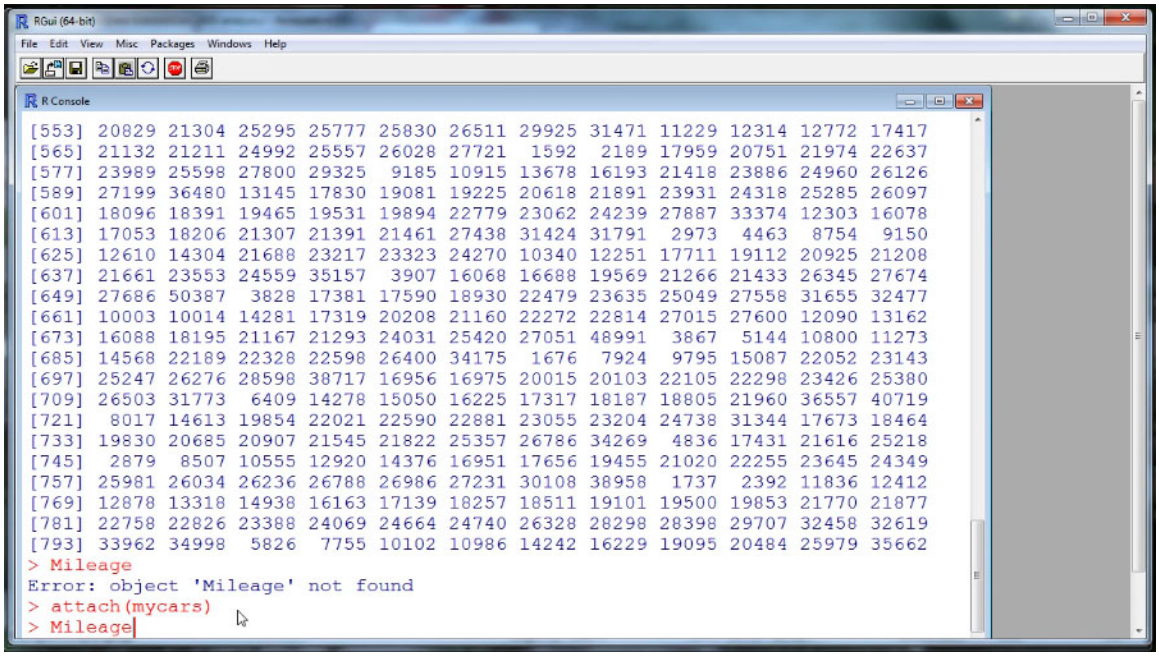


And there we have the mileages of all the cars in our data set.

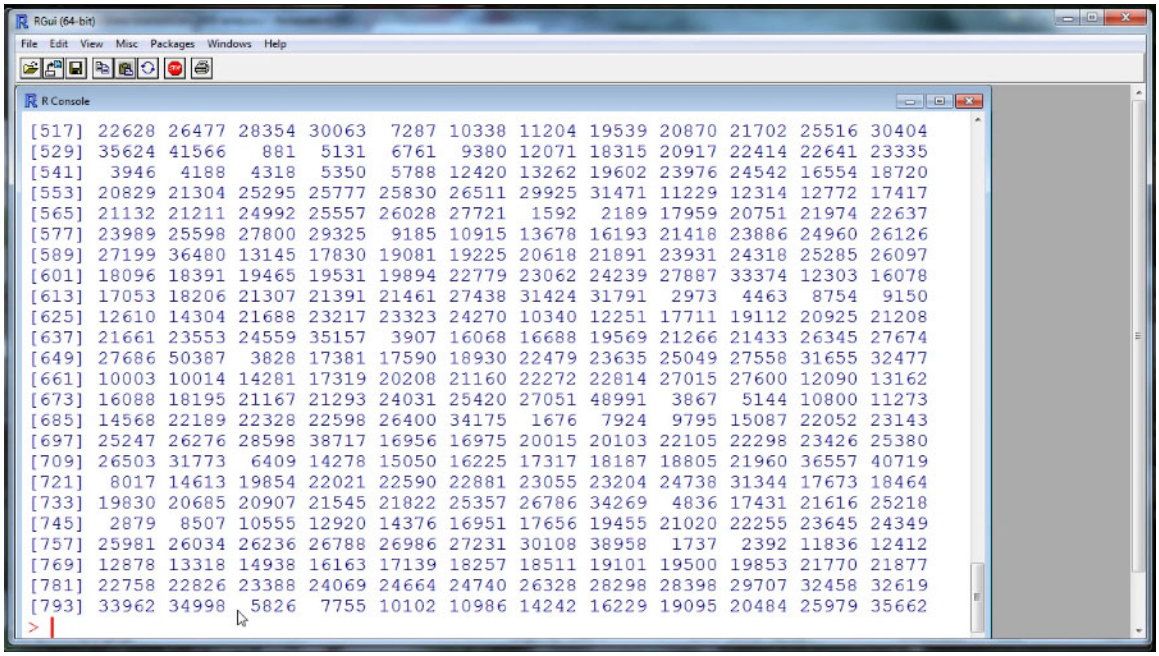
But if we want to look at one column by name, say by typing mileage, we get an error message. R doesn't know what we're talking about.



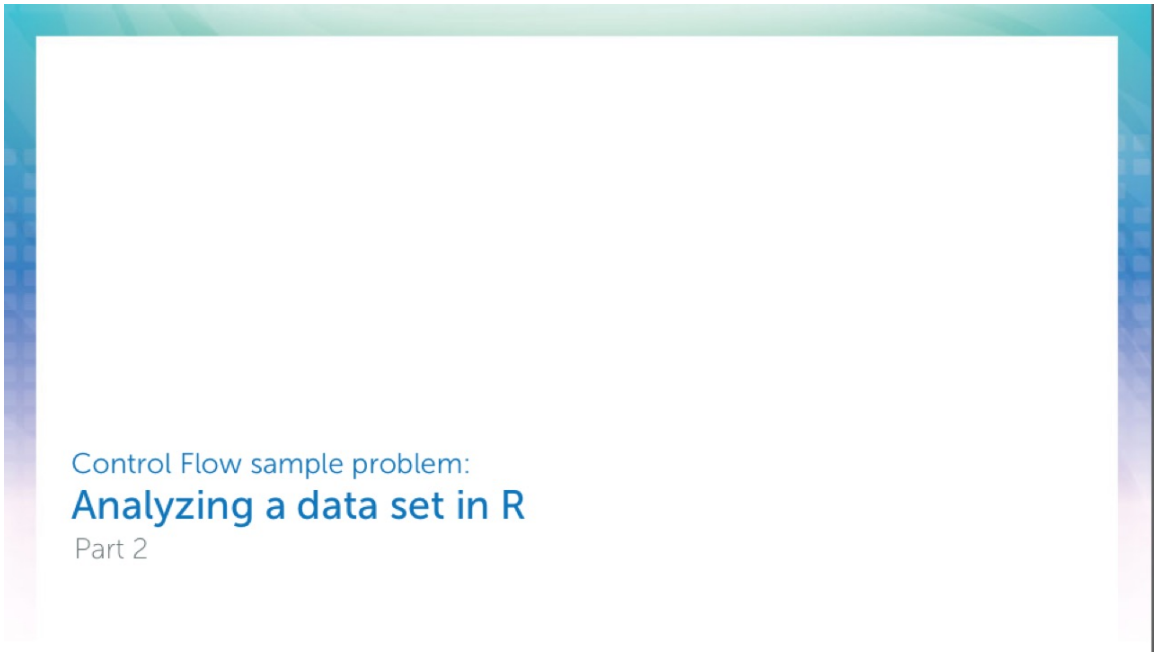
It will be easier to work with the data if we create a variable for each column of the data. We could do this for each column separately. For example, mileage equals mycars, square bracket, comma 2.



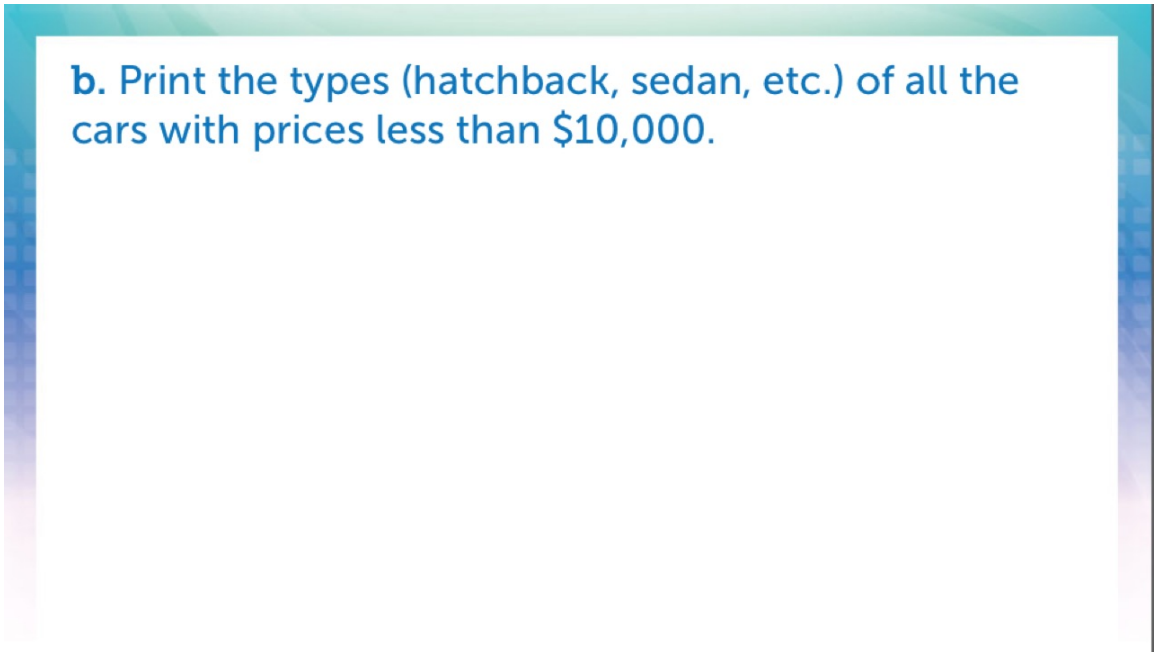
But it's faster to do this automatically. In R this is called attaching the data. We just type attach, and then the variable name where we stored the data set. Now if we type the variable mileage...



