

# **Problems and Solutions in Applied Statistics (2nd ed)**

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# Introduction

[This book](#) contains a collection of problems, and my solutions to them, in applied statistics with R. These come from my courses STAC32, STAC33, and STAD29 at the University of Toronto Scarborough.

You will occasionally see question parts beginning with a \*; this means that other question parts refer back to this one. (One of my favourite question strategies is to ask how two different approaches lead to the same answer, or more generally to demonstrate that there are different ways to see the same thing.)

Thanks to Dann Sioson for spotting some errors and making some useful suggestions.

If *you* see anything, [file an issue](#) on the Github page for now. Likely problems include:

- some LaTeX construction that I didn't catch (eg. block quotes)
- disappeared footnotes (that will show up as an apparently missing sentence in the text)
- references to “in class” or a lecture or a course by course number, which need to be eliminated (in favour of wording like “a previous course”)
- references to other questions or question parts that are *wrong* (likely caused by *not* being “labels” or “refs” in the original LaTeX)
- my contorted English that is difficult to understand.

As I read through looking for problems like these, I realize that there ought to be a textbook that reflects my way of doing things. There isn't one (yet), though there are lecture notes. Current versions of these are at:

- [the STAC32 website](#)
- [the STAC33 website](#)
- [the STAD29 website](#)

A little background:

STAC32 is an introduction to R as applied to statistical methods that have (mostly) been learned in previous courses. This course is designed for students who have a second non-mathematical applied statistics course such as [this](#). The idea is that students have already seen a little of regression and analysis of variance (and the things that precede them), and need mainly an introduction of how to run them in R.

STAC33 is an introduction to R, and applied statistics in general, for students who have a background in mathematical statistics. The way our courses are structured, these students have a strong mathematical background, but not very much experience in applications, which this course is designed to provide. The material covered is similar to STAC32, with a planned addition of some ideas in bootstrap and practical Bayesian statistics. There are some questions on these here.

STAD29 is an overview of a number of advanced statistical methods. I start from regression and proceed to some regression-like methods (logistic regression, survival analysis, log-linear frequency table analysis), then I go a little further with analysis of variance and proceed with MANOVA and repeated measures. I finish with a look at classical multivariate methods such as discriminant analysis, cluster analysis, principal components and factor analysis. I cover a number of methods in no great depth; my aim is to convey an understanding of what these methods are for, how to run them and how to interpret the results. Statistics majors and specialists cannot take this course for credit (they have separate courses covering this material with the proper mathematical background). D29 is intended for students in other disciplines who find themselves wanting to learn more statistics; we have an [Applied Statistics Minor program](#) for which C32 and D29 are two of the last courses.

## Packages used somewhere in this book

The bottom lines are below used with the `conflicted` package: if a function by the name shown is in two or more packages, prefer the one from the package shown.

```
library(tidyverse)
library(smmr)
library(MASS)
library(nnet)
library(survival)
library(survminer)
library(car)
library(lme4)
library(ggbiplot)
library(ggrepel)
library(broom)
library(rpart)
library(bootstrap)
library(cmdstanr)
library(posterior)
library(bayesplot)
library(tmaptools)
```

```
library(leaflet)
library(conflicted)
conflict_prefer("summarize", "dplyr")
conflict_prefer("select", "dplyr")
conflict_prefer("filter", "dplyr")
conflict_prefer("mutate", "dplyr")
conflict_prefer("count", "dplyr")
conflict_prefer("arrange", "dplyr")
conflict_prefer("rename", "dplyr")
conflict_prefer("id", "dplyr")
```

All of these packages are on CRAN, and may be installed via the usual `install.packages`, with the exceptions of:

- `smmr` on Github: install with

```
devtools::install_github("nxskok/smmr")
```

- `ggbiplot` on Github: install with

```
devtools::install_github("vqv/ggbiplot")
```

- `cmdstanr`, `posterior`, and `bayesplot`: install with

```
install.packages("cmdstanr",
                 repos = c("https://mc-stan.org/r-packages/",
                           getOption("repos")))
install.packages("posterior",
                 repos = c("https://mc-stan.org/r-packages/",
                           getOption("repos")))
install.packages("bayesplot",
                 repos = c("https://mc-stan.org/r-packages/",
                           getOption("repos")))
```

# 1 Getting used to R and R Studio

My solutions follow the problems. Look ahead if you get stuck. Don't forget `library(tidyverse)` if you need it:

## 1.1 Using R Studio online

- (a) Point your web browser at <http://r.datatools.utoronto.ca>. Click on the button to the left of “R Studio” (it will show blue), click the orange Log in to Start, and log in using your UTorID and password.

Solution

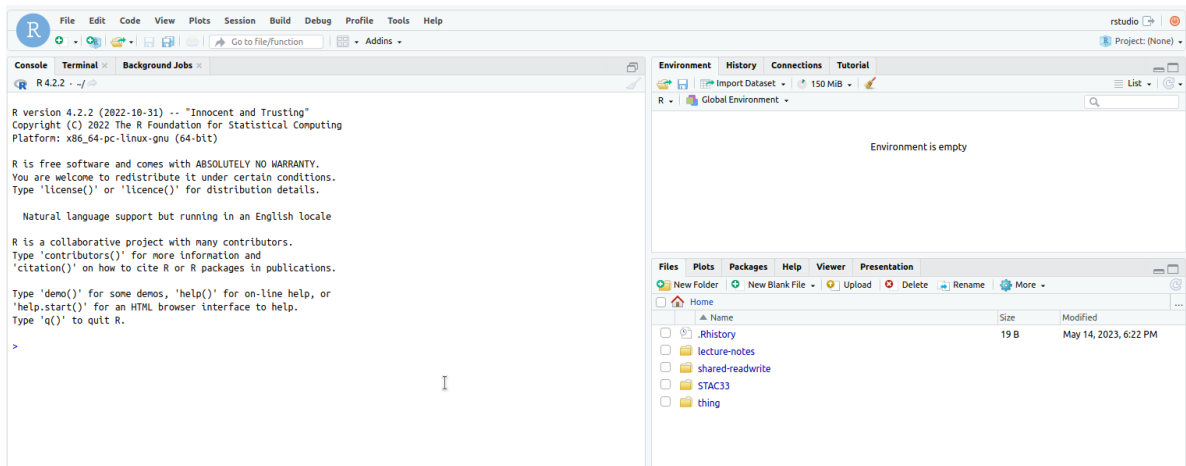
This is about what you should see first, before you click the orange thing:



After logging in, open: ☐ Jupyter Notebook ☒ RStudio ☐ JupyterLab

Log in to start

You will see a progress bar as things start up, and then you should see something like this:



This is R Studio, ready to go.

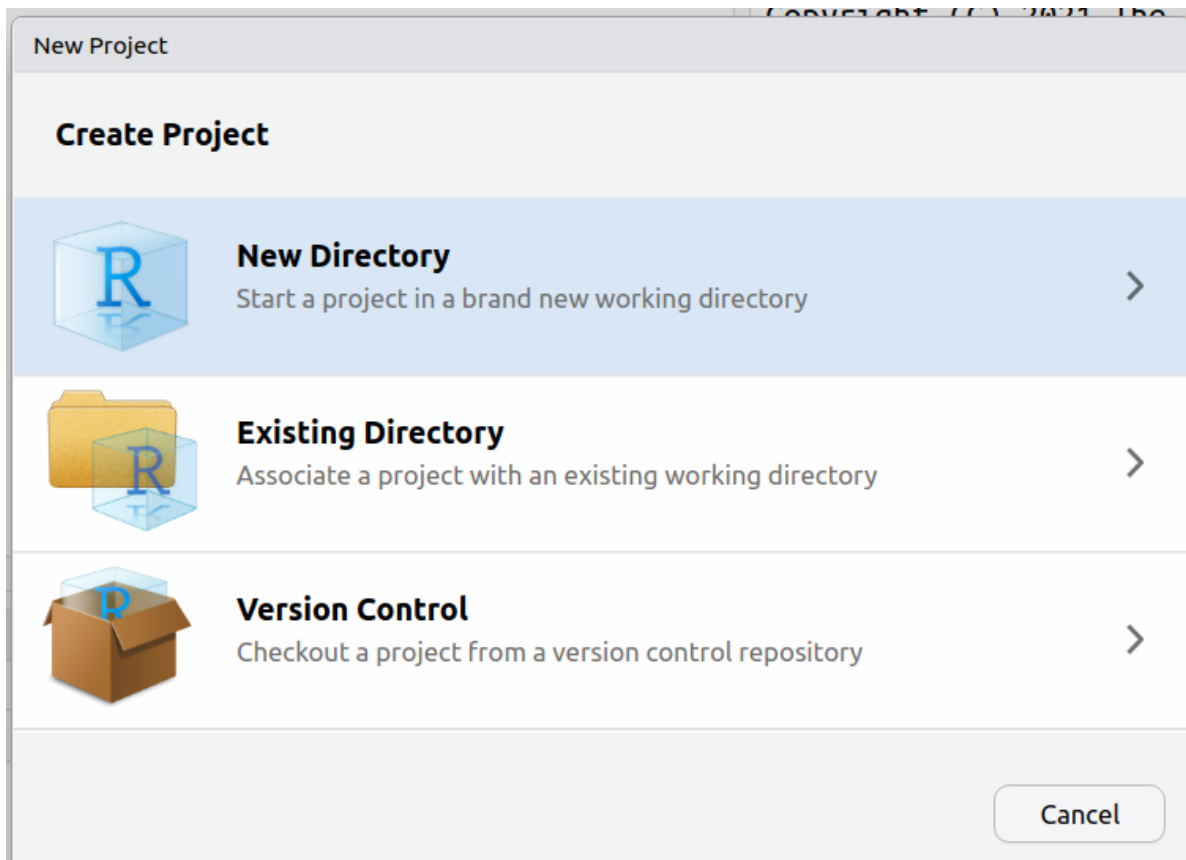
If you are already logged in to something else on the same browser that uses your UTorID and password, you may come straight here without needing to log in again.

■

(b) Take a look around, and create a new Project. Give the new project any name you like.

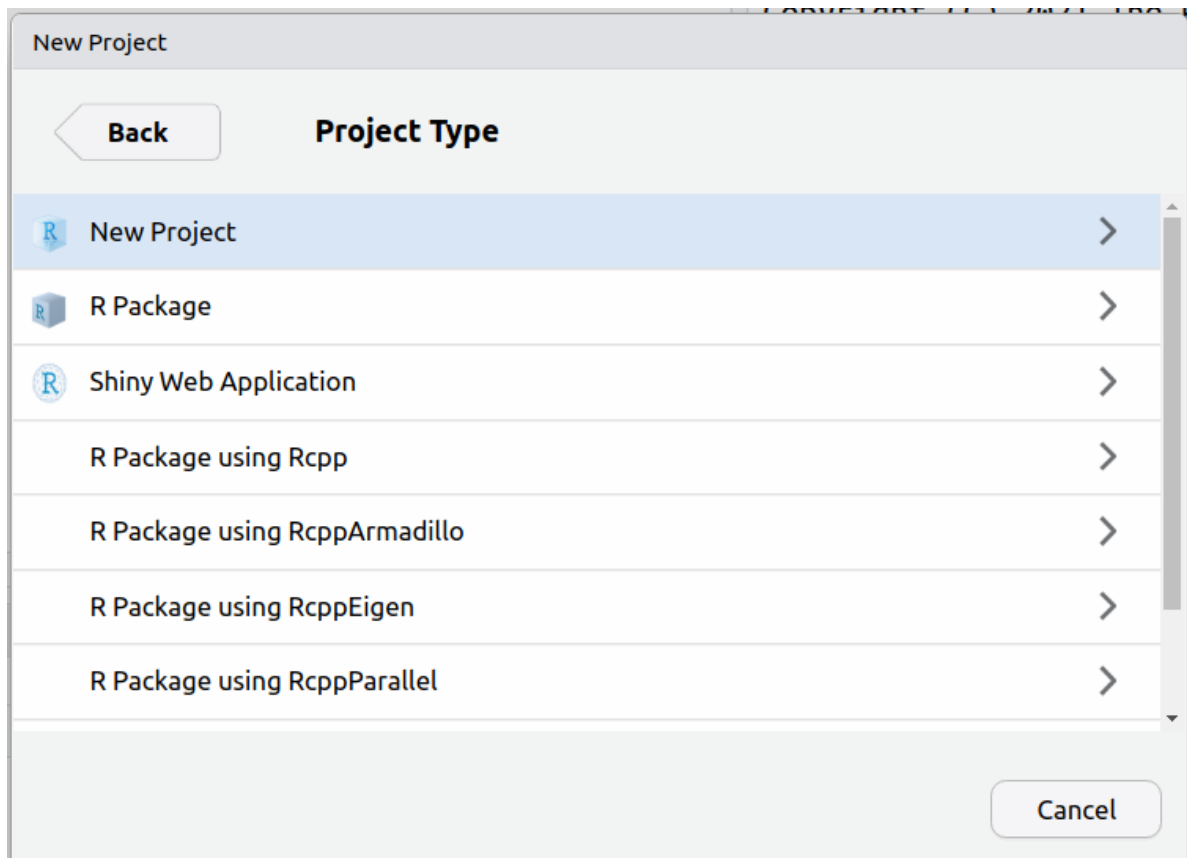
Solution

Select File and New Project to get this:

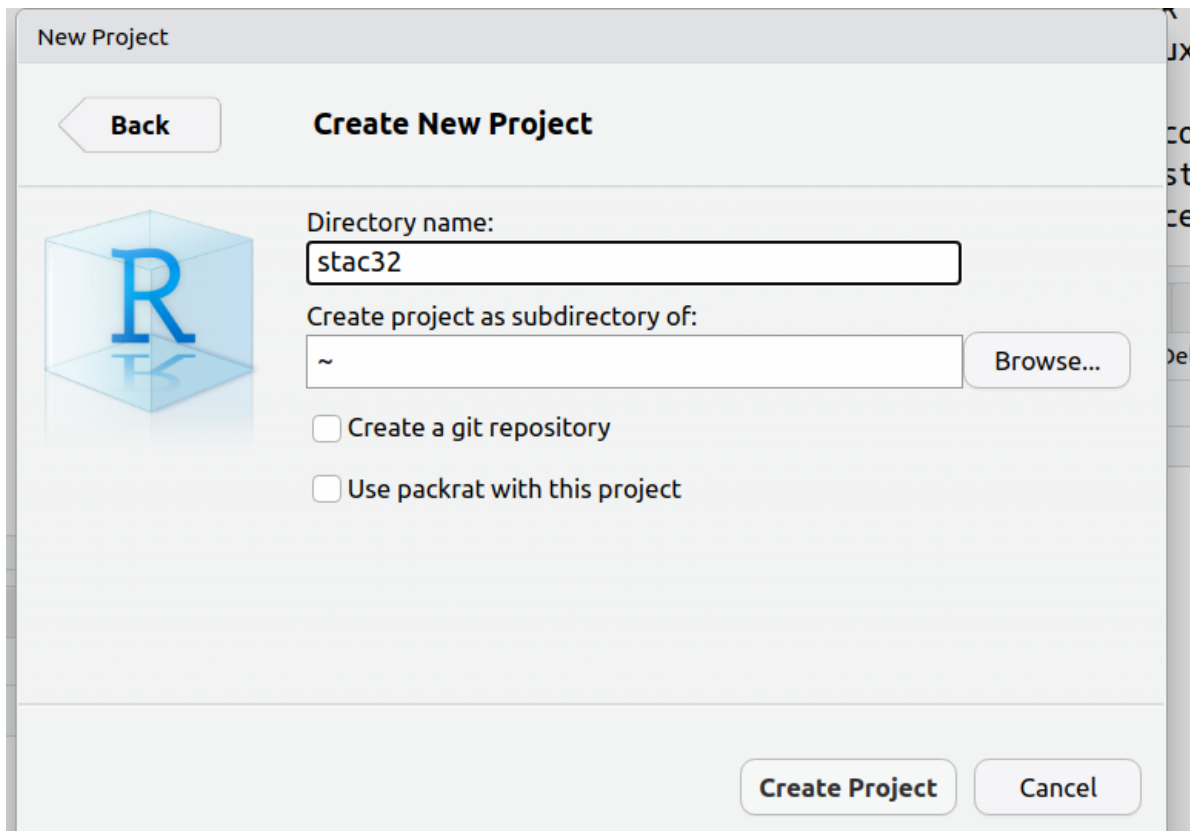


Click on New Directory (highlighted blue on mine). This will create a new folder to put your new project in, which is usually what you want to do. The idea is that a project is a container for a larger collection of work, such as all your assignments in this course. That brings you to this:

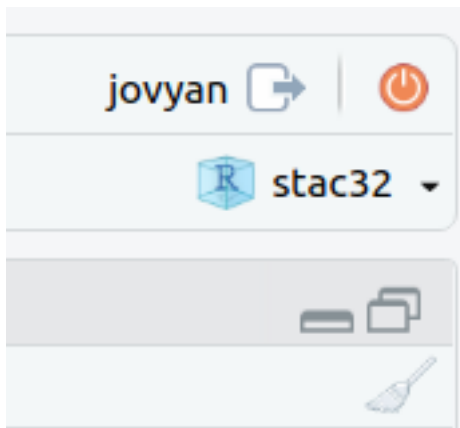




where you click on New Project (highlighted on mine), and:



Give your project a name, as I did. Then click Create Project. At this point, R Studio will be restarted in your new project. You can tell which project you are in by looking top right, and you'll see the name of your project next to the R symbol:



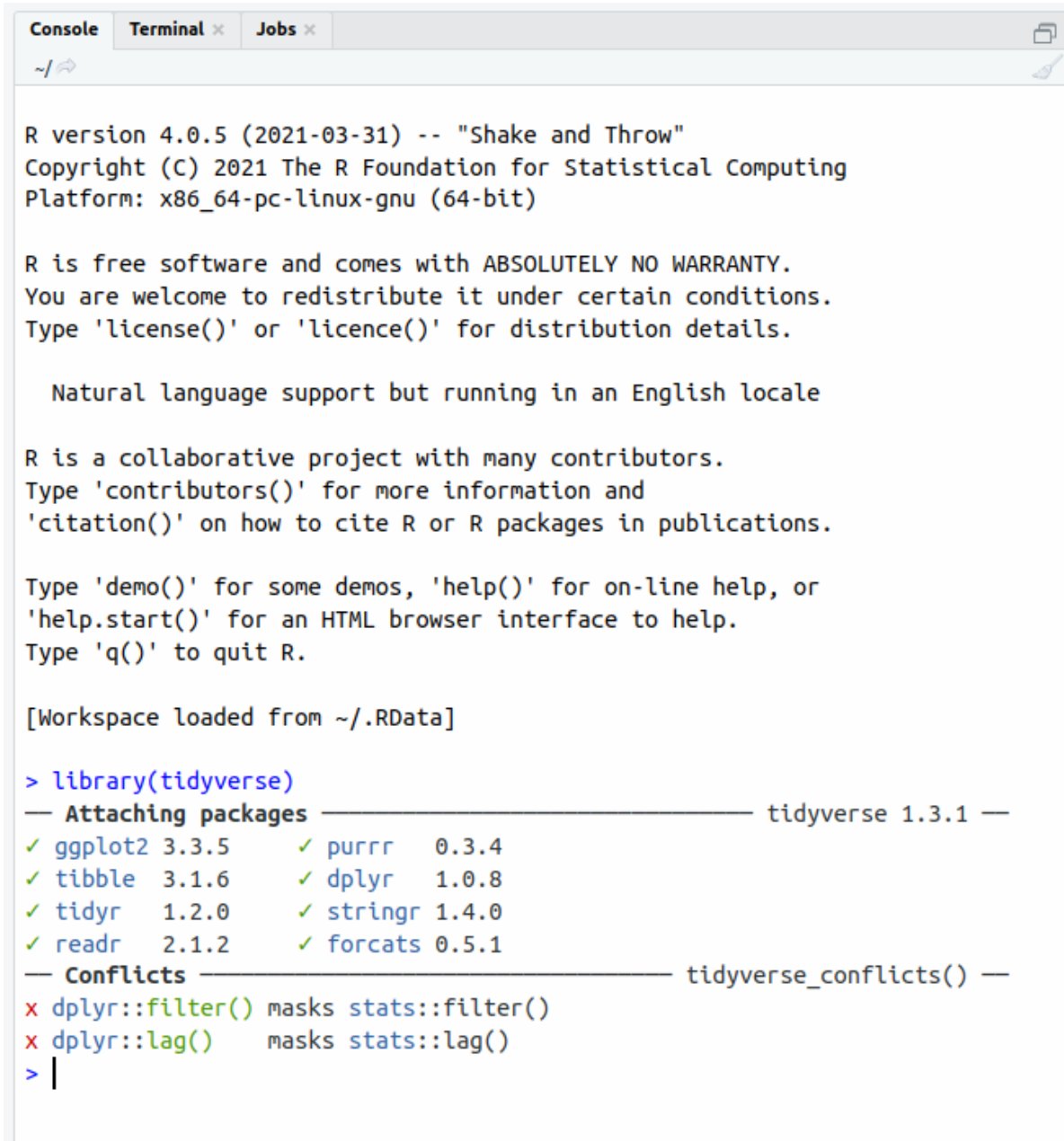
■

(c) One last piece of testing: find the Console window (which is probably on the left). Click

next to the blue `>`, and type `library(tidyverse)`. Press Enter.

Solution

It may think a bit, and then you'll see something like this:



```
Console Terminal x Jobs x
~/
R version 4.0.5 (2021-03-31) -- "Shake and Throw"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

[Workspace loaded from ~/.RData]

> library(tidyverse)
— Attaching packages — tidyverse 1.3.1 —
✓ ggplot2 3.3.5    ✓ purrr 0.3.4
✓ tibble 3.1.6     ✓ dplyr 1.0.8
✓ tidyr 1.2.0      ✓ stringr 1.4.0
✓ readr 2.1.2      ✓ forcats 0.5.1
— Conflicts — tidyverse_conflicts() —
x dplyr::filter() masks stats::filter()
x dplyr::lag()     masks stats::lag()
> |
```

Aside: I used to use a cloud R Studio called `rstudio.cloud`. If you see or hear any references to that, it means the same thing as R Studio on `r.datatools` or `jupyter`. (You can still use

`rstudio.cloud` if you want; it used to be completely free, but now the free tier won't last you very long; the `utoronto.calink` is free as long as you are at U of T.) I'm trying to get rid of references to R Studio Cloud as I see them, but I am bound to miss some, and in the lecture videos they are rather hard to find.

Now we can get down to some actual work.



## 1.2 Getting started

This question is to get you started using R.

- (a) Start R Studio Cloud, in some project. (If you started up a new project in the previous question and are still logged in, use that; if not, create a new project.)
- (b) We're going to do some stuff in R here, just to get used to it. First, make an R Notebook by selecting File, New File and R Notebook.
- (c) Change the title to something of your choosing. Then go down to line 5, click on the Insert button and select R. You should see a "code chunk" appear at line 5, which we are going to use in a moment.
- (d) Type the line of code shown below into the chunk in the R Notebook:

`mtcars`

- (e) Run this command. To do that, look at the top right of your code chunk block (shaded in a slightly different colour). You should see a gear symbol, a down arrow and a green "play button". Click the play button. This will run the code, and show the output below the code chunk.
- (f) Something a little more interesting: `summary` obtains a summary of whatever you feed it (the five-number summary plus the mean for numerical variables). Obtain this for our data frame. To do this, create a new code chunk below the previous one, type `summary(mtcars)` into the code chunk, and run it.
- (g) Let's make a boxplot of the gas mileage data. This is a "poor man's boxplot"; we'll see a nicer-looking way later. To do it this way, make another new code chunk, enter the code `boxplot(mtcars$mpg)` into it, and run the chunk.

- (h) Some aesthetics to finish with: delete the template notebook (all the stuff you didn't type below your code chunks and output). Then add some narrative text above and below your code chunks. Above the code chunk is where you say what you are going to do (and maybe why you are doing it), and below is where you say what you conclude from the output you just obtained.
- (i) Save your notebook (the usual way with File and Save). This saves it *on the R Studio Cloud servers* (and not on your computer). This means that when you come back to R Studio Cloud later, even from another device, this notebook will still be available to you. Now click Preview. This produces a pretty HTML version of your notebook.
- (j) Optional extra: practice handing in your previewed R notebook, as if it were an assignment that was worth something. (It is good to get the practice in a low-stakes situation, so that you'll know what to do next week.)
- (k) Optional extra. Something more ambitious: make a scatterplot of gas mileage `mpg`, on the  $y$  axis, against horsepower, `hp`, on the  $x$ -axis.

