

# Stat 220 Introduction to Data Science

Deepak Bastola

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# Course overview

Greetings and welcome to Introduction to Data Science! In this course, we will delve into the computational aspects of data analysis, covering topics such as data acquisition, management, and visualization tools. Throughout this course, we will emphasize the principles of data-scientific, reproducible research and dynamic programming, utilizing the R/RStudio ecosystem.

If you have taken Stat 120, 230, or 250 at Carleton, you will find yourself well-equipped to handle the material. However, it is important to refresh your R and R-markdown skills before the start of the class. Specifically, I expect all students to be able to load a data set into R, calculate basic summary statistics, and perform basic exploratory data analysis. In the first week of class, we will delve into Git and GitHub version control, though prior exposure to these topics is not necessary.

## 0.1 Learning Objectives

- Develop research questions that can be answered by data. Import/scrape data into R and reshape it to the form necessary for analysis.
- Manipulate common types of data, including numeric, categorical (factors), text, date-times, geo-location variables in order to provide insight into your data and facilitate analysis.
- Explore data using both graphical and numeric methods to provide insight and uncover relationships/patterns.
- Utilize fundamental programming concepts such as iteration, conditional execution, and functions to streamline your code.
- Build, tune, use, and evaluate basic statistical learning models to uncover clusters and classify observations.
- Draw informed conclusions from your data and communicate your findings using both written and interactive platforms.

## 0.2 Course Requirements



# Set-up Instructions



# Chapter 1

## What is R, RStudio, and RMarkdown?

R is a free and open source statistical programming language that facilitates statistical computation. There are a myriad of application that can be done in R, thanks to a huge online support community and dedicated packages. However, R has no graphical user interface and it has to be run by typing commands into a text interface.

### 1.1 What is RStudio?

RStudio provides graphical interface to R! You can think of RStudio as a graphical front-end to R that that provides extra functionality. The use of the R programming language with the RStudio interface is an essential component of this course.

### 1.2 R Studio Server

The quickest way to get started is to go to <https://maize2.mathcs.carleton.edu>, which opens an R Studio window in your web browser. Once logged in, I recommend that you do the following:

- Step 1: Create a folder for this course where you can save all of your work. In the Files window, click on New Folder.
- Step 2: Click on Tools -> Global Options -> R Markdown. Then uncheck the box that says “Show output inline...”

(It is also possible to download RStudio on your own laptop. Instructions may be found at the end of this document.)

## 1.3 R/RStudio

The use of the R programming language with the RStudio interface is an essential component of this course. You have two options for using RStudio:

- The **server version** of RStudio on the web at (<https://maize2.mathcs.carleton.edu>). The advantage of using the server version is that all of your work will be stored in the cloud, where it is automatically saved and backed up. This means that you can access your work from any computer on campus using a web browser. This server may run slow during peak days/hours. I also recommend you to download a local version of R server in your computer in case of rare outages.
- A **local version** of RStudio installed on your machine. This option is highly recommended due to the computational resources this course demands. Using this version you can only store your files in your local machine. Additionally, we can save our work on GitHub. We will learn how to use GitHub in the beginning of the course. Both R and RStudio are free and open-source. Please make sure that you have recently updated both R and RStudio.

## 1.4 Installing R/RStudio (not needed if you are using the maize server)

Download the latest version of R: <https://cran.r-project.org/> Download the free Rstudio desktop version: <https://www.rstudio.com/products/rstudio/download/>

Use the default download and install options for each. For R, download the “precompiled binary” distribution rather than the source code

### Updating R/RStudio (not needed if you are using the maize server)

If you have used a local version of R/RStudio before and it is still installed on your machine, then you should make sure that you have the most recent versions of each program.

- To check your version of R, run the command `getRversion()` and compare your version to the newest version posted on <https://cran.r-project.org/>. If you need an update, then install the newer version using the installation directions above.

- In RStudio, check for updates with the menu option **Help > Check for updates**. Follow directions if an update is needed.