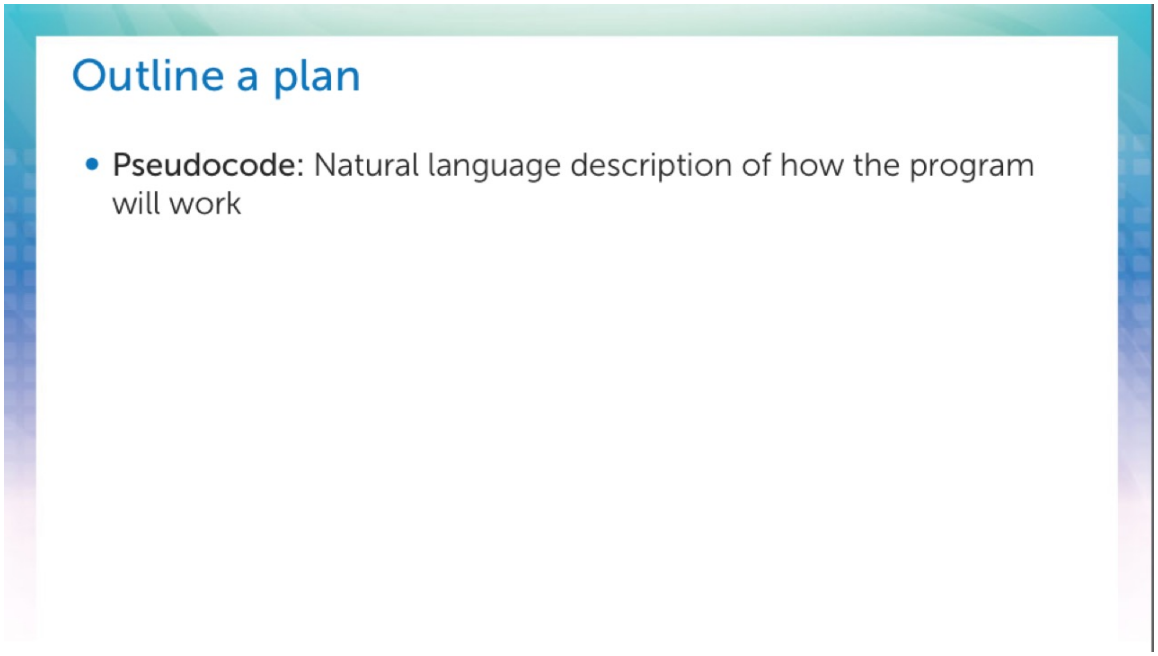
...we get back that long vector of mileages that we saw when we were looking at the second column of data.



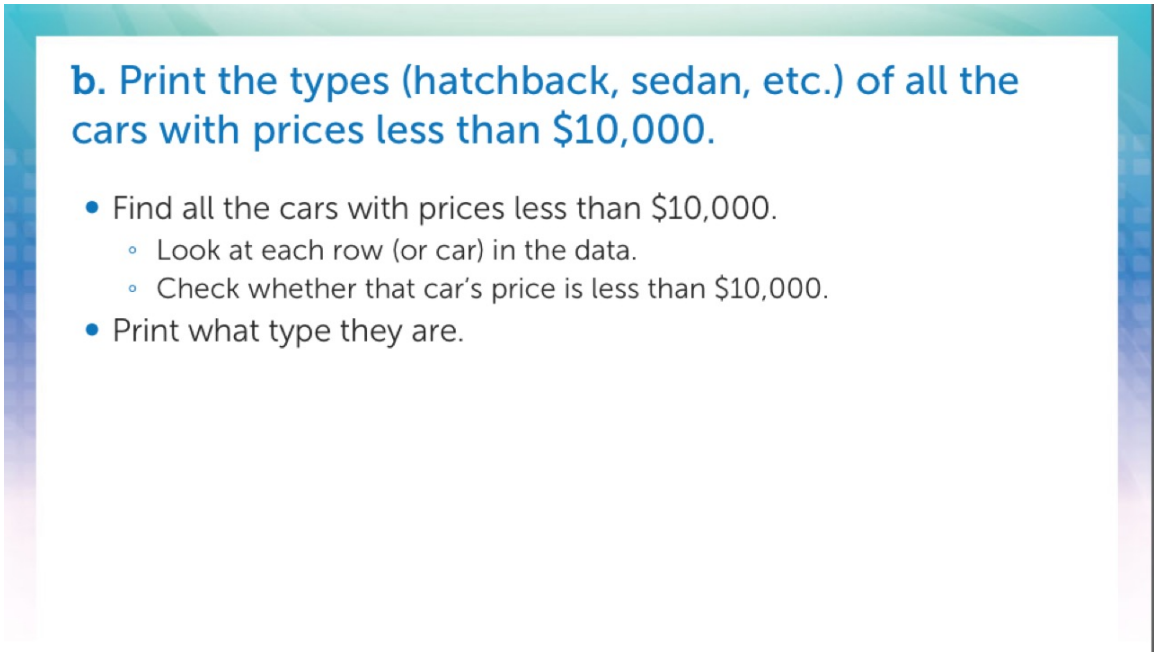
Let's look at the second part of our hypothetical control flow problem.



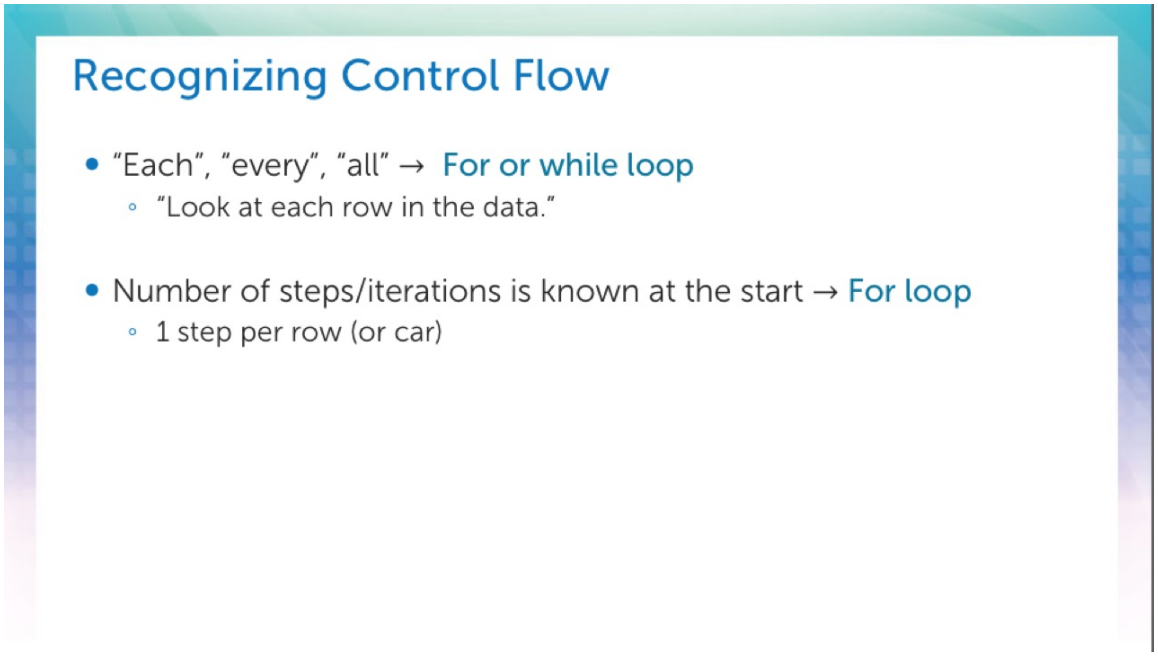
We want to print the types of all the cars with prices less than $10,000. There are several ways to solve this problem, but we're learning about control flow, so let's do it that way.



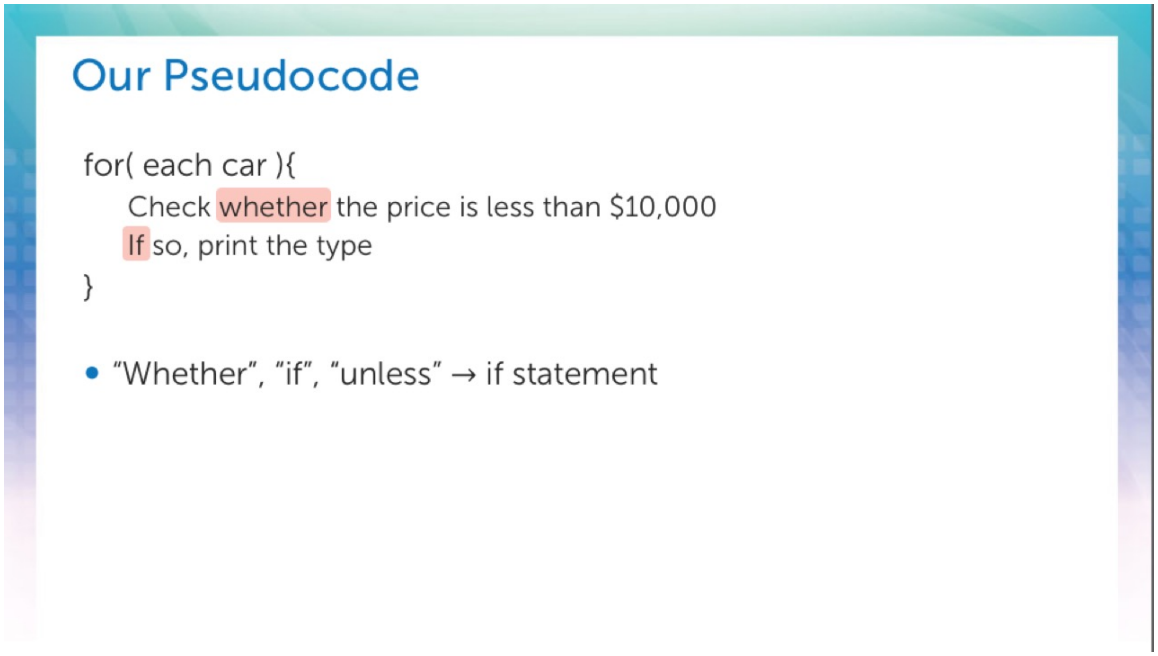
When you're writing a computer program it's a good idea to plan out how you're going to write it using pseudo code, which is a description of how the program will work in plain language.



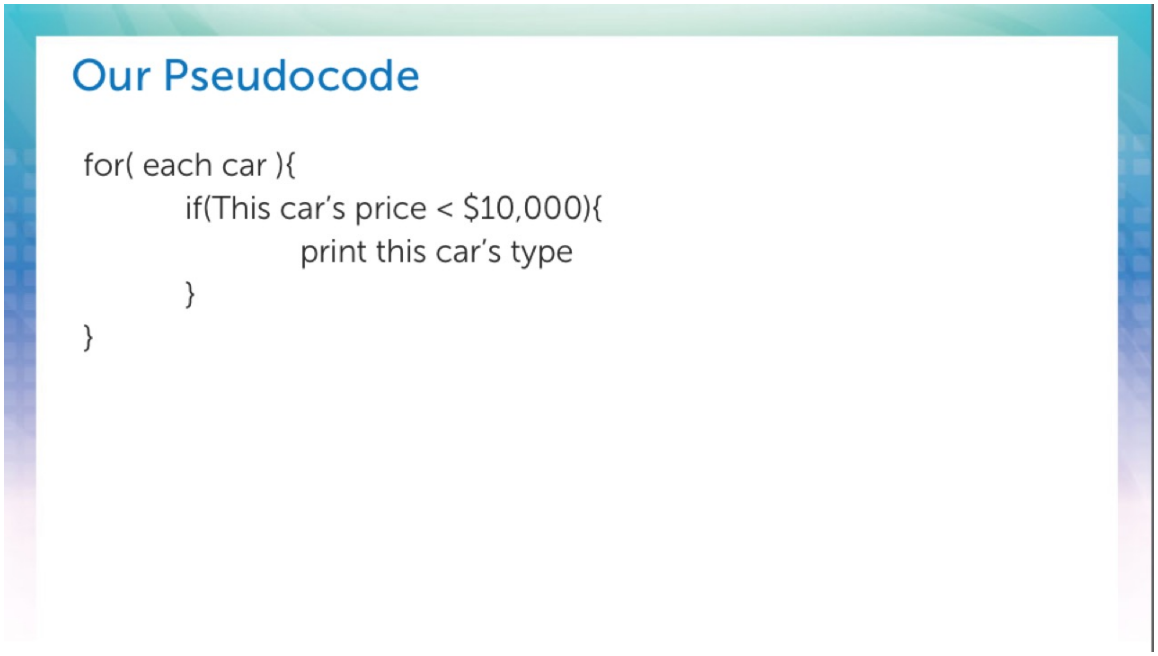
So what do we want our program to do? Well, first we want to find all of the cars with prices less than $10,000, and then we want to print what type they are. Let's see if we can break down that first bullet point into a little more detail. In order to find the cars with prices less than $10,000. We can first look at each row, or car in the data, and check whether its price is less than $10,000.