## 1.3 Reading data from a file

In this question, we read a file from the web and do some descriptive statistics and a graph. This is very like what you will be doing on future assignments, so it's good to practice it now.

Take a look at the data file at <http://ritsokiguess.site/datafiles/jumping.txt>. These are measurements on 30 rats that were randomly made to do different amounts of jumping by group (we'll see the details later in the course). The control group did no jumping, and the other groups did "low jumping" and "high jumping". The first column says which jumping group each rat was in, and the second is the rat's bone density (the experimenters' supposition was that more jumping should go with higher bone density).

- (a) What are the two columns of data separated by? (The fancy word is "delimited").
- (b) Make a new R Notebook. Leave the first four lines, but get rid of the rest of the template document. Start with a code chunk containing `library(tidyverse)`. Run it.
- (c) Put the URL of the data file in a variable called `my_url`. Then use `read_delim` to read in the file. (See solutions for how.) `read_delim` reads data files where the data values are always separated by the same single character, here a space. Save the data frame in a variable `rats`.
- (d) Take a look at your data frame, by making a new code chunk and putting the data frame's name in it (as we did with `mtcars`).
- (e) Find the mean bone density for rats that did each amount of jumping.

- (f) Make a boxplot of bone density for each jumping group.

## 1.4 Reading files different ways

This question is about different ways of reading data files. If you're using R Studio Cloud (online), start at the beginning. If you're using R Studio running on your own computer, start at part (here).

- (a) Log in to R Studio Cloud. Open up a project (or start a new one), and watch the spinning circles for a few minutes. When that's done, create a new R Notebook with File, New File, R Notebook. Delete the "template" notebook, but not the top four lines with `title:` and `output:` in them. Add a code chunk that contains `library(tidyverse)` and run it.

Solution

So far you (with luck) have something that looks like this:

The screenshot shows the RStudio interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. Below the menu bar is a toolbar with icons for file operations and a search bar labeled 'Go to file/function'. The main editor window shows a file named 'Untitled1\*' with the following R code:

```

1 ---
2 title: "R Notebook"
3 output: html_notebook
4 ---
5
6 ## Packages
7
8 ```{r}
9 library(tidyverse)
10 ```

```

Below the code editor, the console output is displayed, showing the packages being attached and any conflicts:

```

— Attaching packages —
✓ ggplot2 3.0.0    ✓ purrr  0.2.5
✓ tibble  1.4.2    ✓ dplyr  0.7.6
✓ tidyr   0.8.1    ✓ stringr 1.3.1
✓ readr   1.1.1    ✓ forcats 0.3.0
— Conflicts —
✗ dplyr::filter() masks stats::filter()
✗ dplyr::lag()    masks stats::lag()

```

If you have an error rather than that output, you probably need to install the `tidyverse` first. Make another code chunk, containing

```
install.packages("tidyverse")
```

and run it. Wait for it to finish. It may take a while. If it completes successfully (you might see the word `DONE` at the end), delete that code chunk (you don't need it any more) and try again with the `library(tidyverse)` chunk. It should run properly this time.



- (b) \* The easiest kind of files to read in are ones on the Internet, with a URL address that begins with `http` or `https`. I have a small file at [link](http://ritsokiguess.site/datafiles/testing.txt). Click the link to see it, and keep the tab open for the next part of this question. This is a text file with three things on each line, each separated by exactly one space. Read the data file into a data frame, and display your data frame.

#### Solution

Data values separated by exactly one space is the kind of thing that `read_delim` reads, so make another code chunk and fill it with this:

```
my_url <- "http://ritsokiguess.site/datafiles/testing.txt"
testing <- read_delim(my_url, " ")
```

Rows: 6 Columns: 3

-- Column specification -----

Delimiter: " "

chr (1): g

dbl (2): x, y

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

```
testing
```

# A tibble: 6 x 3

	x	y	g
	<dbl>	<dbl>	<chr>
1	1	10	a
2	2	11	b
3	3	14	a
4	4	13	b
5	5	18	a
6	6	21	b

When you run that, you'll see something like my output. The first part is `read_delim` telling you what it saw in the file: two columns of (whole) numbers and one column of text. The top line of the file is assumed to contain names, which are used as the names of the columns of your data frame. The bottom part of the output, obtained by putting the name of the data frame on a line by itself in your code chunk, is what the data frame actually looks like. You



ought to get into the habit of eyeballing it and checking that it looks like the values in the data file.

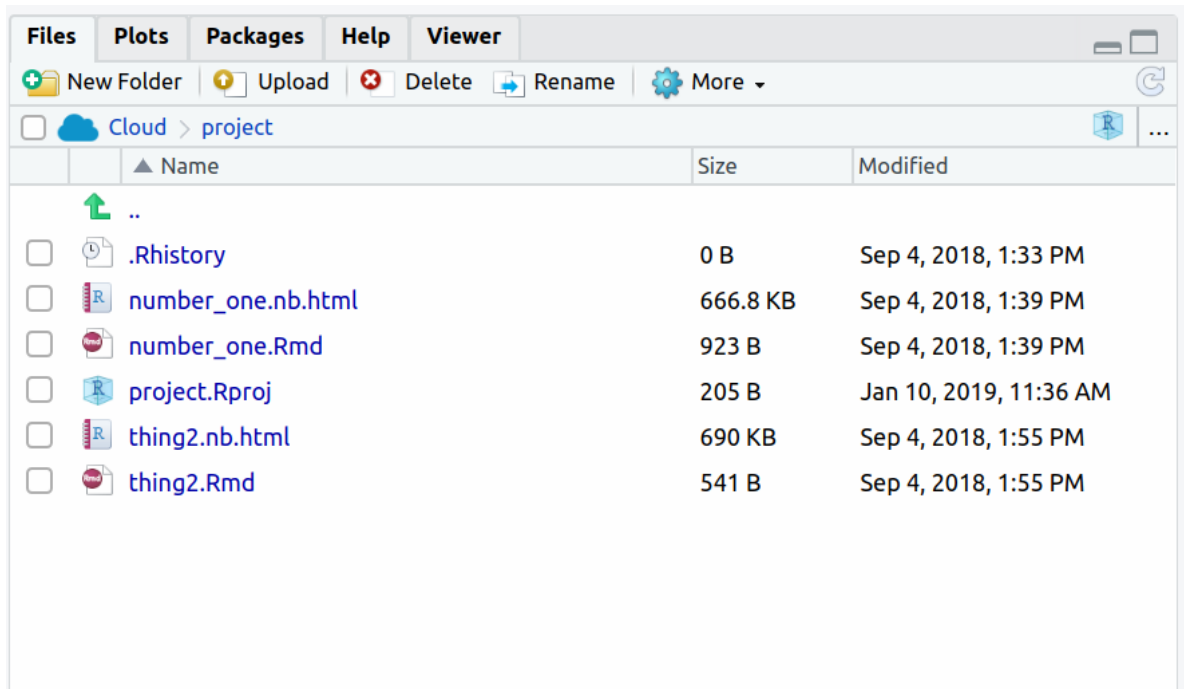
The things on the left side of the equals signs are variables that you are creating in R. You get to choose the names for them. My habit is to use `my_url` for URLs of files that I am going to read in, and (usually) to give my data frames names that say something about what they contain, but this is your choice to make.

■

- (c) You might have data in a file on your own computer. To read data from such a file, you first have to *upload* it to R Studio Cloud, and then read it from there. To practice this: open a text editor (like Notepad or TextEdit). Go back to the web browser tab containing the data you used in the previous part. Copy the data from there and paste it into the text editor. Save it somewhere on your computer (like the Desktop). Upload that file to R Studio Cloud, read in the data and verify that you get the right thing. (For this last part, see the Solution.)

### Solution

I copied and pasted the data, and saved it in a file called `testing.txt` on my computer. I'm assuming that you've given it a similar name. Then go back to R Studio Cloud. You should have a Files pane bottom right. If you don't see a pane bottom right at all, press Control-Shift-0 to show all the panes. If you see something bottom right but it's not Files (for example a plot), click the Files tab, and you should see a list of things that look like files, like this:



Click the Upload button (next to New Folder), click Choose File. Use the file finder to track down the file you saved on your computer, then click OK. The file should be uploaded to the same folder on R Studio Cloud that your project is, and appear in the Files pane bottom right. To read it in, you supply the file name to `read_delim` thus:

```
testing2 <- read_delim("testing.txt", " ")
```

Rows: 6 Columns: 3

-- Column specification -----

Delimiter: " "

chr (1): g

dbl (2): x, y

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

and then you look at it in the same way as before:

```
testing2
```

# A tibble: 6 x 3

	x	y	g
	<dbl>	<dbl>	<chr>
1	1	10	a
2	2	11	b
3	3	14	a
4	4	13	b
5	5	18	a
6	6	21	b

Check.



- (d) You might have a spreadsheet on your computer. Create a `.csv` file from it, and use the ideas of the last part to read it into R Studio Cloud.

Solution

Open the spreadsheet containing the data you want to read into R. If there are several sheets in the workbook, make sure you're looking at the right one. Select File, Save As, select "CSV" or "comma-separated values" and give it a name. Save the resulting file somewhere.

Then follow the same steps as the previous part to upload it to your project on R Studio Cloud. (If you look at the actual file, it will be plain text with the data values having commas between them, as the name suggests. You can open the file in R Studio Cloud by clicking on it in the Files pane; it should open top left.)

The final step is to read it into an R data frame. This uses `read_csv`; there are several `read_` functions that read in different types of file, and you need to use an appropriate one.

My spreadsheet got saved as `cars.csv`, so:

```
cars <- read_csv("cars.csv")
```

```
Rows: 38 Columns: 6
```

```
-- Column specification -----
```

```
Delimiter: ","
```

```
chr (2): Car, Country
```

```
dbl (4): MPG, Weight, Cylinders, Horsepower
```

```
i Use `spec()` to retrieve the full column specification for this data.
```

```
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
cars
```

```
# A tibble: 38 x 6
```

	Car	MPG	Weight	Cylinders	Horsepower	Country
	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<chr>
1	Buick Skylark	28.4	2.67	4	90	U.S.
2	Dodge Omni	30.9	2.23	4	75	U.S.
3	Mercury Zephyr	20.8	3.07	6	85	U.S.
4	Fiat Strada	37.3	2.13	4	69	Italy
5	Peugeot 694 SL	16.2	3.41	6	133	France
6	VW Rabbit	31.9	1.92	4	71	Germany
7	Plymouth Horizon	34.2	2.2	4	70	U.S.
8	Mazda GLC	34.1	1.98	4	65	Japan
9	Buick Estate Wagon	16.9	4.36	8	155	U.S.
10	Audi 5000	20.3	2.83	5	103	Germany

```
# i 28 more rows
```

Some information about different types of cars.

You are now done with this question.



- (e) \* Start here if you downloaded R and R Studio and they are running on your own computer. Open a web browser and point it at [link](http://ritsokiguess.site/datafiles/testing.txt). Click the link to see it, and keep the tab open for the next part of this question. This is a text file with three things on each line, each separated by exactly one space. Read the data file into a data frame, and display your data frame.

#### Solution

Data values separated by exactly one space is the kind of thing that `read_delim` reads, so make another code chunk and fill it with this:

```
my_url <- "http://ritsokiguess.site/datafiles/testing.txt"
testing <- read_delim(my_url, " ")
```

Rows: 6 Columns: 3

-- Column specification -----

Delimiter: " "

chr (1): g

dbl (2): x, y

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

```
testing
```

# A tibble: 6 x 3

	x	y	g
	<dbl>	<dbl>	<chr>
1	1	10	a
2	2	11	b
3	3	14	a
4	4	13	b
5	5	18	a
6	6	21	b

When you run that, you'll see something like my output. The first part is `read_delim` telling you what it saw in the file: two columns of (whole) numbers and one column of text. The top line of the file is assumed to contain names, which are used as the names of the columns of your data frame. The bottom part of the output, obtained by putting the name of the data frame on a line by itself in your code chunk, is what the data frame actually looks like. You

ought to get into the habit of eyeballing it and checking that it looks like the values in the data file.

The things on the left side of the equals signs are variables that you are creating in R. You get to choose the names for them. My habit is to use `my_url` for URLs of files that I am going to read in, and (usually) to give my data frames names that say something about what they contain, but this is your choice to make.