**\*\* Did it work? (A sanity check after your install/update) \*\***

Do whatever is appropriate for your operating system to launch RStudio. You should get a window similar to the screenshot you see here, but yours will be more boring because you haven't written any code or made any figures yet!

Put your cursor in the pane labeled *Console*, which is where you interact with the live R process. Create a simple object with code like `x <- 2 * 4` (followed by enter or return). Then inspect the `x` object by typing `x` followed by enter or return. You should see the value 8 printed. If this happened, you've succeeded in installing R and RStudio!

## 1.5 What is RMarkdown?

An R Markdown file (.Rmd file) combines R commands and written analyses, which are 'knit' together into an HTML, PDF, or Microsoft Word document.

An R Markdown file contains three essential elements:

- Header: The header (top) of the file contains information like the document title, author, date and your preferred output format (pdf\_document, word\_document, or html\_document).
- Written analysis: You write up your analysis after the header and embed R code where needed. The online help below shows ways to add formatting details like bold words, lists, section labels, etc to your final pdf/word/html document. For example, adding **\*\*** before and after a word will bold that word in your compiled document.
- R chunks: R chunks contain the R commands that you want evaluated. You embed these chunks within your written analysis and they are evaluated when you compile the document.

## 1.6 Install LaTeX (for knitting R Markdown documents to PDF):

You need a Latex compiler to create a pdf document from a R Markdown file. If you use the maize server, you don't need to install anything. If you are using a local RStudio, you should install a Latex compiler. Below are the recommended installers for Windows and Mac:

- MacTeX for Mac (3.2GB)
- MiKTeX for Windows (190MB)
- Alternatively, you can install the `tinytex` R package by running `install.packages("tinytex")` in the console.

## 1.7 Updating R/RStudio (not needed if you are using the maize2 server)

If you have used a local version of R/RStudio before and it is still installed on your machine, then you should make sure that you have the most recent versions of each program.

- To check your version of R, run the command `getRversion()` and compare your version to the newest version posted on <https://cran.r-project.org/>. If you need an update, then install the newer version using the installation directions above.
- In RStudio, check for updates with the menu option **Help > Check for updates**. Follow directions if an update is needed.

## 1.8 Opening a new file

If using Rstudio on your computer, using the **File>Open File** menu to find and open this .Rmd file.

If using Maize Rstudio from your browser:

- In the Files tab, select **Upload** and **Choose File** to find the .Rmd that you downloaded. Click *OK* to upload to your course folder/location in the maize server account.
- Click on the .Rmd file in the appropriate folder to open the file.

## 1.9 Running codes and knitting .Rmd files:

- You can run a line of code by placing your cursor in the line of code and clicking **Run Selected Line(s)**
- You can run an entire chunk by clicking the green triangle on the right side of the code chunk.



- After each small edit or code addition, **Knit** your Markdown. If you wait until the end to Knit, it will be harder to find errors in your work.
- Format output type: You can use any of pdf\_document, html\_document type, or word\_document type.
- **Maize users:** You may also need to allow for “pop-up” in your web browser when knitting documents.

## 1.10 Few More Instructions

The default setting in Rstudio when you are running chunks is that the “output” (numbers, graphs) are shown **inline** within the Markdown Rmd. If you prefer to have your plots appear on the right of the console and not below the chunk, then change the settings as follows:

1. Select Tools > Global Options.
2. Click the R Markdown section and uncheck (if needed) the option Show output inline for all R Markdown documents.
3. Click OK.

Now try running R chunks in the .Rmd file to see the difference. You can recheck this box if you prefer the default setting.

## 1.11 VPN

If you plan to do any work off campus this term, you need to install Carleton’s VPN. This will allow you to access the **maize** server (if needed).

### Installing the GlobalProtect VPN

Follow the directions here to install VPN.