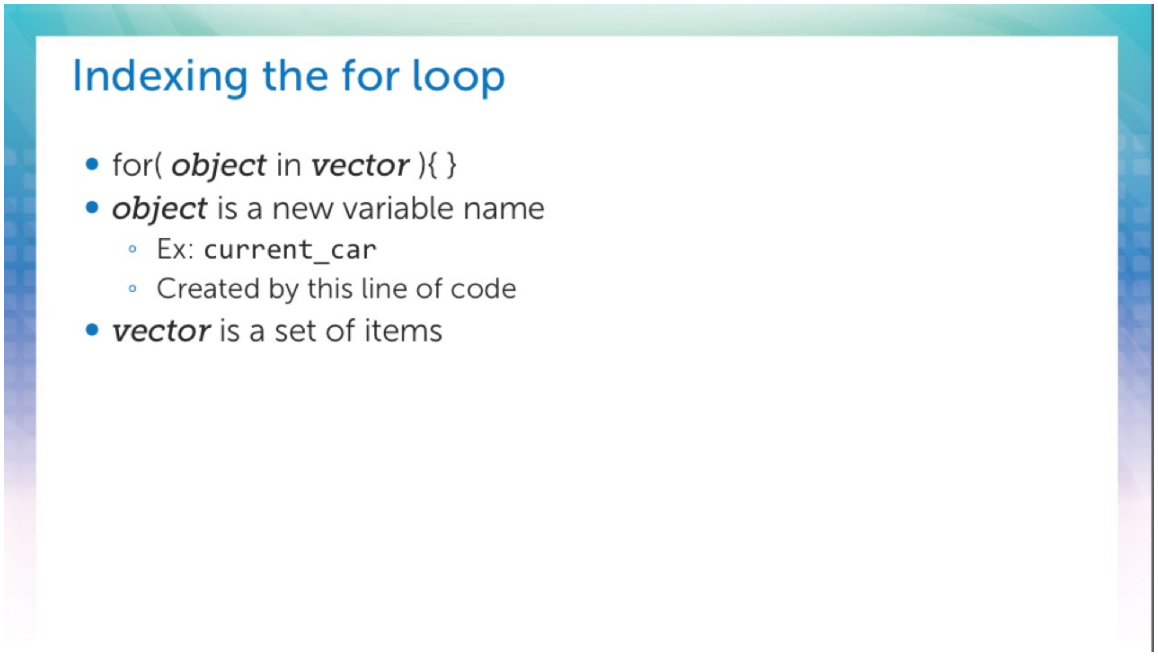
So how can we write this using a control flow structure? Well we use the words, look at each row in the data. The word each is a good clue that we either want a for loop or a while loop. In this case we know how many steps or iterations we want to do. One step per row, and we know how many rows the data set has, we can look at the start of the program. That's a good clue that a for loop will be helpful. We could also do this using a while loop, but a for loop is more intuitive.



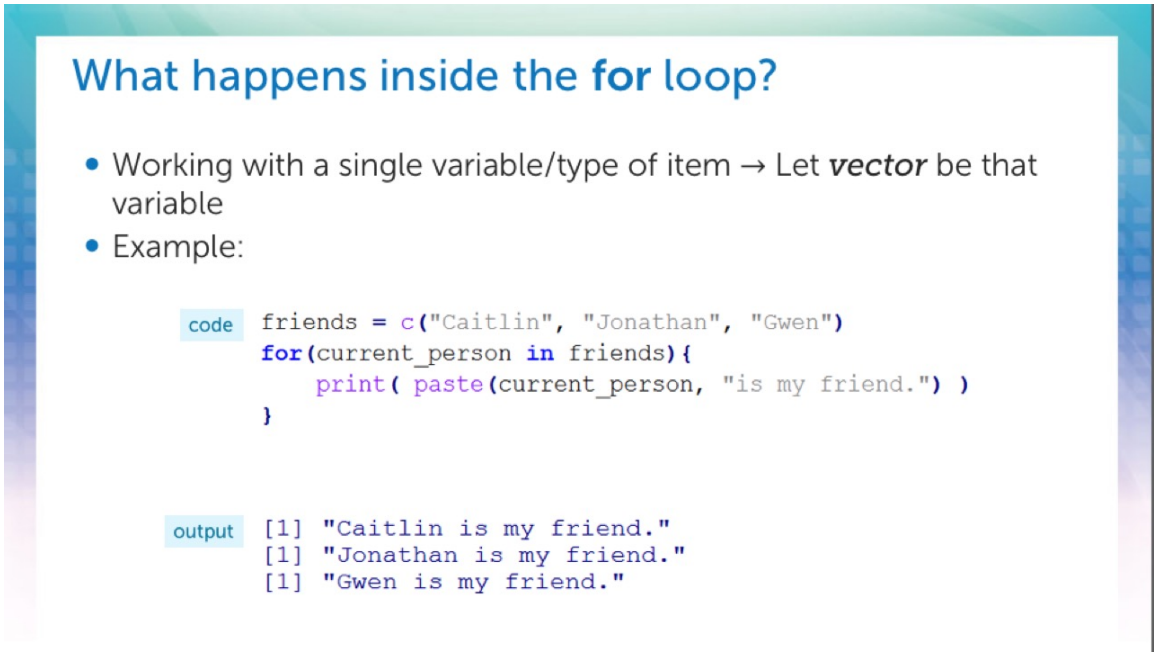
So we can begin our pseudocode with a for loop. For each car we're going to do some things. So what things do we want to do for each car? We said we wanted to check whether it's price was less than $10,000, and if so, print it's type. Here we've used the words whether and if. Those are good hints that we want to use an if statement.



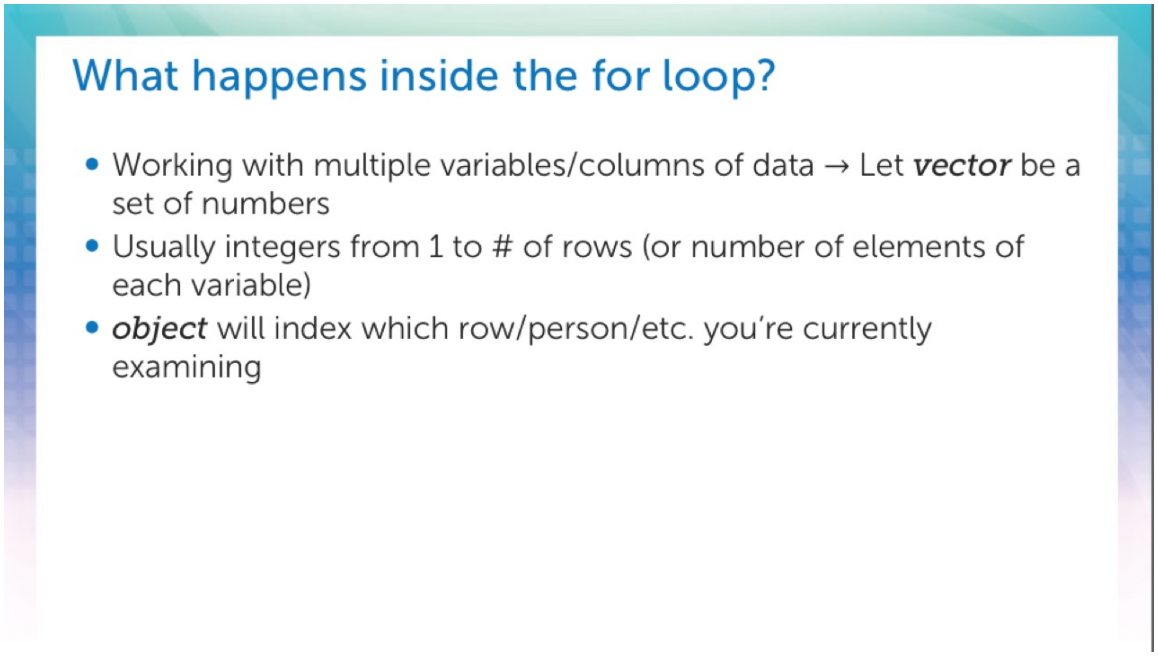
So we can fill that in with pseudocode by saying, if this car's price is less than $10,000. Notice that we're still using plain English to say this car's price, and each car. We'll fill those in with correct R code later on. Right now we're just getting our general understanding of the structure of the code. Now inside this if statement we want to print this car's type, and we can fill in the correct R code to do this later as well. For now, how can we be more specific about what goes inside the parentheses in the for loop?



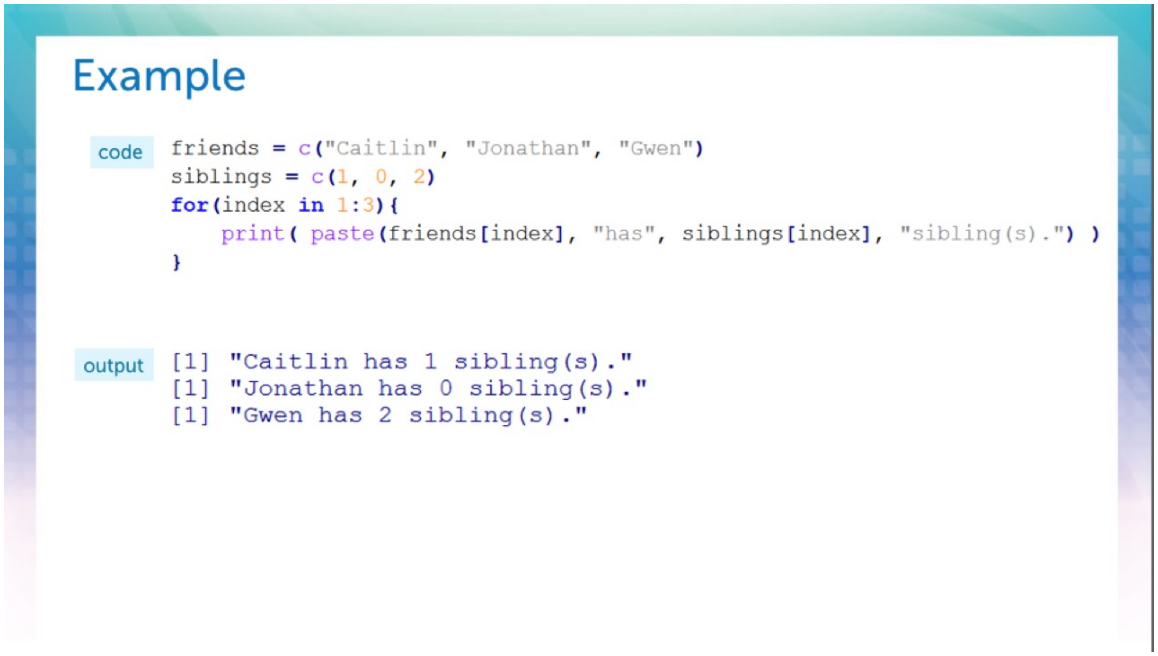
The general structure for for loops in R is for some object in some vector. Where object is the name of a new variable. For example, in this case we could use current underscore car. This variable is created by this line of code. So unlike in some other programming languages we don't need to initialize or create a variable before the for loop starts. Vector is a set of items that object is going to iterate over. That is, object will start by being equal to the first element in vector. The second time through the for loop it will be equal to the second element, and so on.