(This part is exactly the same whether you are running R Studio Cloud or have R Studio running on your computer. A remote file is obtained in exactly the same way regardless.)



- (f) You might have data in a file on your own computer. To read data from such a file, R has to know where to find it. Each R project lives in a folder, and one way of specifying where a data file is is to give its complete path relative to the folder that R Studio is running its current project in. This is rather complicated, so we will try a simpler way. To set this up, open a text editor (like Notepad or TextEdit). Go back to the web browser tab containing the data you used in the previous part. Copy the data from there and paste it into the text editor. Save it somewhere on your computer (like the Desktop). Follow the steps in the solution below to read the data into R.

#### Solution

I copied and pasted the data, and saved it in a file called `testing.txt` on my computer. I'm assuming that you've given it a similar name. Go back to R Studio. Create a new code chunk containing this:

```
f <- file.choose()
```

Run this code chunk. You'll see a file chooser. Find the file you saved on your computer, and click Open (or OK or whatever you see). This saves what R needs to access the file in the variable `f`. If you want to, you can look at it:

```
f
```

and you'll see what looks like a file path in the appropriate format for your system (Windows, Mac, Linux). To read the data in, you supply the file path to `read_delim` thus:

```
testing2 <- read_delim(f, " ")
```

and then you look at it in the same way as before:

```
testing2
```

```
# A tibble: 6 x 3
      x     y g
  <dbl> <dbl> <chr>
1     1     10 a
2     2     11 b
3     3     14 a
4     4     13 b
5     5     18 a
6     6     21 b
```

Check.



- (g) You might have a spreadsheet on your computer. Create a `.csv` file from it, and use the ideas of the last part to read it into R Studio.

Solution

Open the spreadsheet containing the data you want to read into R. If there are several sheets in the workbook, make sure you're looking at the right one. Select File, Save As, select "CSV" or "comma-separated values" and give it a name. Save the resulting file somewhere.

Then read it into an R data frame. This uses `read_csv`; there are several `read_` functions that read in different types of file, and you need to use an appropriate one. Before that, though, again run

```
f <- file.choose()
```

to find the `.csv` file on your computer, and then

```
cars <- read_csv(f)
```

to read it in. My spreadsheet was

```
cars
```

```
# A tibble: 38 x 6
  Car           MPG Weight Cylinders Horsepower Country
  <chr>      <dbl>  <dbl>    <dbl>    <dbl>  <chr>
1 Buick Skylark  28.4    2.67      4         90 U.S.
2 Dodge Omni    30.9    2.23      4         75 U.S.
3 Mercury Zephyr 20.8    3.07      6         85 U.S.
4 Fiat Strada   37.3    2.13      4         69 Italy
```

5	Peugeot 694 SL	16.2	3.41	6	133 France
6	VW Rabbit	31.9	1.92	4	71 Germany
7	Plymouth Horizon	34.2	2.2	4	70 U.S.
8	Mazda GLC	34.1	1.98	4	65 Japan
9	Buick Estate Wagon	16.9	4.36	8	155 U.S.
10	Audi 5000	20.3	2.83	5	103 Germany

# i 28 more rows

Some information about different types of cars.



My solutions follow:

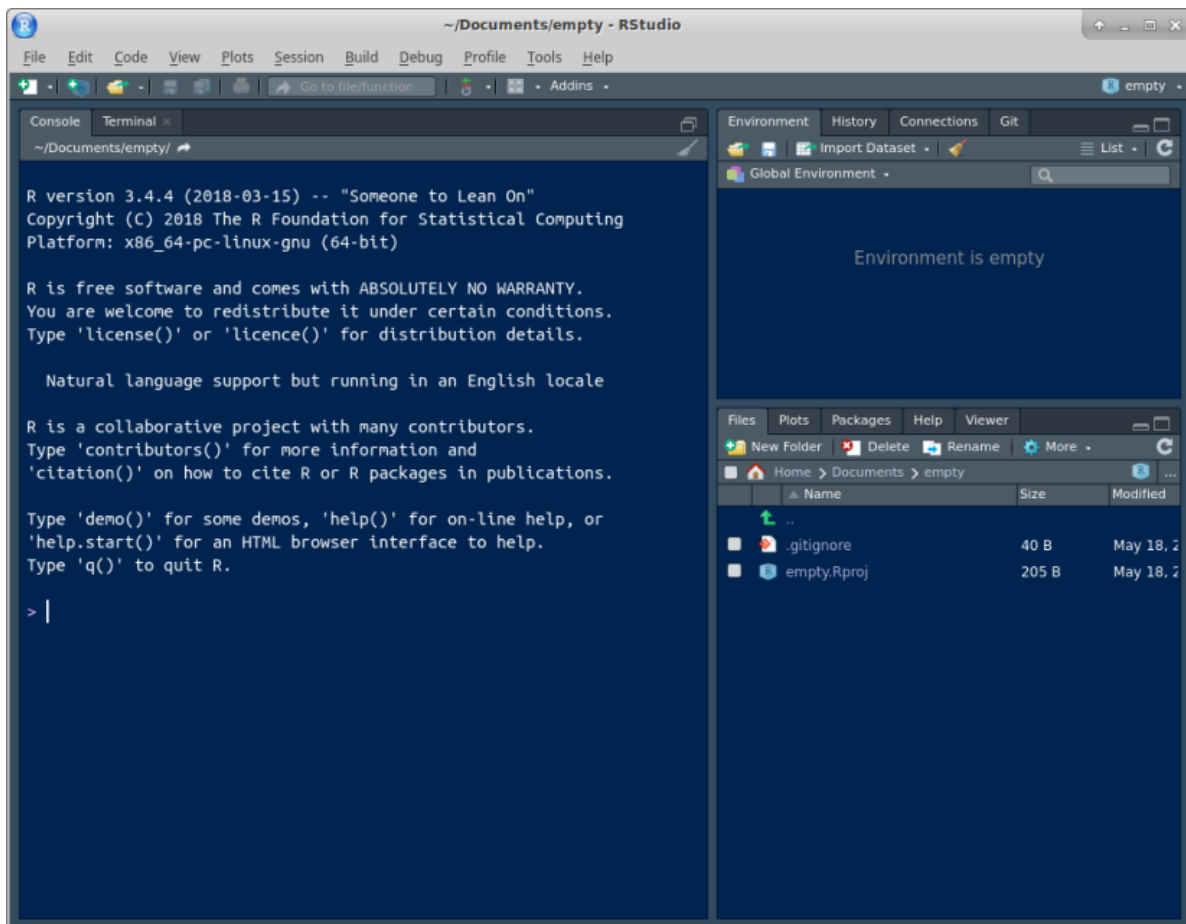
## 1.5 Getting started

This question is to get you started using R.

- (a) Start R Studio Cloud, or the R Studio on Jupyter, in some project. (If you started up a new project in the previous question and are still logged in, use that; if not, create a new project with File, New Project, and New Directory. Then select New Project and give it a name. Click Create Project. This will give you an empty workspace to start from.)

Solution

You ought to see something like this. I have a dark blue background here, which you probably do not.



It won't look exactly like that (for example, the background will probably be white) but there should be one thing on the left half, and at the top right it'll say "Environment is empty". Extra: if you want to tweak things, select Tools (at the top of the screen) and from it Global Options, then click Appearance. You can make the text bigger or smaller via Editor Font Size, and choose a different colour scheme by picking one of the Editor Themes (which previews on the right). My favourite is Tomorrow Night Blue. Click Apply or OK when you have found something you like. (I spend a lot of time in R Studio, and I like having a dark background to be easier on my eyes.)

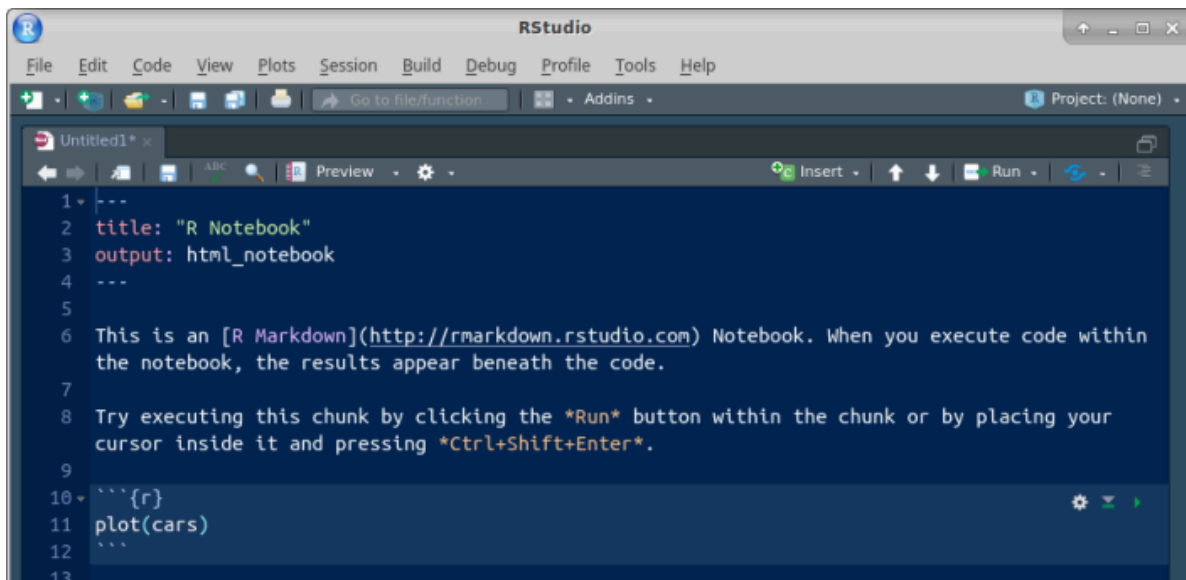
■

- (b) We're going to do some stuff in R here, just to get used to it. First, make an R Notebook by selecting File, New File and R Notebook.

Solution

The first time, you'll be invited to "install some packages" to make the Notebook thing work. Let it do that by clicking Yes. After that, you'll have this:





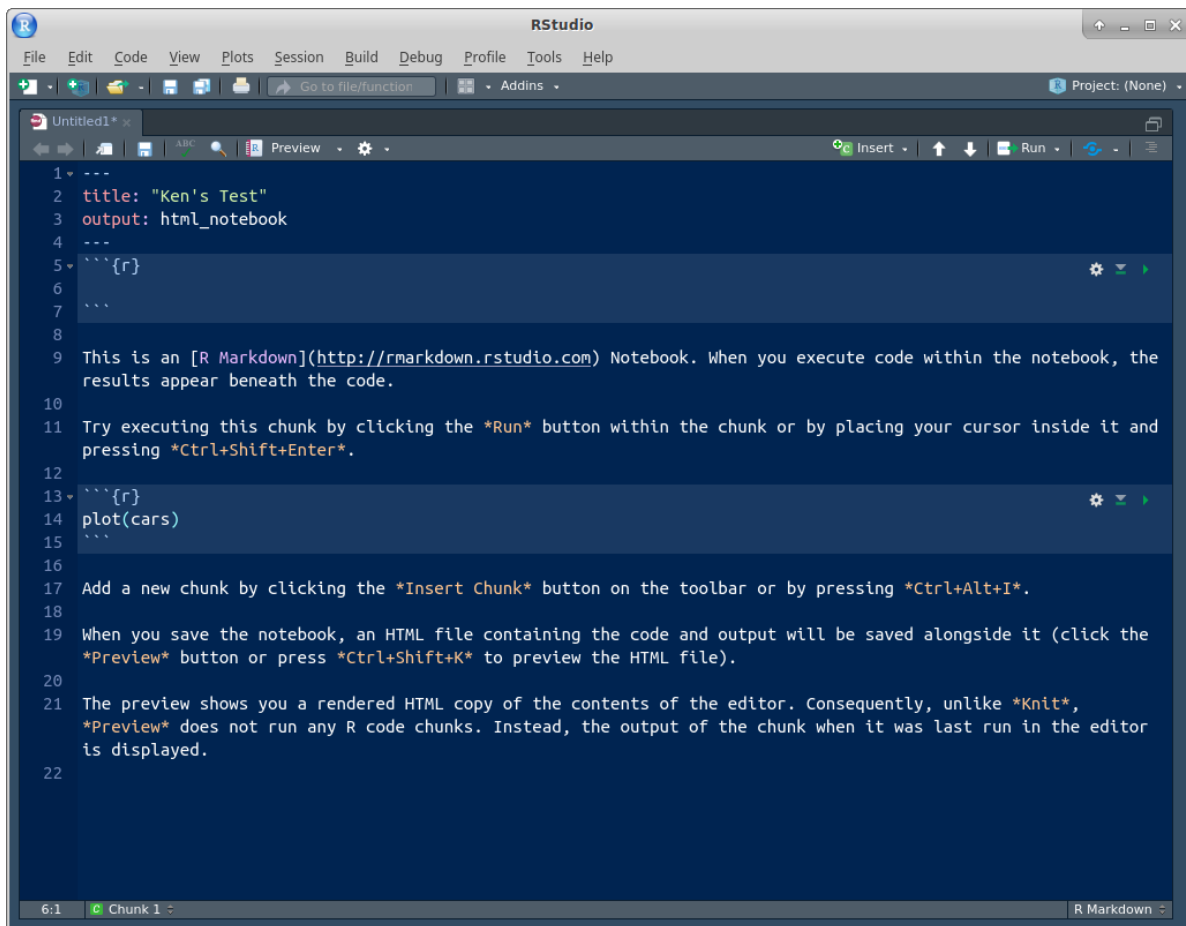
Find the Insert and Run buttons along the top of the R Notebook window. We'll be using them shortly. (The template notebook may or may not be maximized; it doesn't matter either way. You might see all four panes or as few as one. If you want to control that, select View at the top, then Panes, then either Show All Panes or Zoom Source, as you prefer. In the menus, you'll also see keyboard shortcuts for these, which you might find worth learning.)