## Chapter 2

# Assignments in Stat 220

### 2.1 Do's and Don't of collaboration for individual assignments

- You *can* discuss homework problems with classmates but you must write up **your own** homework solutions and **do your own work in R (no sharing commands or output)**.
  - **Do not share R commands/code in any way**, including, but not limited to, sending commands via email, slack, text, or showing commands in a shared screen with the intention of showing a classmate your solution to a problem.
  - You **can** share a screen to help troubleshoot a coding problem in R.
- You *can* use the following resources to complete your homework:
  - Carleton faculty (myself, other math or statistics faculty, etc)
  - discussions with classmates (see above) or knowledgeable friends
  - Carleton resources like stats lab assistants
  - student solutions provided in the back of your student textbook or in the student solution manual.
- You *cannot* use any resources other than the ones listed above to complete assignments (homework, reports, etc) for this class. (e.g. you cannot use a friend's old assignments or reports, answers found on the internet, textbook (instructor) solutions manual, etc.)

#### 2.1.1 Examples that violate the academic integrity policy

- sending your .Rmd homework file to another person in the class

- receiving an .Rmd homework file from another person
- sharing a screen and copying code, verbatim, from another person
- sending/receiving R commands
- neglecting to acknowledge classmates with whom you worked with on an assignment

## 2.2 Format and Content

Submit via GitHub (for most assignments) an organized and correctly ordered assignment.

- Content: Good data scientists need to do more than just write code; they should be able to interpret and explain their analyzes.
  - Provide a **written answer** first, followed by any required R code and output.
  - Use **complete sentences** when answering any problem that requires an explanation or overall problem summary.
- When including code:
  - Be sure to show the natural sequence of work needed to answer the problem.
  - Include brief comments explain your code steps.
  - Do not include typos or unnecessary commands/output.
  - Always include code output.
- At the top of each individual assignment **include the names of classmates that you worked with** on all or part of the assignment (but each person must write up their assignment on their own)

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**Disability Accommodations:** Carleton College is committed to providing equitable access to learning opportunities for all students. The Disability Services office (Henry House, 107 Union Street) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations. If you have, or think you may have, a disability (e.g., mental health, attentional, learning, autism spectrum disorders, chronic health, traumatic brain injury and concussions, vision, hearing, mobility, or speech impairments), please contact [disability@carleton.edu](mailto:disability@carleton.edu) or call Sam Thayer ('10), Accessibility Specialist (x4464) or Chris Dallager, Director of Disability Services (x5250) to arrange a confidential discussion regarding equitable access and reasonable accommodations.

**Academic Honesty:** All work that you turn in under your name must follow Carleton's academic integrity policy. The use of textbook solution manuals (physical or online solutions), homework, reports or exams done by past students are not allowed. Look at the College's Writing Across the Curriculum website for additional guidance on plagiarism and how to avoid plagiarism in their writing.



## Chapter 3

# Software in Stat 220

You will work with many .Rmd Markdown files in this course. These include class activities, homework template, project helper files etc. To stay organized, I *strongly* suggest you create a **stat220** folder that contains the following sub-folders:

- **stat220** folder
  - **Assignments:** This folder will contain subfolders for each assignment. Each assignment subfolder (e.g. homework1, homework2, ...) will be a Github connected RStudio project that you will create **once an assignment is posted**.
  - **Content:** This folder should be used to save any non-assignment files (e.g. slides, examples) for this class. You will create this subfolder by creating an RStudio project (see step 5 below).

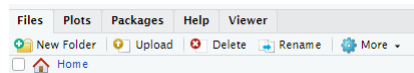
To get started with this organization, follow the steps below.

---

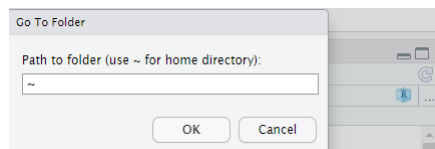
### 3.1 File organization: Using maize

The server (online) version of Rstudio is run from a unix server. You can navigate this file system using unix commands, but I assume that most or all of you will just use Rstudio to access your files on this server.