In order to decide what goes in that variable vector, we need to think about what happens inside the for loop. If we're working with a single variable, or a single type of item, then we can let vector be that variable. For example, suppose I want to print the sentence, current person is my friend. Where current person gets filled in with the name of each of my friends, from this vector friends. That means that my for loop can iterate over that vector, friends. Because I'm only working with that one variable of friends. In this case this code would produce output that looks like this.

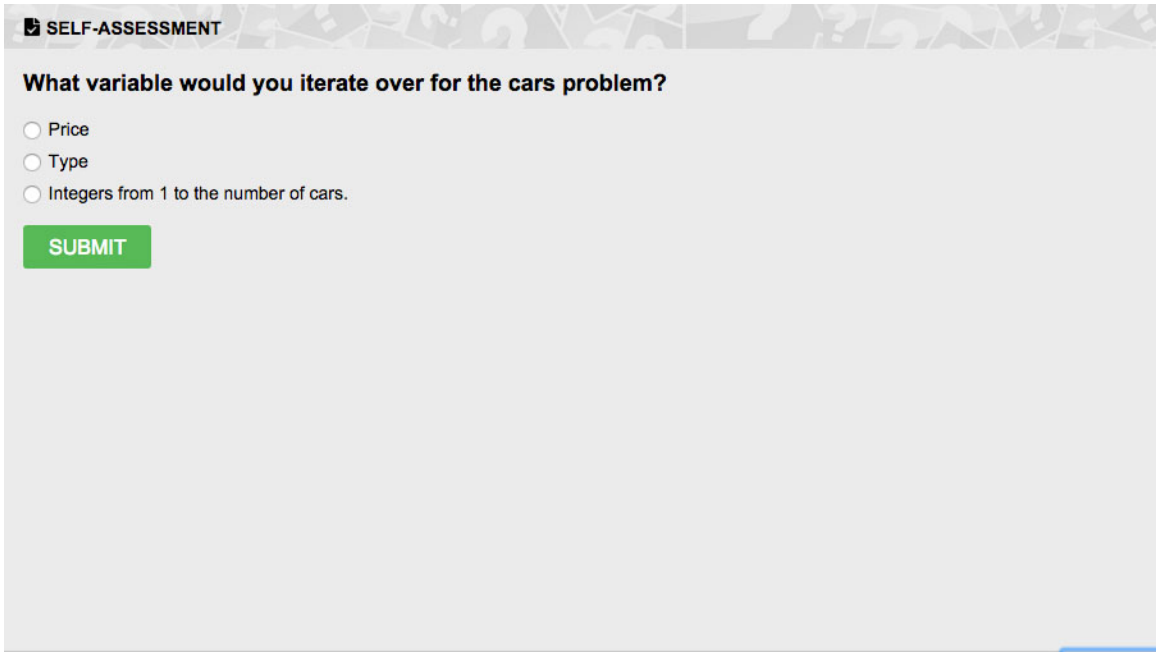


On the other hand, if we're working with multiple variables, or multiple columns of data, then it's a good idea to let vector be a set of numbers, usually the integers from 1 up to the number of rows or the number of elements of each variable. Then object will index which row or person or whatever we're currently examining.



For example, suppose I want to print sentences telling how many siblings each of my friends has. Here I'm working with two vectors. Friends, which gives my friends names, and siblings, which gives the number of siblings each friend has. Because I'm working with two vectors in the for loop I'm letting vector be the numbers from one to three.

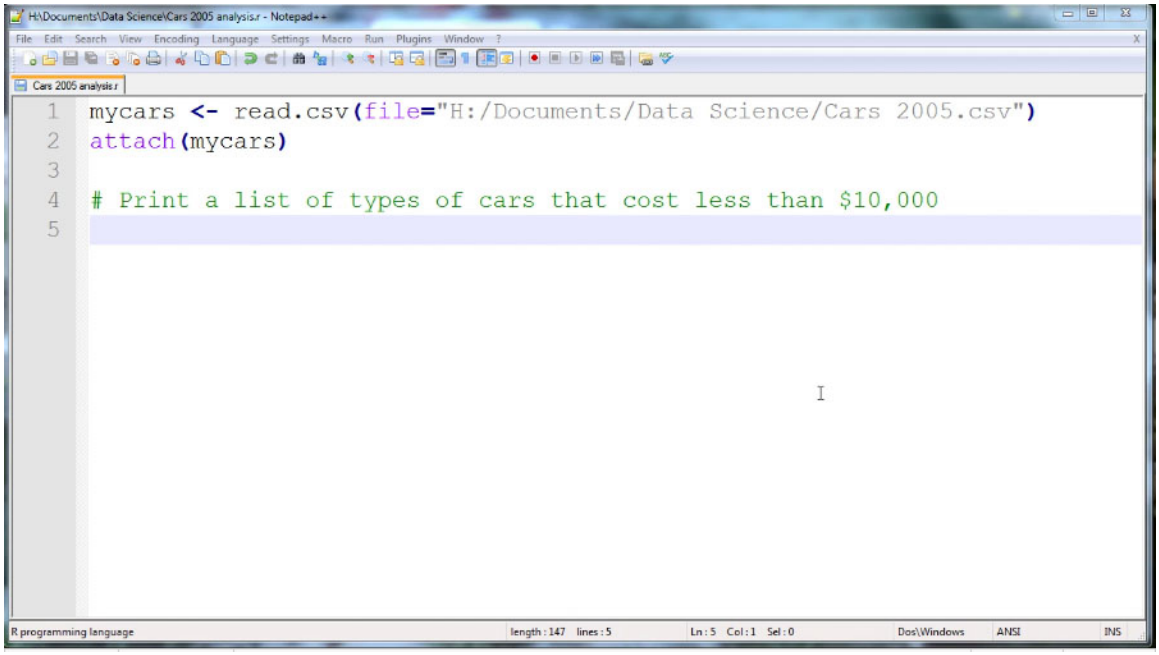
The first time through this for loop the variable index will equal one. So I'll be printing friends square bracket one. That means the first element of the friends vector. So that's Caitlin's name. Then I'll print the word has, the first element of the siblings vector, which is the number one, and then the word sibling. And we'll repeat this for each of the values of index from one to three. In this case this code produces output that looks like this.



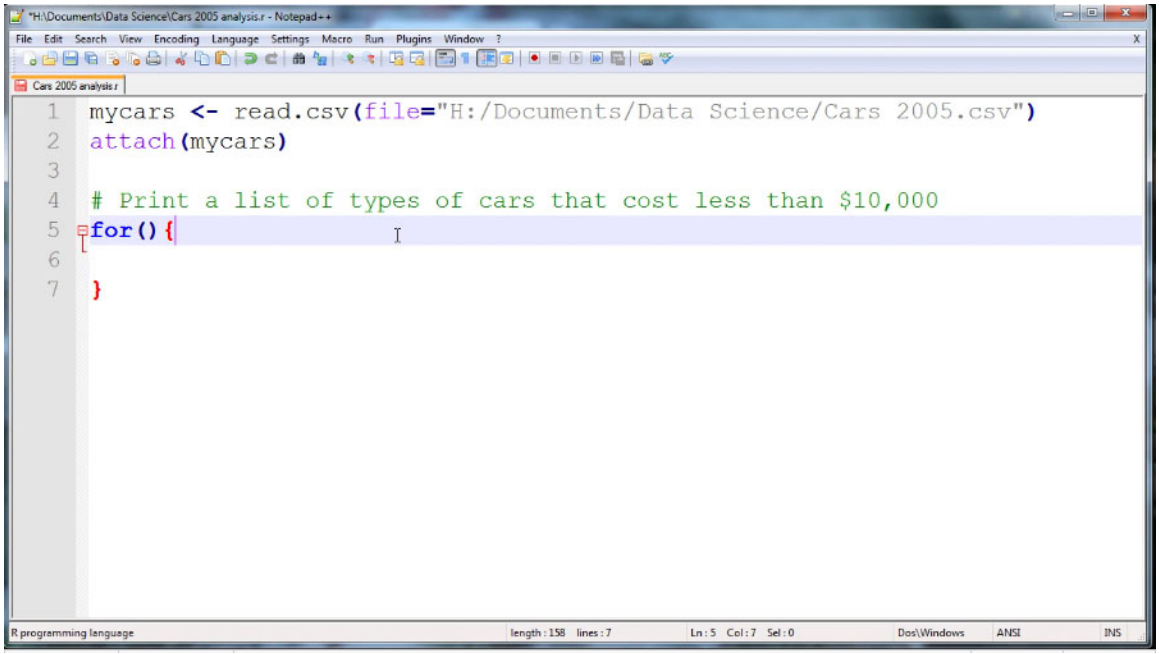
Question 1: What variable would you iterate over for the cars problem?

- ☐ Price
- ☐ Type
- ☐ Integers from 1 to the number of cars.

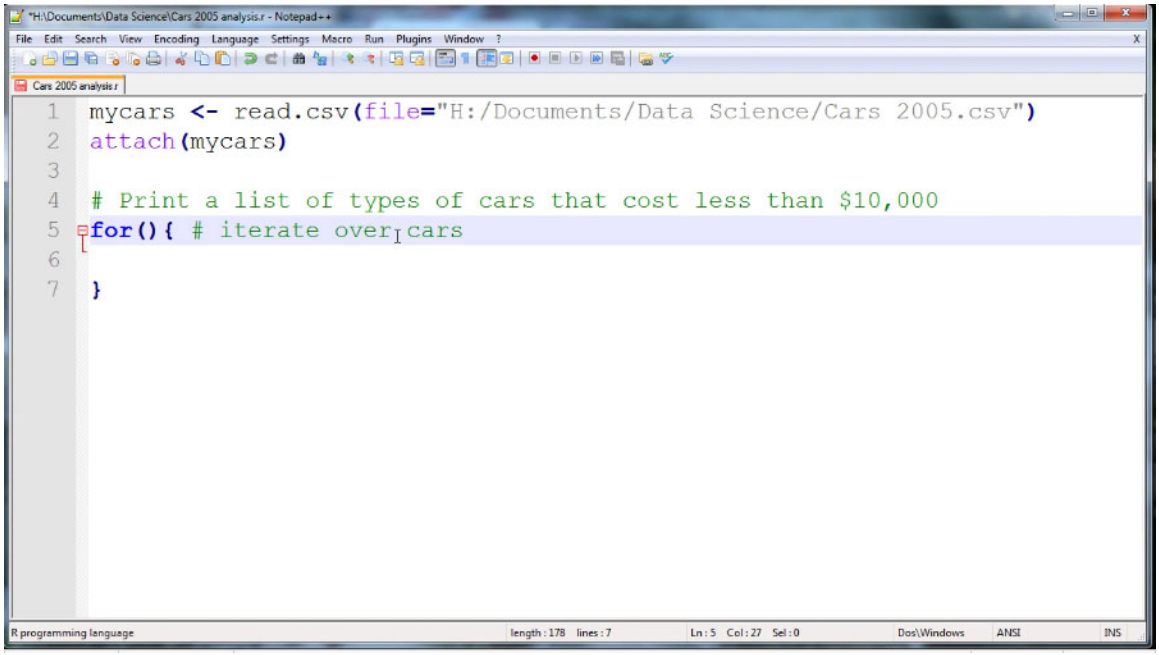
*See page 62 for Question 1 answer.