■

- (c) Change the title to something of your choosing. Then go down to line 5, click on the Insert button and select R. You should see a “code chunk” appear at line 5, which we are going to use in a moment.

Solution

Something like this:



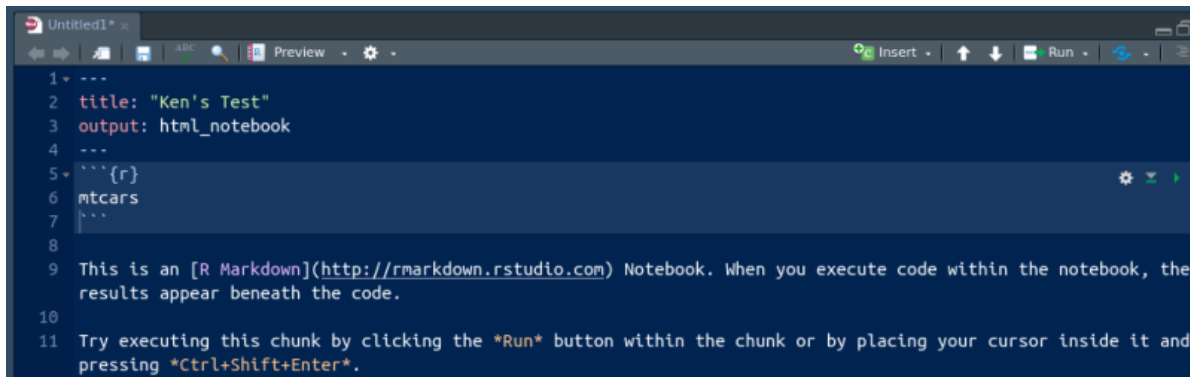
■

(d) Type the line of code shown below into the chunk in the R Notebook:

```
mtcars
```

Solution

What this will do: get hold of a built-in data set with information about some different models of car, and display it.



```
1 ---
2 title: "Ken's Test"
3 output: html_notebook
4 ---
5 ```{r}
6 mtcars
7 ```
8
9 This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute code within the notebook, the
10 results appear beneath the code.
11 Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and
    pressing *Ctrl+Shift+Enter*.
```

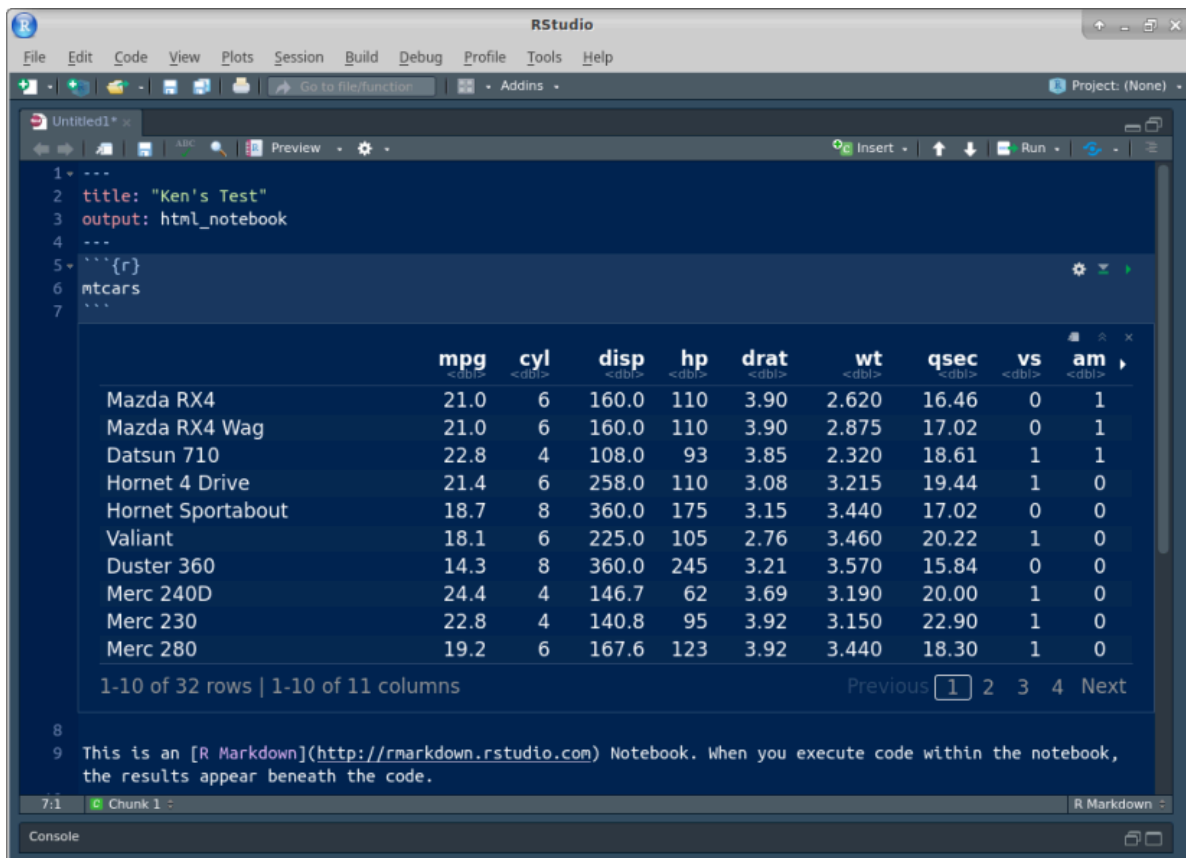
In approximately five seconds, you'll be demonstrating that for yourself.

■

- (e) Run this command. To do that, look at the top right of your code chunk block (shaded in a slightly different colour). You should see a gear symbol, a down arrow and a green “play button”. Click the play button. This will run the code, and show the output below the code chunk.

Solution

Here's what I get (yours will be the same).



This is a rectangular array of rows and columns, with individuals in rows and variables in columns, known as a “data frame”. When you display a data frame in an R Notebook, you see 10 rows and as many columns as will fit on the screen. At the bottom, it says how many rows and columns there are altogether (here 32 rows and 11 columns), and which ones are being displayed. You can see more rows by clicking on Next, and if there are more columns, you’ll see a little arrow next to the rightmost column (as here next to `am`) that you can click on to see more columns. Try it and see. Or if you want to go to a particular collection of rows, click one of the numbers between Previous and Next: 1 is rows 1–10, 2 is rows 11–20, and so on. The column on the left without a header (containing the names of the cars) is called “row names”. These have a funny kind of status, kind of a column and kind of not a column; usually, if we need to use the names, we have to put them in a column first. In future solutions, rather than showing you a screenshot, expect me to show you something like this:

```
mtcars
```

```
# A tibble: 32 x 11
  mpg   cyl  disp    hp  drat    wt   qsec    vs  am gear carb
<dbl> <dbl> <dbl>   <dbl> <dbl>   <dbl> <dbl>   <dbl> <dbl> <dbl> <dbl>
```

```

1  21      6  160    110  3.9   2.62  16.5    0    1    4    4
2  21      6  160    110  3.9   2.88  17.0    0    1    4    4
3  22.8    4  108     93  3.85   2.32  18.6    1    1    4    1
4  21.4    6  258    110  3.08   3.22  19.4    1    0    3    1
5  18.7    8  360    175  3.15   3.44  17.0    0    0    3    2
6  18.1    6  225    105  2.76   3.46  20.2    1    0    3    1
7  14.3    8  360    245  3.21   3.57  15.8    0    0    3    4
8  24.4    4  147.    62  3.69   3.19  20      1    0    4    2
9  22.8    4  141.    95  3.92   3.15  22.9    1    0    4    2
10 19.2    6  168.   123  3.92   3.44  18.3    1    0    4    4
# i 22 more rows

```

The top bit is the code, the bottom bit with the **##** the output. In this kind of display, you only see the first ten rows (by default).

If you don't see the "play button", make sure that what you have really is a code chunk. (I often accidentally delete one of the special characters above or below the code chunk). If you can't figure it out, delete this code chunk and make a new one. Sometimes R Studio gets confused.

On the code chunk, the other symbols are the settings for this chunk (you have the choice to display or not display the code or the output or to not actually run the code). The second one, the down arrow, runs all the chunks prior to this one (but not this one).

The output has its own little buttons. The first one pops the output out into its own window; the second one shows or hides the output, and the third one deletes the output (so that you have to run the chunk again to get it back). Experiment. You can't do much damage here.



- (f) Something a little more interesting: **summary** obtains a summary of whatever you feed it (the five-number summary plus the mean for numerical variables). Obtain this for our data frame. To do this, create a new code chunk below the previous one, type **summary(mtcars)** into the code chunk, and run it.

Solution

This is what you should see:

```

8
9- ***{r}
0 summary(mtcars)
1

```

mpg	cyl	disp	hp	drat	wt
Min. :10.40	Min. :4.000	Min. : 71.1	Min. : 52.0	Min. :2.760	Min. :1.513
1st Qu.:15.43	1st Qu.:4.000	1st Qu.:120.8	1st Qu.: 96.5	1st Qu.:3.080	1st Qu.:2.581
Median :19.20	Median :6.000	Median :196.3	Median :123.0	Median :3.695	Median :3.325
Mean :20.09	Mean :6.188	Mean :230.7	Mean :146.7	Mean :3.597	Mean :3.217
3rd Qu.:22.80	3rd Qu.:8.000	3rd Qu.:326.0	3rd Qu.:180.0	3rd Qu.:3.920	3rd Qu.:3.610
Max. :33.90	Max. :8.000	Max. :472.0	Max. :335.0	Max. :4.930	Max. :5.424

qsec	vs	am	gear	carb
Min. :14.50	Min. :0.0000	Min. :0.0000	Min. :3.000	Min. :1.000
1st Qu.:16.89	1st Qu.:0.0000	1st Qu.:0.0000	1st Qu.:3.000	1st Qu.:2.000
Median :17.71	Median :0.0000	Median :0.0000	Median :4.000	Median :2.000
Mean :17.85	Mean :0.4375	Mean :0.4062	Mean :3.688	Mean :2.812
3rd Qu.:18.90	3rd Qu.:1.0000	3rd Qu.:1.0000	3rd Qu.:4.000	3rd Qu.:4.000
Max. :22.90	Max. :1.0000	Max. :1.0000	Max. :5.000	Max. :8.000

or the other way:

```
summary(mtcars)
```

mpg	cyl	disp	hp
Min. :10.40	Min. :4.000	Min. : 71.1	Min. : 52.0
1st Qu.:15.43	1st Qu.:4.000	1st Qu.:120.8	1st Qu.: 96.5
Median :19.20	Median :6.000	Median :196.3	Median :123.0
Mean :20.09	Mean :6.188	Mean :230.7	Mean :146.7
3rd Qu.:22.80	3rd Qu.:8.000	3rd Qu.:326.0	3rd Qu.:180.0
Max. :33.90	Max. :8.000	Max. :472.0	Max. :335.0

drat	wt	qsec	vs
Min. :2.760	Min. :1.513	Min. :14.50	Min. :0.0000
1st Qu.:3.080	1st Qu.:2.581	1st Qu.:16.89	1st Qu.:0.0000
Median :3.695	Median :3.325	Median :17.71	Median :0.0000
Mean :3.597	Mean :3.217	Mean :17.85	Mean :0.4375
3rd Qu.:3.920	3rd Qu.:3.610	3rd Qu.:18.90	3rd Qu.:1.0000
Max. :4.930	Max. :5.424	Max. :22.90	Max. :1.0000

am	gear	carb
Min. :0.0000	Min. :3.000	Min. :1.000
1st Qu.:0.0000	1st Qu.:3.000	1st Qu.:2.000
Median :0.0000	Median :4.000	Median :2.000
Mean :0.4062	Mean :3.688	Mean :2.812
3rd Qu.:1.0000	3rd Qu.:4.000	3rd Qu.:4.000
Max. :1.0000	Max. :5.000	Max. :8.000

For the gas mileage column `mpg`, the mean is bigger than the median, and the largest value

is unusually large compared with the others, suggesting a distribution that is skewed to the right.