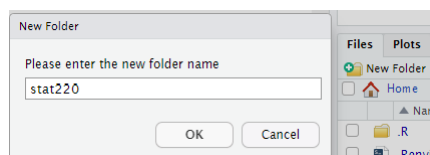
1. In Rstudio, click the **Files** *tab* in the lower right-hand window.  
Note: this is **not** the same as the **File** *menu* option.



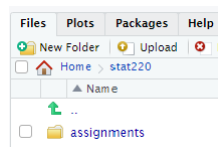
2. Verify that you are in your **HOME** folder (should simply say Home right under the New Folder button). To navigate to your Home folder (if somehow you are not in it), click the ... button (far right side of the **Files** tab) and enter a ~ (tilde) symbol



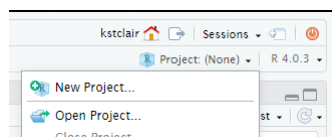
- 3. Click the **New Folder** button and name the folder **stat220**.



- 4. Click on this newly created (empty) **stat220** folder. Within the folder create another **New Folder** and name it **assignments**.

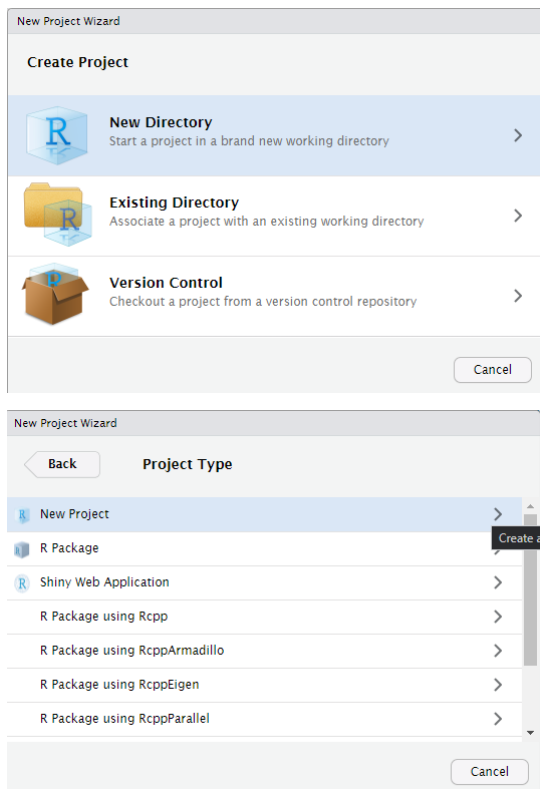


- 5. Within the **stat220** folder, create an **RStudio project** called **content** with the following steps:
  - a. Click the **Project** button in the upper righthand corner of your RStudio window and select **New Project....**

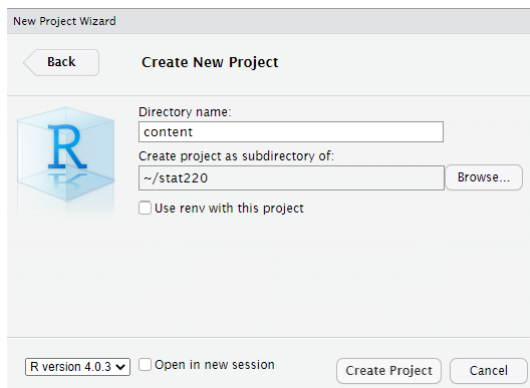


- b. Select **New Directory** and then **New Project**

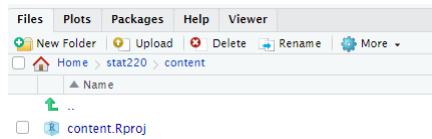




- c. Enter **content** as the **Directory name** and use the **Browse** button to find your **stat220** folder. Then click **Create Project**.



- d. You should now have a new folder called **content** in your **stat220** folder and this folder will contain an RStudio project **.Rproj**. Feel free to add subfolders to this **content** folder (e.g. slides, examples, etc).