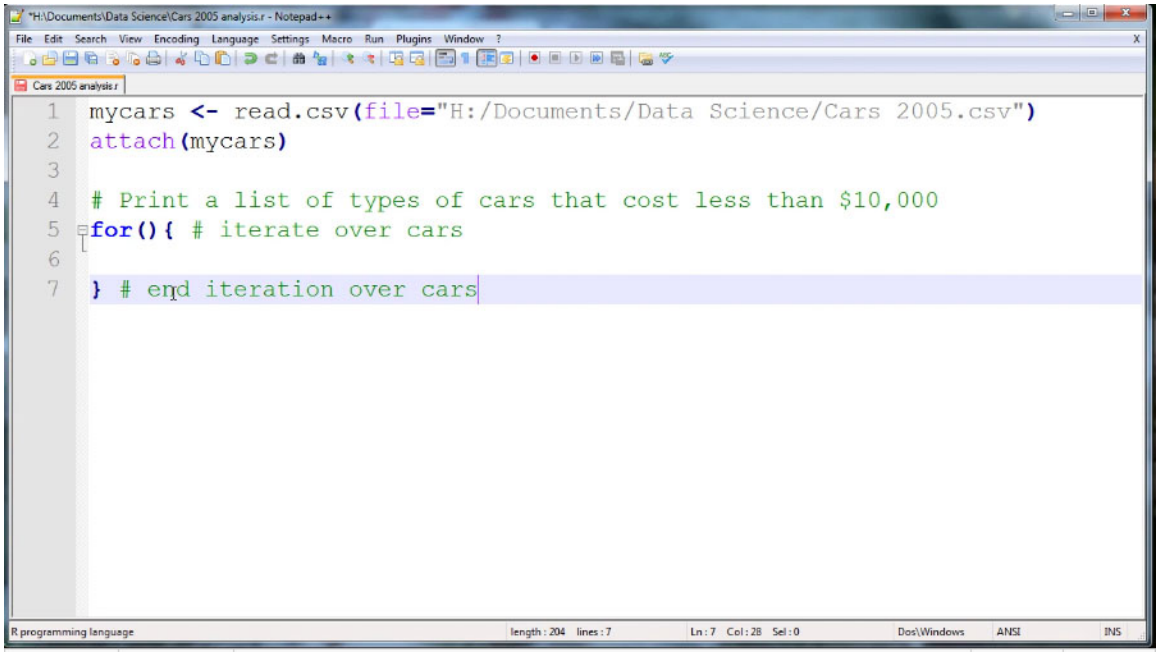
Let's write the code to print a list of the types of cars that cost less than $10,000. Whenever you're working with control flow structures it's a good idea to work in a script. So you have everything the way you want it before you try to run the program.



Based on our pseudocode the outermost structure should be a for loop. So I'll type that structure in here.

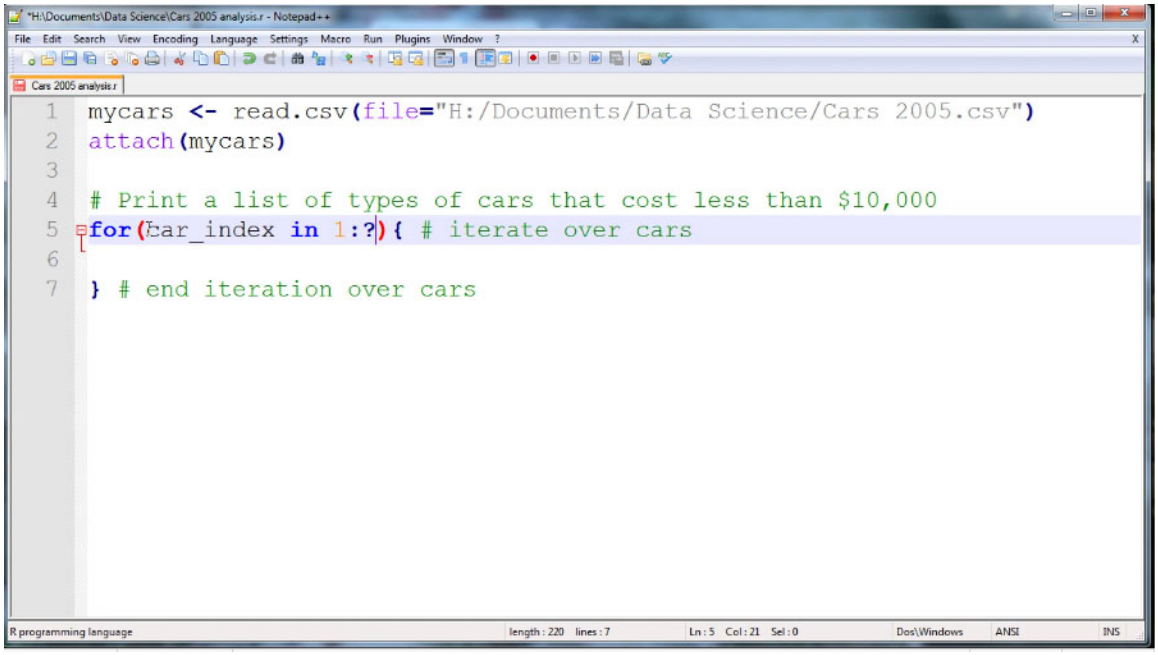


And I'll also label what this for loop is supposed to do using a comment. This for loop should iterate over the cars. Remember R will ignore everything that comes after the pound sign or hash mark on a line. So using a comment this way is a good way to remind yourself and other programmers what this code is supposed to do.



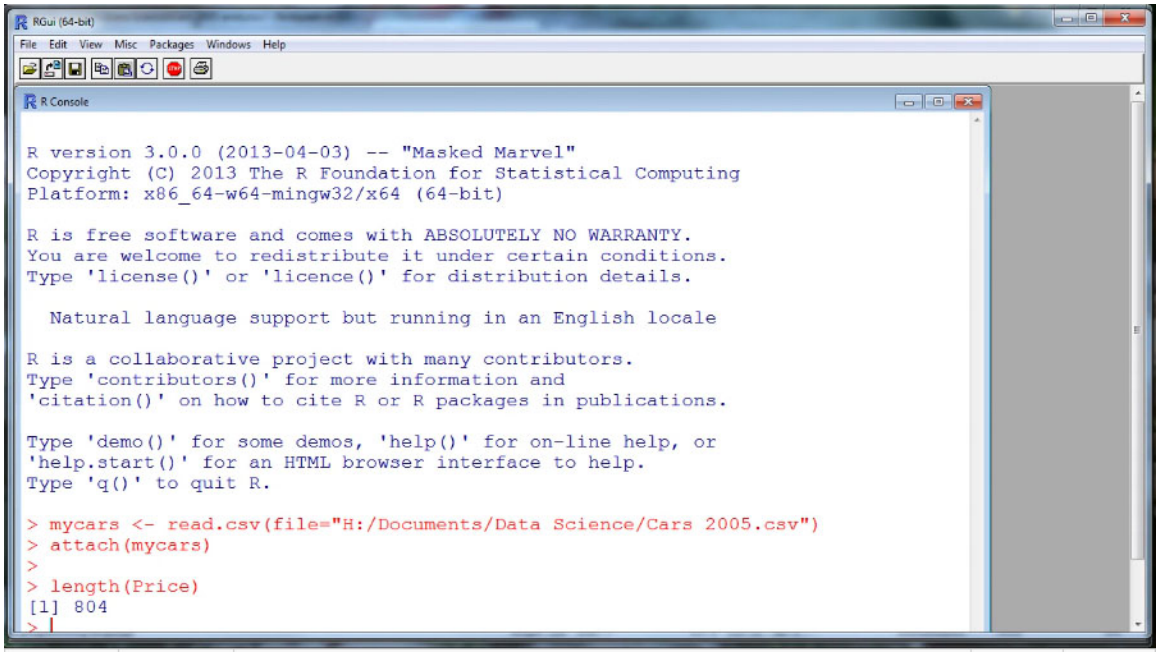
I also like to put a comment at the end of my for loop, to remind myself what this for loop was doing.

Here we're ending the iteration over the cars. This is helpful for when I have multiple control flow structures nested together. I can keep track of which closed curly bracket goes with which structure.

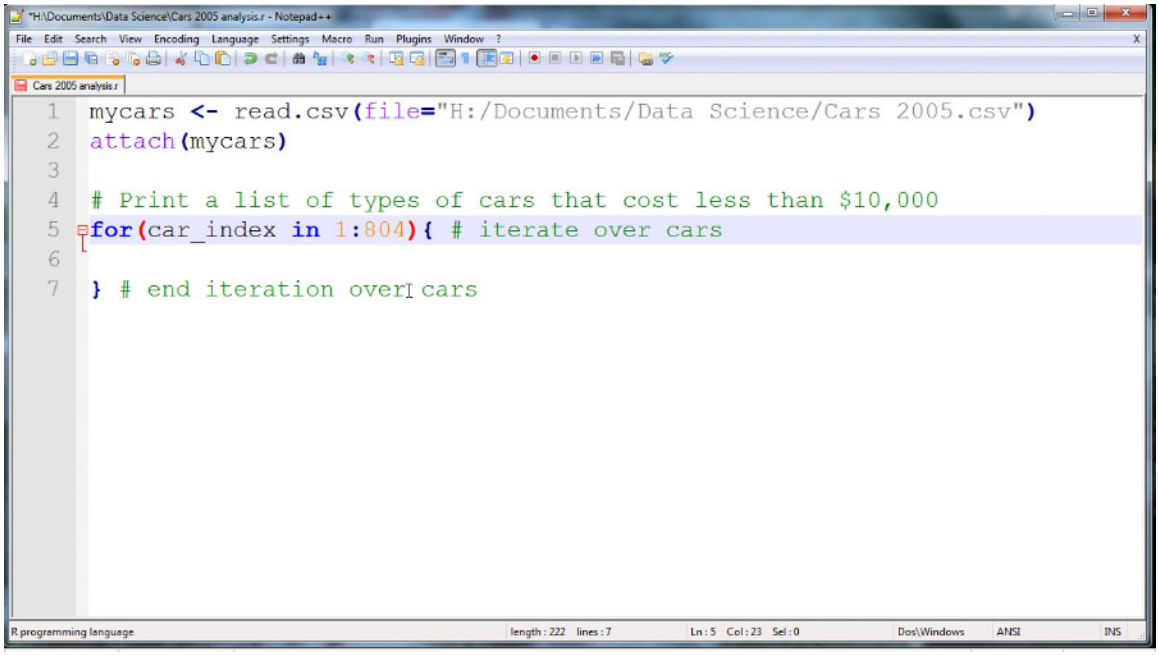


In this loop we'll be testing the price and printing the type. That's two different columns of data, so we want to use a numerical index. I'll call it car underscore index. And we want that to iterate over the numbers from one up to some number. We want to iterate over all the cars.