There are 11 numeric (quantitative) variables, so we get the five-number summary plus mean for each one. Categorical variables, if we had any here, would be displayed a different way.

(In case you are wondering, the way without screenshots is obtained by *my* writing a notebook with code chunks and running them, so this output genuinely *is* obtained by running the code you see.)

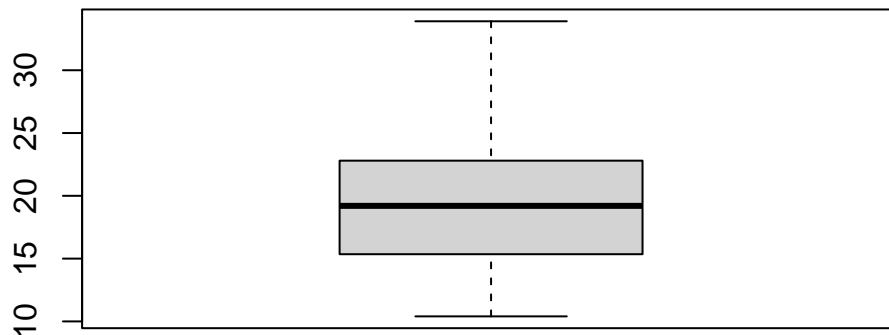
■

- (g) Let's make a boxplot of the gas mileage data. This is a “poor man's boxplot”; we'll see a nicer-looking way later. To do it this way, make another new code chunk, enter the code `boxplot(mtcars$mpg)` into it, and run the chunk.

Solution

This is what you should see:

```
boxplot(mtcars$mpg)
```



The long upper whisker supports our guess from before that the distribution is right-skewed.

■

- (h) Some aesthetics to finish with: delete the template notebook (all the stuff you didn't type below your code chunks and output). Then add some narrative text above and below your code chunks. Above the code chunk is where you say what you are going to do (and maybe why you are doing it), and below is where you say what you conclude from the output you just obtained.

Solution

My complete R Notebook is at <http://ritsokiguess.site/datafiles/a0-notebook-1.Rmd>. Take a look at it. I added one extra thing: my variable names have “backticks” around them. You'll

see the effect of this in a moment. Backtick is on the key to the left of 1 and below Esc on your keyboard, along with a “squiggle” symbol that we’ll be using later in the course.

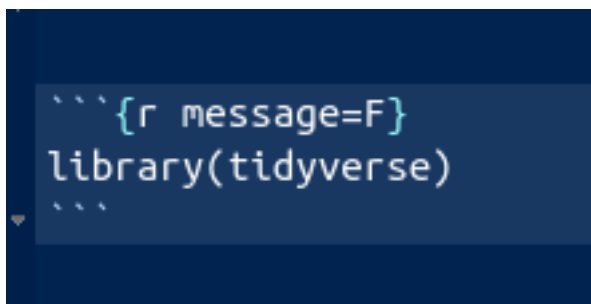


- (i) Save your notebook (the usual way with File and Save). This saves it *on the R Studio Cloud servers* (and not on your computer). This means that when you come back to R Studio Cloud later, even from another device, this notebook will still be available to you. Now click Preview. This produces a pretty HTML version of your notebook.

#### Solution

Note that the HTML document only contains output from the chunks you’ve run in the notebook, so it’s up to you to run them there first.

My HTML document is at <http://ritsokiguess.site/datafiles/a0-notebook-1.nb.html>. Here’s where you see the effect of the backticks: all the variable names are in **typewriter font** so that you can see they are variable names and not something else. If you want to try this notebook out yourself, you have a couple of options: (i) make a new R Notebook on R Studio Cloud and copy-paste the contents of my file (it’s just text), or (ii) download my R Notebook onto your computer, and then upload it to R Studio Cloud. Look in the Files pane bottom right, and next to New Folder you should see Upload. Upload the file from wherever it got saved to when you downloaded it. Extra: if you’re feeling ambitious, click the arrow to the right of Preview and select Knit to Word. The button changes to Knit with a ball of wool beside it. Now, when you “knit” the notebook, you get a Word document directly — look for it in the Files pane. If you want to, you can hand this kind of thing in (on later assignments), but you’ll have to do a little work first: first, find it in your Files list, then click the checkbox to the left of it, then click More (with the gear, on the same line as New Folder and Upload), then select Export (and click Download). This will put a copy in your downloads folder on your computer, and you can open it from there. If you’re feeling extra-ambitious, you can try Knit to PDF. This produces something that looks as if it was written in LaTeX, but actually wasn’t. To make this work, if you have a `library(tidyverse)` line somewhere, as you probably will, find the code chunk it’s in, and make it look like this:



```
```${r message=F}  
library(tidyverse)  
```
```

Then it will work. Extra extra: if you like the keyboard better than the mouse, R Studio has a lot of keyboard shortcuts. Two that are useful now: control-alt-i inserts a code chunk where



the cursor is, and control-shift-enter runs the code chunk that the cursor is in, if it is in one. (Mac users, “command” instead of “control” in both cases.) I use these two a lot.



- (j) Optional extra: practice handing in your previewed R notebook, as if it were an assignment that was worth something. (It is good to get the practice in a low-stakes situation, so that you’ll know what to do next week.)

#### Solution

There are two steps: download the HTML file onto your computer, and then handing it in on Quercus. To download: find the HTML file that you want to download in the Files pane bottom right. There should be two files starting with the same thing, eg. `test1.Rmd`, which is the notebook you wrote, and `test1.nb.html`, which is the previewed version of it, and is the one you want to download. (The `test1` part is the name *you* chose when you saved it.) Click the checkbox to the left of the HTML file. Now click on More above the bottom-right pane. This pops up a menu from which you choose Export. This will pop up another window called Export Files, where you put the name that the file will have on your computer. (I usually leave the name the same.) Click Download. The file will go to your Downloads folder, or wherever things you download off the web go. Now, to hand it in. Open up Quercus at [q.utoronto.ca](http://q.utoronto.ca), log in and navigate to this course. Click Assignments. Click (the title of) Assignment 0. There is a big blue Submit Assignment button top right. Click it. You’ll get a File Upload at the bottom of the screen. Click Choose File and find the HTML file that you downloaded. Click Open (or equivalent on your system). The name of the file should appear next to Choose File. Click Submit Assignment. You’ll see Submitted at the top right. If you want to try this again, you can Re-submit Assignment as many times as you like. (For the real thing, you can use this if you realize you made a mistake in something you submitted. The graders’ instructions, for the real thing, are to grade the *last* file submitted, so in that case you need to make sure that the last thing submitted includes *everything* that you want graded. Here, though, it doesn’t matter.)

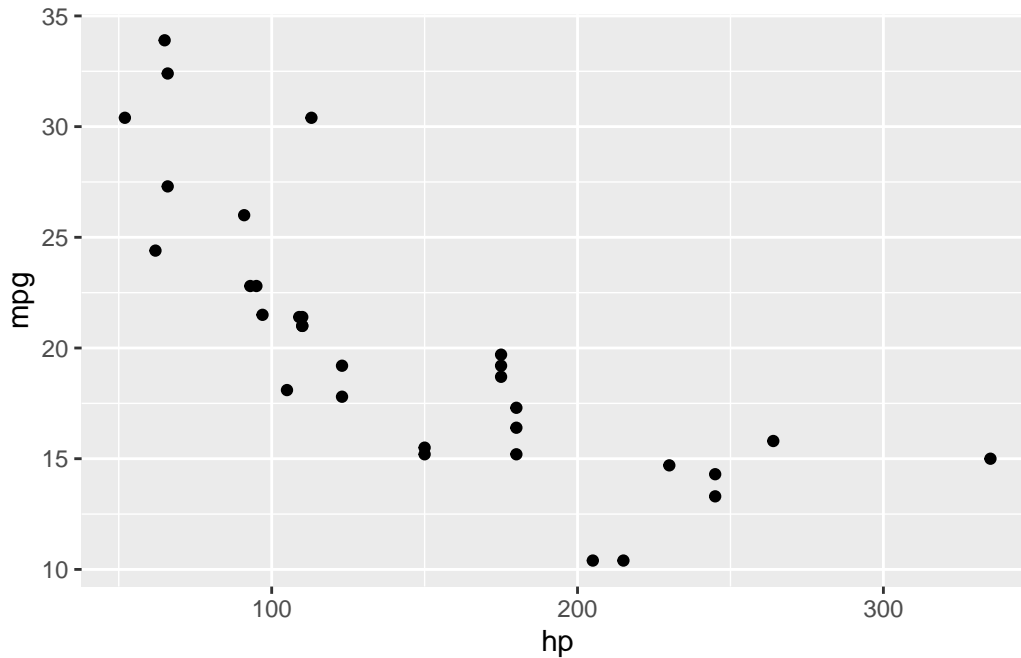


- (k) Optional extra. Something more ambitious: make a scatterplot of gas mileage `mpg`, on the  $y$  axis, against horsepower, `hp`, on the  $x$ -axis.

#### Solution

That goes like this. I’ll explain the steps below.

```
library(tidyverse)
ggplot(mtcars, aes(x=hp, y=mpg))+geom_point()
```



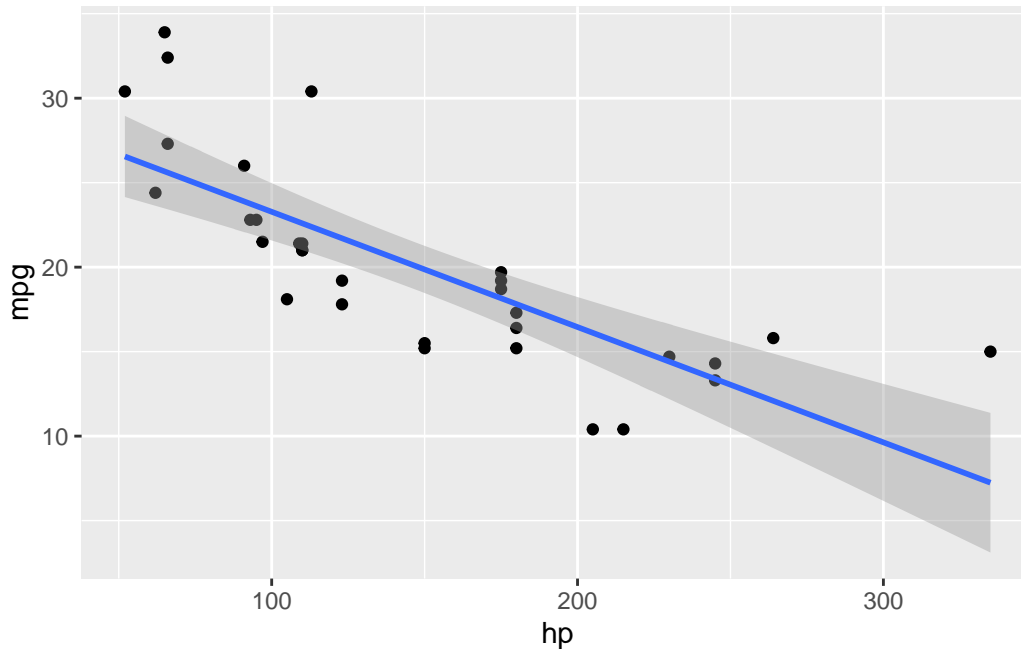
```
$ %$ %$
```

This shows a somewhat downward trend, which is what you'd expect, since a larger `hp` value means a more powerful engine, which will probably consume more gas and get *fewer* miles per gallon. As for the code: to make a `ggplot` plot, as we will shortly see in class, you first need a `ggplot` statement that says what to plot. The first thing in a `ggplot` is a data frame (`mtcars` here), and then the `aes` says that the plot will have `hp` on the *x*-axis and `mpg` on the *y*-axis, taken from the data frame that you specified. That's all of the what-to-plot. The last thing is how to plot it; `geom_point()` says to plot the data values as points.