**Warning:** Do not create an RStudio project in the main stat220 folder because it is not good practice to have RStudio projects in subfolders of another project (e.g. a project within a project is not recommended).

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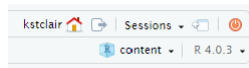
## 3.2 File organization: Using your own Rstudio

Create a folder called **stat220** somewhere on your computer. Within this folder create an **assignments** subfolder. Then complete **step 5** from above to create a **content** RStudio project folder.

---

## 3.3 RStudio projects

Once you've created a project, your R session should be running within that project folder. You can check which project you are in by checking the project name in the upper righthand part of your RStudio window. Here we see the **content** project is open:



Running R from an RStudio project sets your **working directory** to the project folder:

```
> getwd()
[1] "/Accounts/kstclair/stat220/content"
```

This allows for easy file path access to all files related to this project.

To **start** a project, click on the **.Rproj** file or use the **Open Project...** option shown in step 5 above.

---

## 3.4 Best practices (or what not to do)

- Never save files to a lab computer hard drive (e.g. desktop, downloads, etc). They will be erased when you log off.
- Do not use gmail as a file storage system! Avoid emailing yourself files that you created (and saved) on a lab computer. Eventually you will lose work this way.
- Avoid using online versions of google drive and dropbox. Similar to gmail, downloading, editing a doc, then uploading it back to drive/dropbox is another great way to lose work.
- Avoid this and this.

## 3.5 Git and GitHub

Git is version control software that you install locally on your computer. Git is already installed on the maize RStudio server.

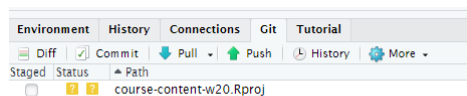
Github is a cloud-based service for hosting git projects. It allows multiple users to share and contribute to projects and it is how you will be submitting homework assignments and projects for this class. More information about Git and Github can also be found in Getting setup with Git and GitHub and Git and Github.

If you are using a local install of R/RStudio, then you will need to install Git.

### Installing Git

Directions for both Windows & Mac here: <http://happygitwithr.com/install-git.html>.

1. If you are using **maize**, then there is nothing you need to install.
2. Windows users should follow Option 1 in 6.2.
3. Mac users can follow Option 1 in 6.3 if comfortable, otherwise follow Option 2
4. Linux users can follow 6.4.



## 3.6 Slack

We will use Slack for all course communication. Sign up for our course Slack team here! You will need to create an account with a username, and log in

to read and post. You can download a standalone Slack application to your Mac, Windows, Linux and/or Android/iOS device. You can control whether you receive notifications on new posts by going to Preferences, as well as decide which ‘channels’ to subscribe to. A ‘channel’ is a discussion thread, which is used to organize communications into topics. You can learn more about Slack features [here](#).

Several channels have been set up for specific parts of the course. Feel free to ask questions anytime. You can browse the available channels in our team by clicking on “Channels” on the left-hand panel.

### 3.7 Acknowledgements

This installation guide is based on the guide from Adam Loy and Katie St. Clair.

## Chapter 4

# GitHub Guide for Students in Stat 220

### 4.1 Overview

If you are using the maize RStudio server, then you can connect to GitHub without any extra software downloads. If you are using RStudio on your computer, then you will need to download Git software (as directed in Software in Stat 220) to use GitHub connected projects. You will use GitHub to submit homework and collaborate on projects.

### 4.2 Getting setup with Git and GitHub

If you are **not** working on the maize RStudio server, then make sure that you have installed all of the software mentioned in Software in Stat 220. In addition, you should install the `usethis` and `gitcreds` R packages.

Everyone needs to connect Git and GitHub by doing the following:

1. Register for account on GitHub (<https://github.com/>). I recommend using a username that incorporates your name (e.g., dbastola) and Carleton email address for your Github account.
2. If you haven't done so already, accept the invite to the class organization DataScienceSpring23. This organization is where all course homework files and project repositories will live.
3. Setup options in Git by running the following code chunk in your console:

```
#install.packages("usethis") # uncomment to install
usethis::use_git_config(user.name = "Jane Doe", user.email = "jane@example.org")
```

changing the first two arguments to your own name and email (this should be the email associated with your GitHub account).