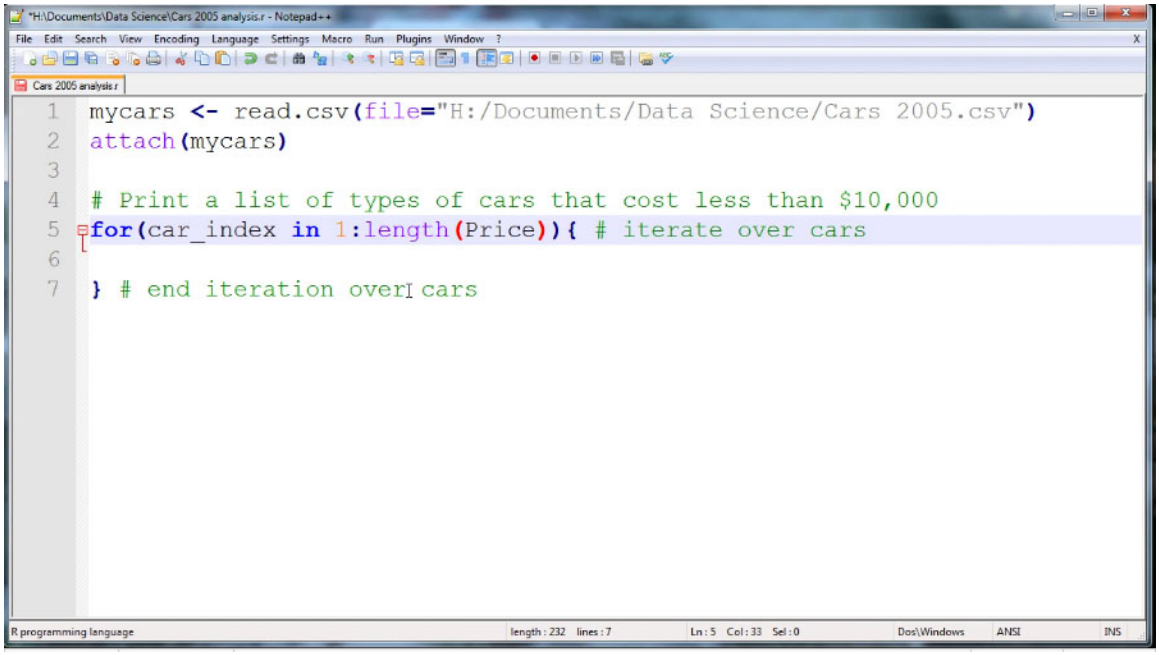
So the maximum value that car index can take on, should be the total number of rows in the data set. That's the same as the length of any one of the column vectors.



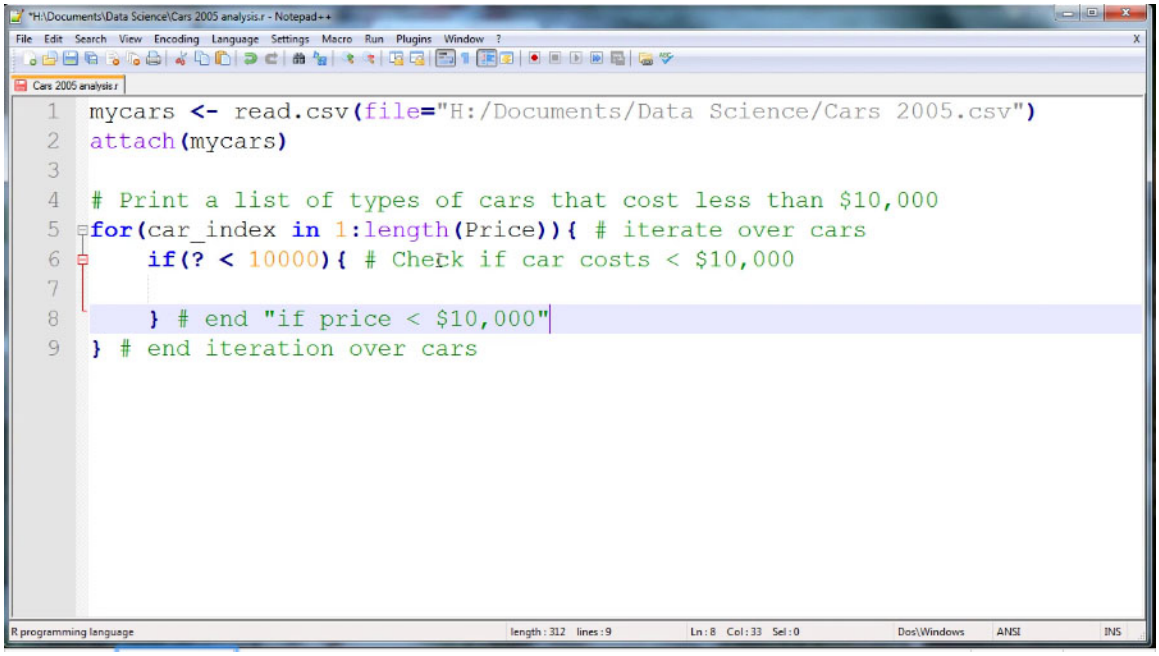
If we switch over to R we can use the length function to find the length of any of those column vectors, say price. And there are 804 entries in that data set.



So we could type 804 in place of the question mark.

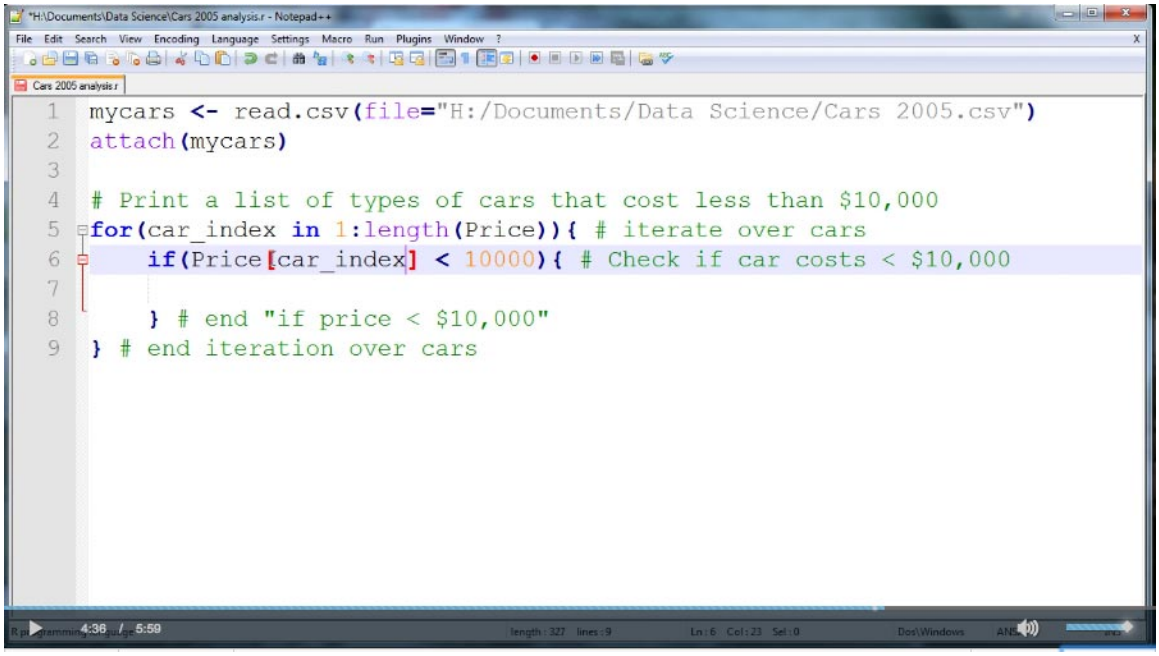


But to make our code more general, we could use the length of price instead. That way if we got a new data set of used cars in some other year, all we would have to do is change the file name that we're reading in, and the rest of our code, including this for loop, would still work.

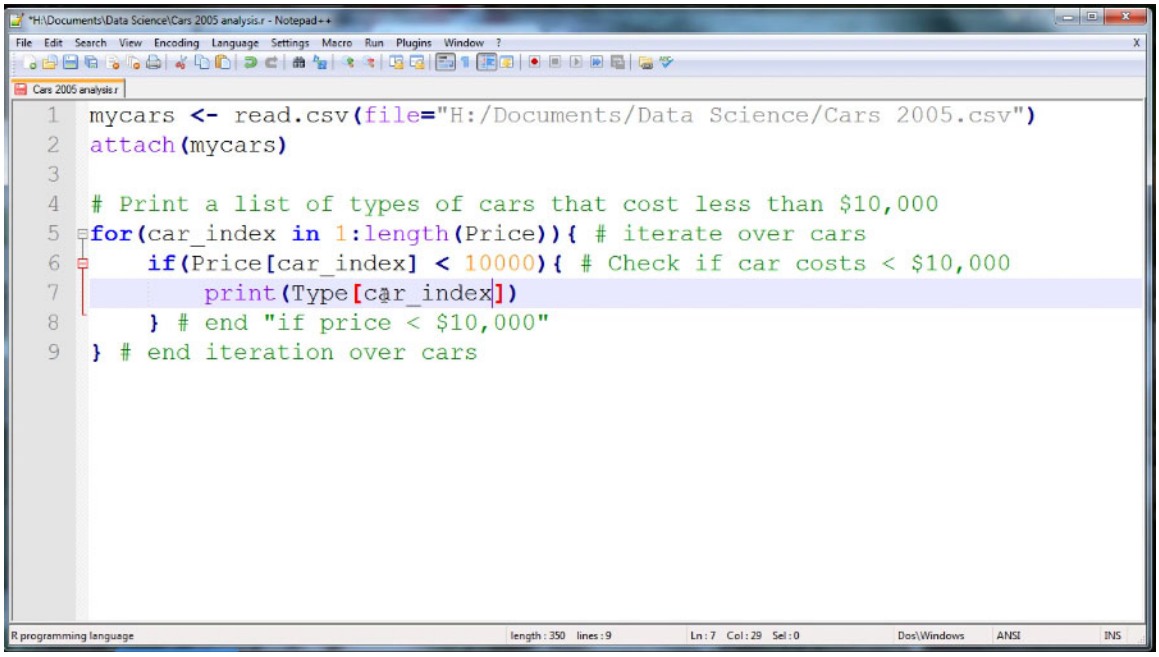


Now inside the for loop we want to test if the car's price is less than $10,000.

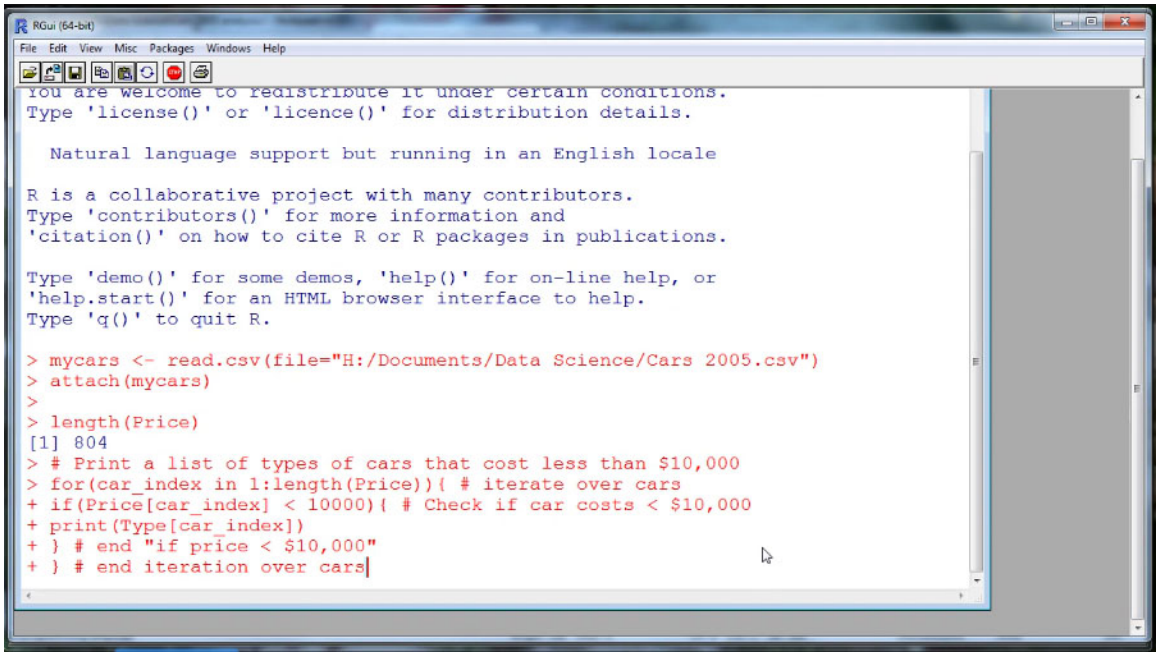
I'm just going to leave a question mark for the variable that we're testing, but we want to test if it's less than $10,000. And I'll label this with comments as well. Remember that the variable car index tells us which car, or row, we're looking at. It starts at one in the first iteration through the loop, and increases to two, three, and so on, up to 804.