You might like to add a regression line to the plot. That is a matter of adding this to the end of the plotting command:

```
ggplot(mtcars, aes(x=hp, y=mpg))+geom_point()+geom_smooth(method="lm")
```

```
`geom_smooth()` using formula = 'y ~ x'
```



The line definitely goes downhill. Decide for yourself how well you think a line fits these data.

■

## 1.6 Reading data from a file

In this question, we read a file from the web and do some descriptive statistics and a graph. This is very like what you will be doing on future assignments, so it's good to practice it now.

Take a look at the data file at <http://ritsokiguess.site/datafiles/jumping.txt>. These are measurements on 30 rats that were randomly made to do different amounts of jumping by group (we'll see the details later in the course). The control group did no jumping, and the other groups did “low jumping” and “high jumping”. The first column says which jumping group each rat was in, and the second is the rat's bone density (the experimenters' supposition was that more jumping should go with higher bone density).

(a) What are the two columns of data separated by? (The fancy word is “delimited”).

Solution

Exactly one space. This is true all the way down, as you can check.

■

- (b) Make a new R Notebook. Leave the first four lines, but get rid of the rest of the template document. Start with a code chunk containing `library(tidyverse)`. Run it.

Solution

You will get either the same message as before or nothing. (I got nothing because I had already loaded the `tidyverse` in this session.)

■

- (c) Put the URL of the data file in a variable called `my_url`. Then use `read_delim` to read in the file. (See solutions for how.) `read_delim` reads data files where the data values are always separated by the same single character, here a space. Save the data frame in a variable `rats`.

Solution

Like this:

```
my_url="http://ritsokiguess.site/datafiles/jumping.txt"
rats=read_delim(my_url," ")
```

Rows: 30 Columns: 2

-- Column specification -----

Delimiter: " "

chr (1): group

dbl (1): density

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

The second thing in `read_delim` is the thing that separates the data values. Often when you use `read_delim` it'll be a space.

■

- (d) Take a look at your data frame, by making a new code chunk and putting the data frame's name in it (as we did with `mtcars`).

Solution

```
rats
```

```
# A tibble: 30 x 2
  group    density
  <chr>    <dbl>
1 Control    611
2 Control    621
3 Control    614
4 Control    593
5 Control    593
6 Control    653
7 Control    600
8 Control    554
9 Control    603
10 Control   569
# i 20 more rows
```

There are 30 rows and two columns, as there should be.



(e) Find the mean bone density for rats that did each amount of jumping.

Solution

This is something you'll see a lot: `group_by` followed by `summarize`. Reminder: to get that funny thing with the percent signs (called the “pipe symbol”), type control-shift-M (or equivalent on a Mac):

```
rats %>% group_by(group) %>%
  summarize(m=mean(density))
```

```
# A tibble: 3 x 2
  group    m
  <chr>  <dbl>
1 Control  601.
2 Highjump 639.
3 Lowjump  612.
```

The mean bone density is clearly highest for the high jumping group, and not much different between the low-jumping and control groups.

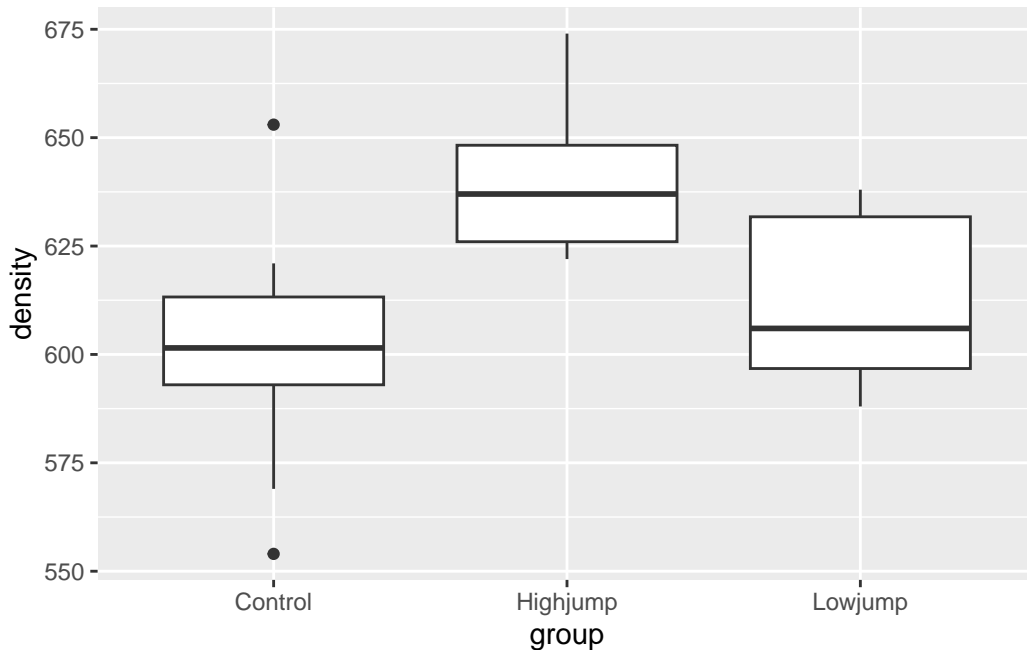


(f) Make a boxplot of bone density for each jumping group.

Solution

On a boxplot, the groups go across and the values go up and down, so the right syntax is this:

```
ggplot(rats,aes(x=group, y=density))+geom_boxplot()
```



Given the amount of variability, the control and low-jump groups are very similar (with the control group having a couple of outliers), but the high-jump group seems to have a consistently higher bone density than the others.

This is more or less in line with what the experimenters were guessing, but it seems that it has to be high jumping to make a difference.

You might recognize that this is the kind of data where we would use analysis of variance, which we will do later on in the course: we are comparing several (here three) groups.



## 1.7 Reading files different ways

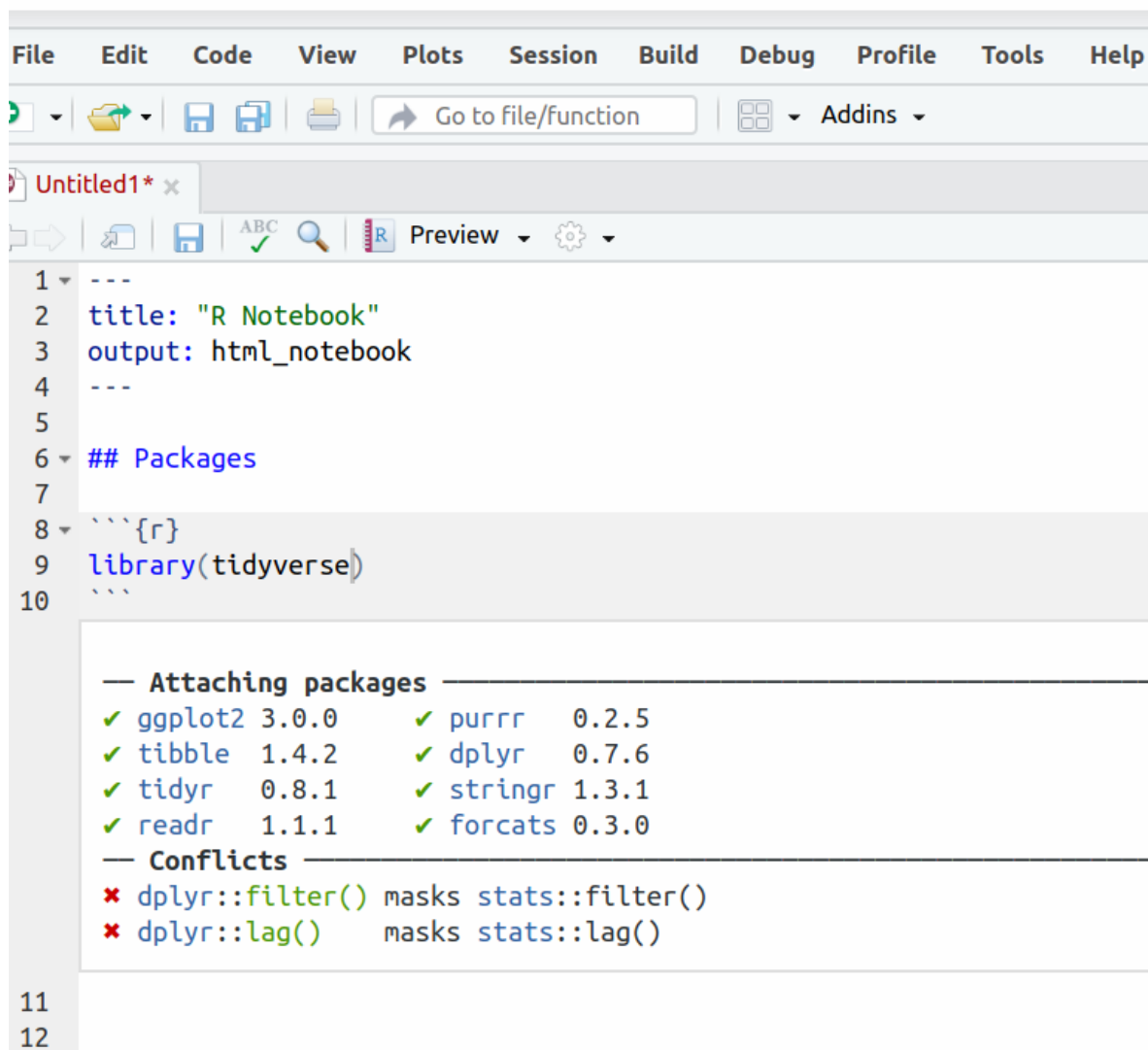
This question is about different ways of reading data files. If you're using R Studio Cloud (online), start at the beginning. If you're using R Studio running on your own computer, start at part (here).

- (a) Log in to R Studio Cloud. Open up a project (or start a new one), and watch the spinning circles for a few minutes. When that's done, create a new R Notebook with File, New File, R Notebook. Delete the "template" notebook, but not the top four lines with `title:` and `output:` in them. Add a code chunk that contains `library(tidyverse)` and run it.

Solution

So far you (with luck) have something that looks like this:

≡ Your Workspace / thing



```
1 ---
2 title: "R Notebook"
3 output: html_notebook
4 ---
5
6 ## Packages
7
8 ```{r}
9 library(tidyverse)
10 ```
```

— Attaching packages —

|                 |                 |
|-----------------|-----------------|
| ✓ ggplot2 3.0.0 | ✓ purrr 0.2.5   |
| ✓ tibble 1.4.2  | ✓ dplyr 0.7.6   |
| ✓ tidyr 0.8.1   | ✓ stringr 1.3.1 |
| ✓ readr 1.1.1   | ✓ forcats 0.3.0 |

— Conflicts —

```
✗ dplyr::filter() masks stats::filter()
✗ dplyr::lag() masks stats::lag()
```

If you have an error rather than that output, you probably need to install the `tidyverse` first. Make another code chunk, containing

```
install.packages("tidyverse")
```

and run it. Wait for it to finish. It may take a while. If it completes successfully (you might see the word DONE at the end), delete that code chunk (you don't need it any more) and try again with the `library(tidyverse)` chunk. It should run properly this time.



- (b) \* The easiest kind of files to read in are ones on the Internet, with a URL address that begins with `http` or `https`. I have a small file at [link](http://ritsokiguess.site/datafiles/testing.txt). Click the link to see it, and keep the tab open for the next part of this question. This is a text file with three things on each line, each separated by exactly one space. Read the data file into a data frame, and display your data frame.