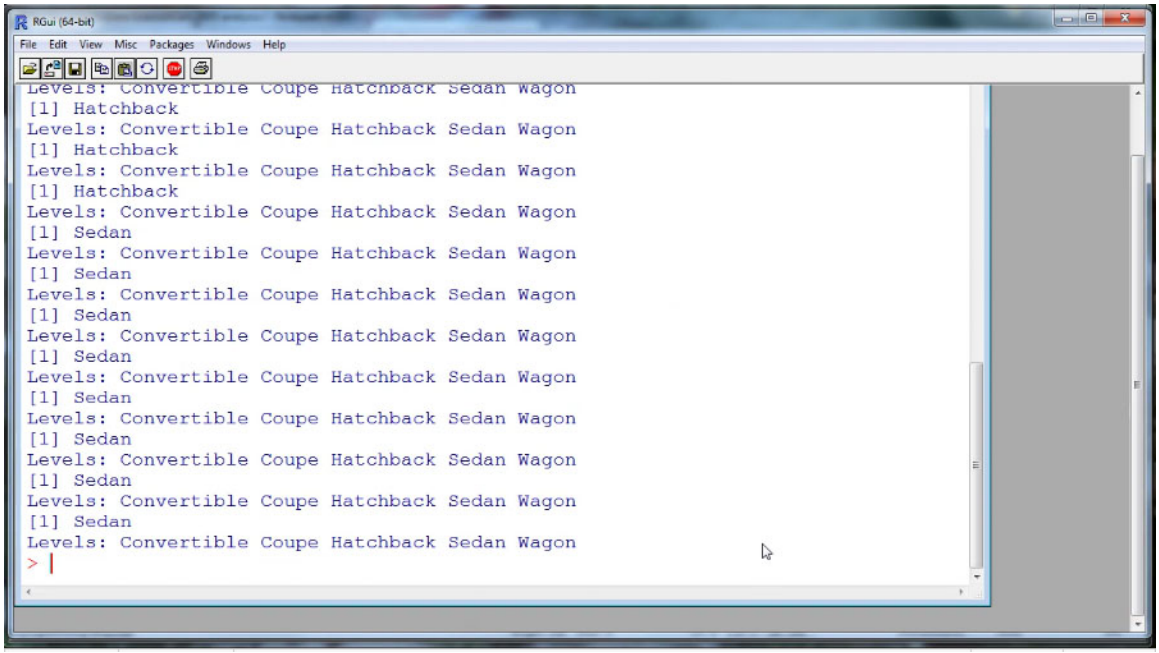
So to look at the price of the current car we want to look at the price column, or variable, and the car index location. So on the first time through the loop car index equals one, we'll be looking at price square bracket one, or the first element in the price vector.



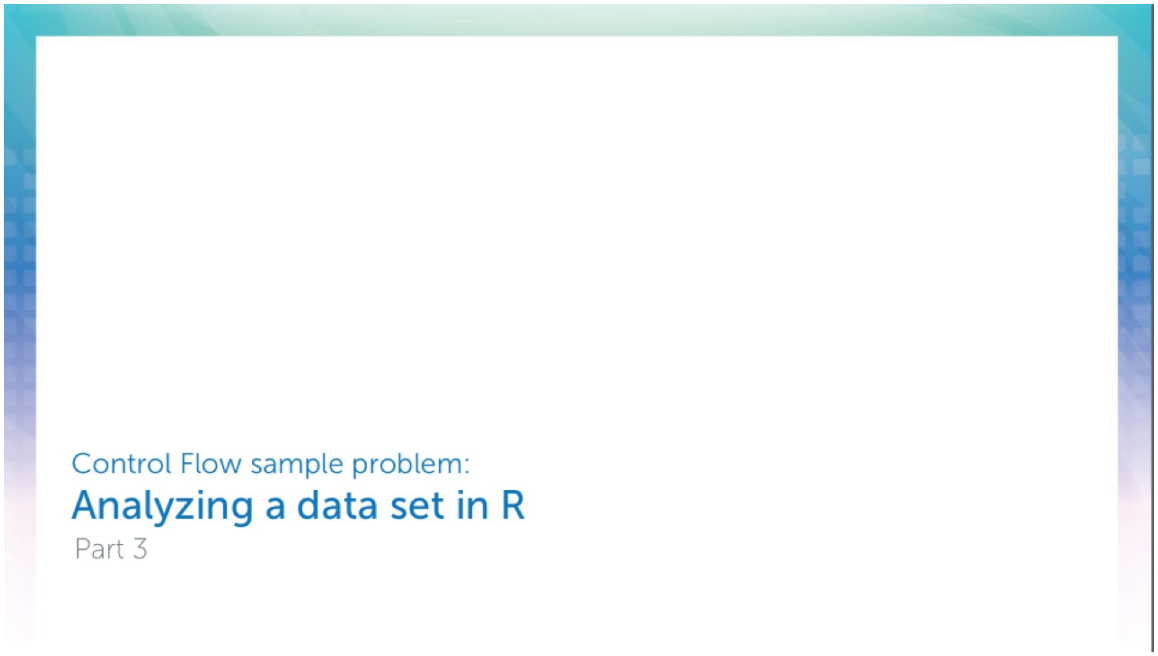
Finally, if this inequality is true, then we want to print the type of the current car using the print function. And the variable we want to print is the type of that same car that we're looking at. So car index.



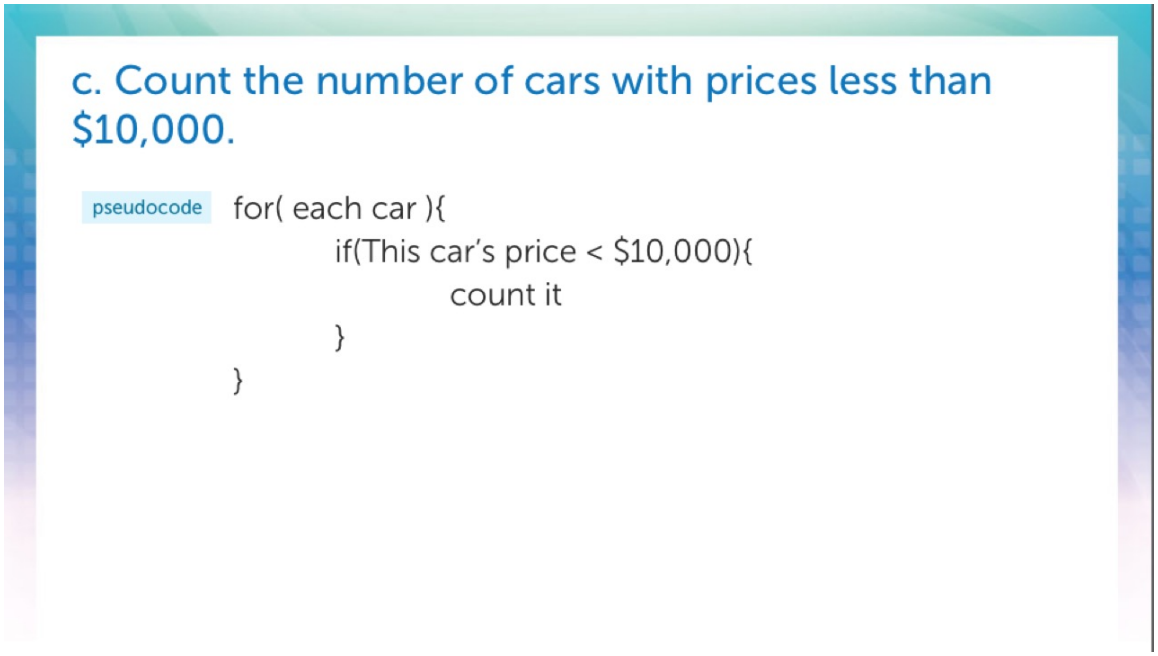
Now we think our code is complete, so we can copy and paste it into R.



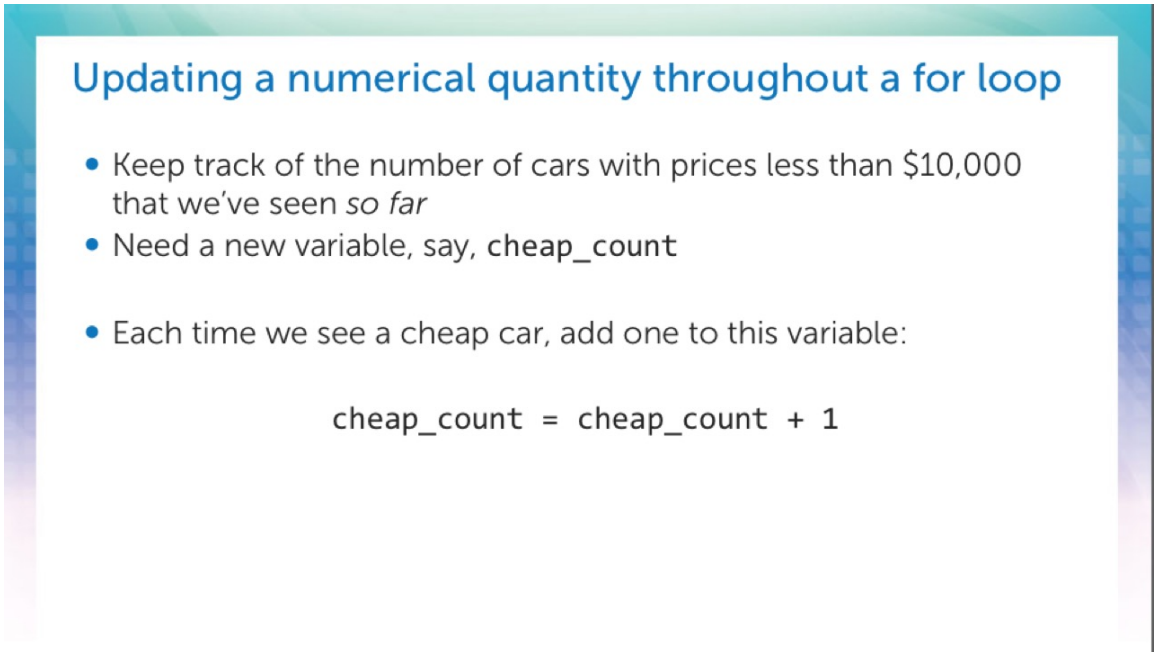
Here we see that the first car in the data set that costs less than $10,000 was a hatchback. The second was us sedan, and so on. The levels here are the different values that the type variable could take on. This was a categorical variable that could take on the values of convertible, coupe, hatchback, sedan, or wagon. But as it turns out, only hatchbacks and sedans appear in the group that costs less than $10,000.



Let's look at the third part of our hypothetical control flow problem.

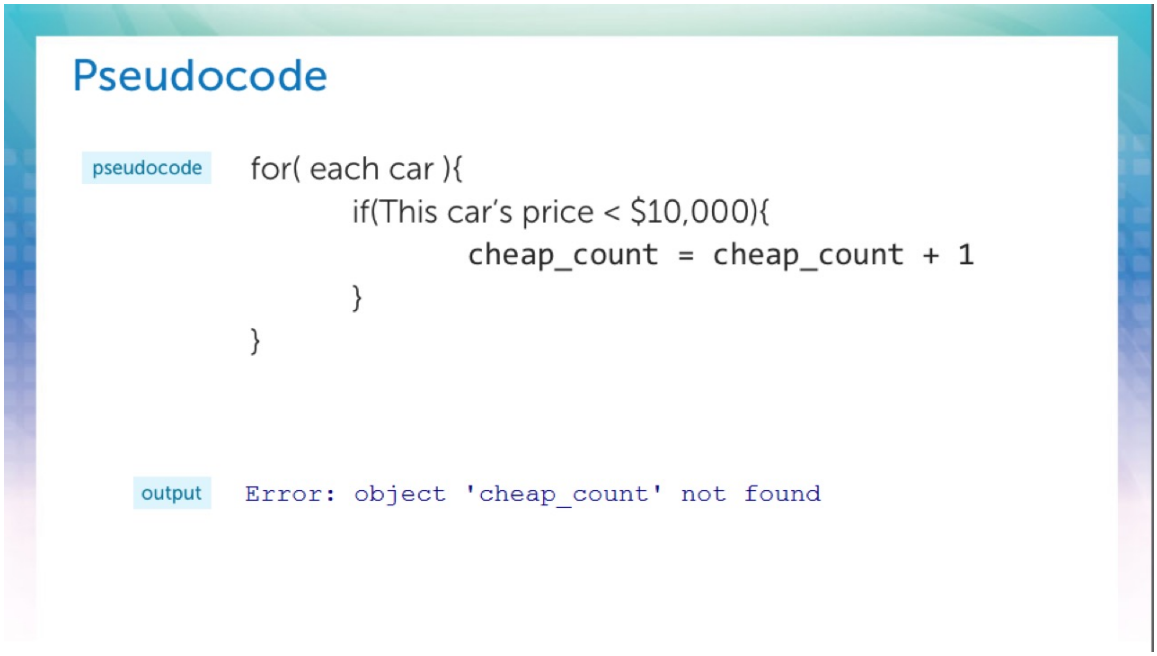


Here we want to count the number of cars with prices less than $10,000. We already printed the types of each of these cars, and there weren't very many of them. So we could just count them by hand, but we'd like to have a way to automate this process in case someone gave us a larger data set. So to do this let's start with the pseudocode that we wrote for part B. For each car we check if the car's price is less than $10,000, but in this case we don't want to print the car's type, we want to count it.

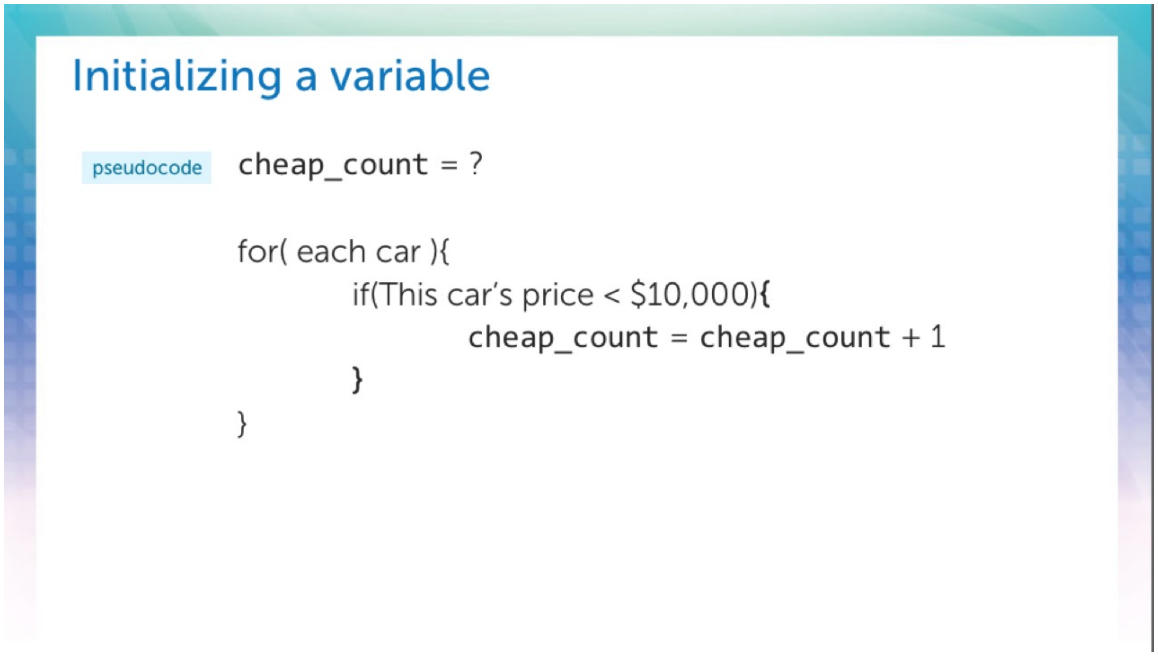


So how can we count it? Well, we want to keep track of the number of cars with prices less than $10,000 that we've seen so far. That means we need a new variable. In this case, we could use cheap, underscore, count. Then each time we see a cheap car, we would add one to this variable, using the equation cheap count equals cheap count plus one.

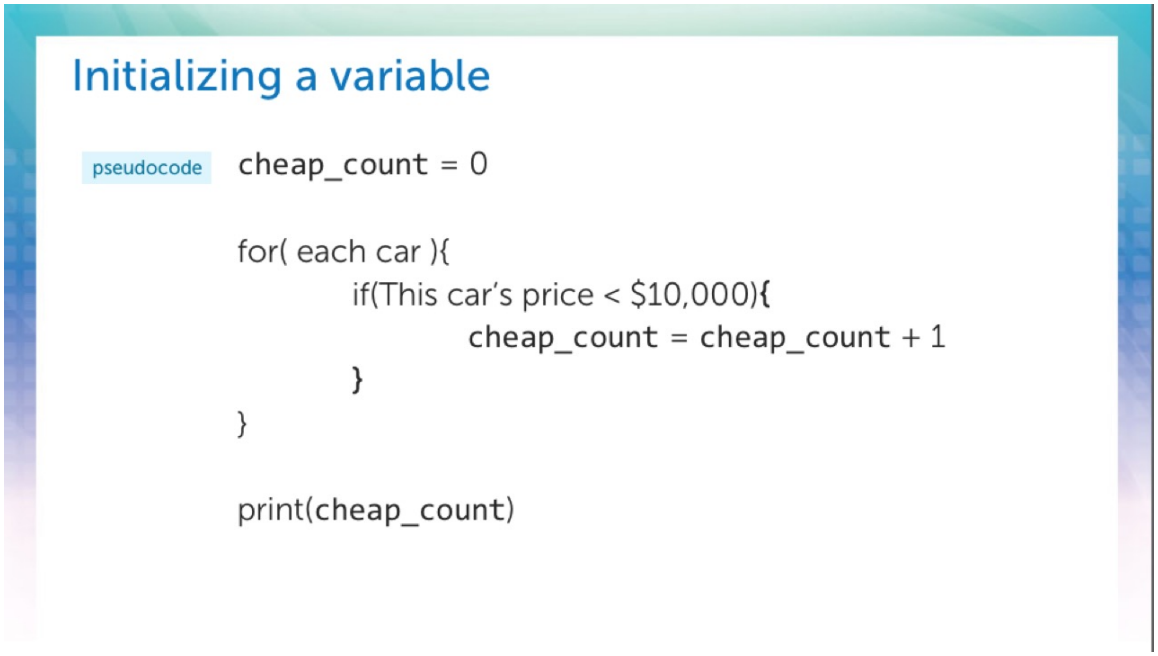
Notice that the left hand side of this equation has a variable that's being assigned a new value. The right hand side has the value that's being assigned to that variable. So even though this is an equation, it's not like an equation for math class. We're not saying that x equals x plus 1, which would be impossible. Instead we're making an assignment of a new value to the variable cheap count. Where the value we're assigning just happens to depend on the previous value of cheap count.



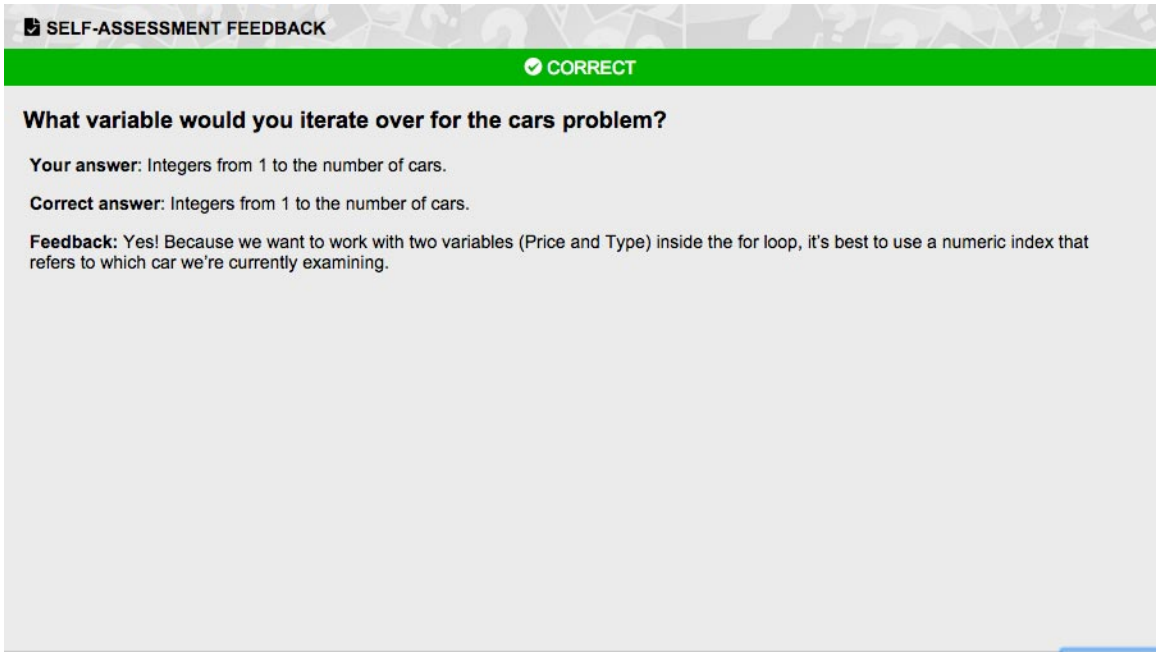
Using this variable cheap count, our pseudocode looks like this. But if we tried to write code based on the structure, and put it into R, R would give us an error message saying, object cheap count not found. That's because each time through the loop we're updating the value of cheap count based on its previous value. But the first time through the loop, there is no previous value to base our new value on. So we need to initialize or define the starting value of cheap account before the for loop starts.



So we can do that by writing a line of code that says, cheap count equals some value. Well what value should that be? Remember that cheap count is supposed to tell the number of cheap cars that we've seen so far. And before the for loop starts, we haven't looked at any cars, therefore we can't have seen any cheap cars. So the initial value of cheap count should be 0.



The last step of this pseudocode should be to print out the results. We want to know the total number of cheap cars after the for loop is over we've looked at all the cars. So that means we've also seen all of the cheap cars that there are. So the variable cheap count will contain the total number of cheap cars in the data set. So we just need to print out that number.



Question 1: What variable would you iterate over for the cars problem?

Correct answer: Integers from 1 to the number of cars.

Feedback: Because we want to work with two variables (Price and Type) inside the for loop, it's best to use a numeric index that refers to which cars we're currently examining.