Solution

Data values separated by exactly one space is the kind of thing that `read_delim` reads, so make another code chunk and fill it with this:

```
my_url <- "http://ritsokiguess.site/datafiles/testing.txt"
testing <- read_delim(my_url, " ")
```

Rows: 6 Columns: 3

-- Column specification -----

Delimiter: " "

chr (1): g

dbl (2): x, y

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

```
testing
```

# A tibble: 6 x 3

|   | x     | y     | g     |
|---|-------|-------|-------|
|   | <dbl> | <dbl> | <chr> |
| 1 | 1     | 10    | a     |
| 2 | 2     | 11    | b     |
| 3 | 3     | 14    | a     |



```
4      4      13 b
5      5      18 a
6      6      21 b
```

When you run that, you'll see something like my output. The first part is `read_delim` telling you what it saw in the file: two columns of (whole) numbers and one column of text. The top line of the file is assumed to contain names, which are used as the names of the columns of your data frame. The bottom part of the output, obtained by putting the name of the data frame on a line by itself in your code chunk, is what the data frame actually looks like. You ought to get into the habit of eyeballing it and checking that it looks like the values in the data file.

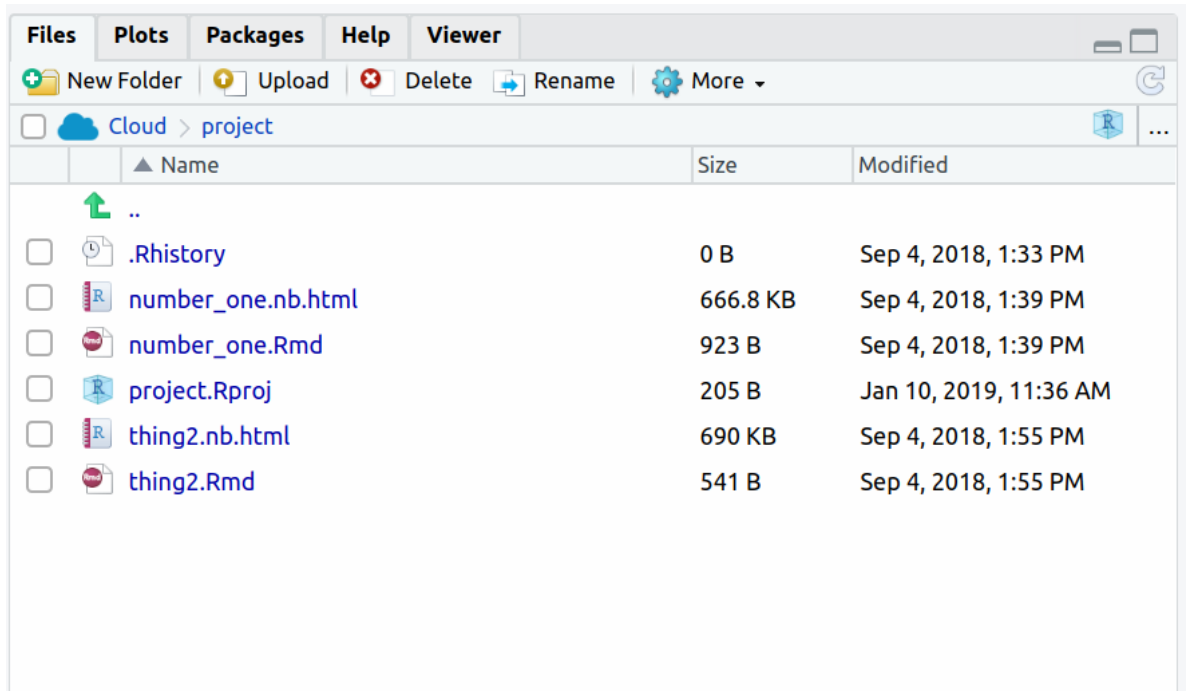
The things on the left side of the equals signs are variables that you are creating in R. You get to choose the names for them. My habit is to use `my_url` for URLs of files that I am going to read in, and (usually) to give my data frames names that say something about what they contain, but this is your choice to make.



- (c) You might have data in a file on your own computer. To read data from such a file, you first have to *upload* it to R Studio Cloud, and then read it from there. To practice this: open a text editor (like Notepad or TextEdit). Go back to the web browser tab containing the data you used in the previous part. Copy the data from there and paste it into the text editor. Save it somewhere on your computer (like the Desktop). Upload that file to R Studio Cloud, read in the data and verify that you get the right thing. (For this last part, see the Solution.)

### Solution

I copied and pasted the data, and saved it in a file called `testing.txt` on my computer. I'm assuming that you've given it a similar name. Then go back to R Studio Cloud. You should have a Files pane bottom right. If you don't see a pane bottom right at all, press Control-Shift-0 to show all the panes. If you see something bottom right but it's not Files (for example a plot), click the Files tab, and you should see a list of things that look like files, like this:



Click the Upload button (next to New Folder), click Choose File. Use the file finder to track down the file you saved on your computer, then click OK. The file should be uploaded to the same folder on R Studio Cloud that your project is, and appear in the Files pane bottom right. To read it in, you supply the file name to `read_delim` thus:

```
testing2 <- read_delim("testing.txt", " ")
```

```
Rows: 6 Columns: 3
```

```
-- Column specification -----
Delimiter: " "
chr (1): g
dbl (2): x, y
```

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

and then you look at it in the same way as before:

```
testing2
```

```
# A tibble: 6 x 3
```

|   | x     | y     | g     |
|---|-------|-------|-------|
|   | <dbl> | <dbl> | <chr> |
| 1 | 1     | 10    | a     |
| 2 | 2     | 11    | b     |
| 3 | 3     | 14    | a     |
| 4 | 4     | 13    | b     |
| 5 | 5     | 18    | a     |
| 6 | 6     | 21    | b     |

Check.



- (d) You might have a spreadsheet on your computer. Create a `.csv` file from it, and use the ideas of the last part to read it into R Studio Cloud.

#### Solution

Open the spreadsheet containing the data you want to read into R. If there are several sheets in the workbook, make sure you're looking at the right one. Select File, Save As, select "CSV" or "comma-separated values" and give it a name. Save the resulting file somewhere.

Then follow the same steps as the previous part to upload it to your project on R Studio Cloud. (If you look at the actual file, it will be plain text with the data values having commas between them, as the name suggests. You can open the file in R Studio Cloud by clicking on it in the Files pane; it should open top left.)

The final step is to read it into an R data frame. This uses `read_csv`; there are several `read_` functions that read in different types of file, and you need to use an appropriate one.

My spreadsheet got saved as `cars.csv`, so:

```
cars <- read_csv("cars.csv")
```

Rows: 38 Columns: 6

-- Column specification -----

Delimiter: ","

chr (2): Car, Country

dbl (4): MPG, Weight, Cylinders, Horsepower

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

```
cars
```

```
# A tibble: 38 x 6
  Car          MPG Weight Cylinders Horsepower Country
  <chr>      <dbl>  <dbl>    <dbl>    <dbl>  <chr>
1 Buick Skylark    28.4   2.67      4        90 U.S.
2 Dodge Omni      30.9   2.23      4        75 U.S.
3 Mercury Zephyr   20.8   3.07      6        85 U.S.
4 Fiat Strada     37.3   2.13      4        69 Italy
5 Peugeot 694 SL   16.2   3.41      6       133 France
6 VW Rabbit       31.9   1.92      4        71 Germany
7 Plymouth Horizon 34.2   2.2       4        70 U.S.
8 Mazda GLC       34.1   1.98      4        65 Japan
9 Buick Estate Wagon 16.9   4.36      8       155 U.S.
10 Audi 5000      20.3   2.83      5       103 Germany
# i 28 more rows
```

Some information about different types of cars.

You are now done with this question.

■

- (e) \* Start here if you downloaded R and R Studio and they are running on your own computer. Open a web browser and point it at [link](http://ritsokiguess.site/datafiles/testing.txt). Click the link to see it, and keep the tab open for the next part of this question. This is a text file with three things on each line, each separated by exactly one space. Read the data file into a data frame, and display your data frame.

Solution

Data values separated by exactly one space is the kind of thing that `read_delim` reads, so make another code chunk and fill it with this:

```
my_url <- "http://ritsokiguess.site/datafiles/testing.txt"
testing <- read_delim(my_url, " ")
```

```
Rows: 6 Columns: 3
```

```
-- Column specification -----
Delimiter: " "
chr (1): g
dbl (2): x, y
```

i Use ``spec()`` to retrieve the full column specification for this data.

i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

```
testing
```

```
# A tibble: 6 x 3
      x     y g
  <dbl> <dbl> <chr>
1     1    10 a
2     2    11 b
3     3    14 a
4     4    13 b
5     5    18 a
6     6    21 b
```

When you run that, you'll see something like my output. The first part is `read_delim` telling you what it saw in the file: two columns of (whole) numbers and one column of text. The top line of the file is assumed to contain names, which are used as the names of the columns of your data frame. The bottom part of the output, obtained by putting the name of the data frame on a line by itself in your code chunk, is what the data frame actually looks like. You ought to get into the habit of eyeballing it and checking that it looks like the values in the data file.

The things on the left side of the equals signs are variables that you are creating in R. You get to choose the names for them. My habit is to use `my_url` for URLs of files that I am going to read in, and (usually) to give my data frames names that say something about what they contain, but this is your choice to make.

(This part is exactly the same whether you are running R Studio Cloud or have R Studio running on your computer. A remote file is obtained in exactly the same way regardless.)



- (f) You might have data in a file on your own computer. To read data from such a file, R has to know where to find it. Each R project lives in a folder, and one way of specifying where a data file is is to give its complete path relative to the folder that R Studio is running its current project in. This is rather complicated, so we will try a simpler way. To set this up, open a text editor (like Notepad or TextEdit). Go back to the web browser tab containing the data you used in the previous part. Copy the data from there and paste it into the text editor. Save it somewhere on your computer (like the Desktop). Follow the steps in the solution below to read the data into R.

#### Solution

I copied and pasted the data, and saved it in a file called `testing.txt` on my computer. I'm assuming that you've given it a similar name. Go back to R Studio. Create a new code chunk containing this:

```
f <- file.choose()
```

Run this code chunk. You'll see a file chooser. Find the file you saved on your computer, and click Open (or OK or whatever you see). This saves what R needs to access the file in the variable `f`. If you want to, you can look at it:

```
f
```

and you'll see what looks like a file path in the appropriate format for your system (Windows, Mac, Linux). To read the data in, you supply the file path to `read_delim` thus:

```
testing2 <- read_delim(f, " ")
```

and then you look at it in the same way as before:

```
testing2
```

```
# A tibble: 6 x 3
      x     y g
  <dbl> <dbl> <chr>
1     1    10 a
2     2    11 b
3     3    14 a
4     4    13 b
5     5    18 a
6     6    21 b
```

Check.



- (g) You might have a spreadsheet on your computer. Create a `.csv` file from it, and use the ideas of the last part to read it into R Studio.

Solution

Open the spreadsheet containing the data you want to read into R. If there are several sheets in the workbook, make sure you're looking at the right one. Select File, Save As, select "CSV" or "comma-separated values" and give it a name. Save the resulting file somewhere.

Then read it into an R data frame. This uses `read_csv`; there are several `read_` functions that read in different types of file, and you need to use an appropriate one. Before that, though, again run

```
f <- file.choose()
```

to find the .csv file on your computer, and then

```
cars <- read_csv(f)
```

to read it in. My spreadsheet was

```
cars
```

```
# A tibble: 38 x 6
```

|    | Car                | MPG   | Weight | Cylinders | Horsepower | Country |
|----|--------------------|-------|--------|-----------|------------|---------|
|    | <chr>              | <dbl> | <dbl>  | <dbl>     | <dbl>      | <chr>   |
| 1  | Buick Skylark      | 28.4  | 2.67   | 4         | 90         | U.S.    |
| 2  | Dodge Omni         | 30.9  | 2.23   | 4         | 75         | U.S.    |
| 3  | Mercury Zephyr     | 20.8  | 3.07   | 6         | 85         | U.S.    |
| 4  | Fiat Strada        | 37.3  | 2.13   | 4         | 69         | Italy   |
| 5  | Peugeot 694 SL     | 16.2  | 3.41   | 6         | 133        | France  |
| 6  | VW Rabbit          | 31.9  | 1.92   | 4         | 71         | Germany |
| 7  | Plymouth Horizon   | 34.2  | 2.2    | 4         | 70         | U.S.    |
| 8  | Mazda GLC          | 34.1  | 1.98   | 4         | 65         | Japan   |
| 9  | Buick Estate Wagon | 16.9  | 4.36   | 8         | 155        | U.S.    |
| 10 | Audi 5000          | 20.3  | 2.83   | 5         | 103        | Germany |

```
# i 28 more rows
```

Some information about different types of cars.