4. In order to push changes to github (i.e. to track changes and submit homework), you will need to prove that you have permission to change a Github repo. This is done with a personal access token (PAT). Note that you will need to install the packages `usethis` and `gitcreds` to do this.

```
usethis::create_github_token()
```

Call ``gitcreds::gitcreds_set()`` to register this token **in** the local Git credentials. It is also a great idea to store this token **in** any password-management software. Opening URL `'https://github.com/settings/tokens/new?scopes=repo,user,gist,workf'`

“Generate token” and store your tokens somewhere safe in your local computer as you will need this again in the future. You can additionally add PAT to your `.Renviro`n file as well. Copy it and paste it into your `.Renviro`n file as system variable `GITHUB_PAT` using

```
usethis::edit_r_environ()
```

Add to the file and save. You can also set the PAT token in R using the following.

```
#install.packages("gitcreds") # uncomment to install
gitcreds::gitcreds_set()
```

You can check that you’ve stored a credential with `gitcreds_get()`:

```
gitcreds::gitcreds_get()
```

You should get something like this:

```
...
#> <gitcreds>
#> protocol: https
#> host      : github.com
#> username: PersonalAccessToken
#> password: <-- hidden -->
...
```

**Treat your PAT token like a password!** For details, follow the step in Section 9.1 on this page to do this: <https://happygitwithr.com/https-pat.html>.

## 4.3 Individual assignments

If you followed the suggestions in the File organization in RStudio page, then you should already have an assignments folder on your computer or maize account.

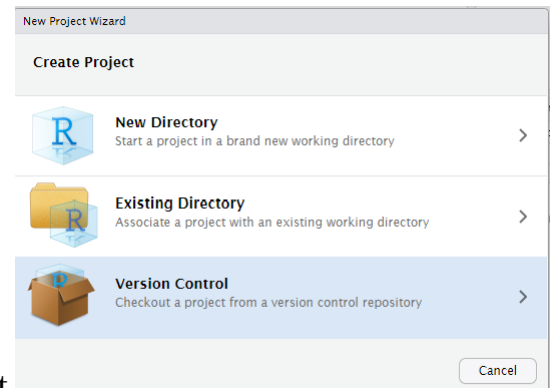
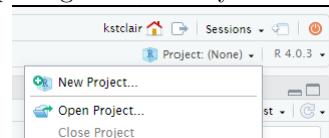
Each new assignment/project will be posted as a repository on GitHub and added directly to your account (within the Stat220 organization). This repository will contain assignment details (README, .Rmd).

### 4.3.1 Creating an individual assignment repo and project

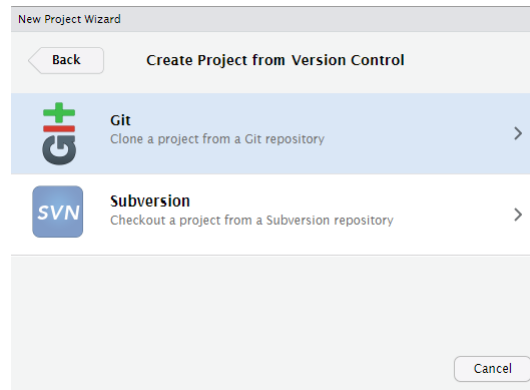
1. Go to our course GitHub organization page (DataScienceSpring23) and find your homework repo, such as `hw1-username` (where your username is attached).
2. Enter the online assignment repository on GitHub. Click the green “Code” button. Most of you should just use the default setting which is to “clone” (copy) using HTTPS. Click the clipboard to the right of the URL to copy the repo location.
3. Now open up RStudio and create a project as follows:

- Click the **Project** button in the upper right corner of your RStudio

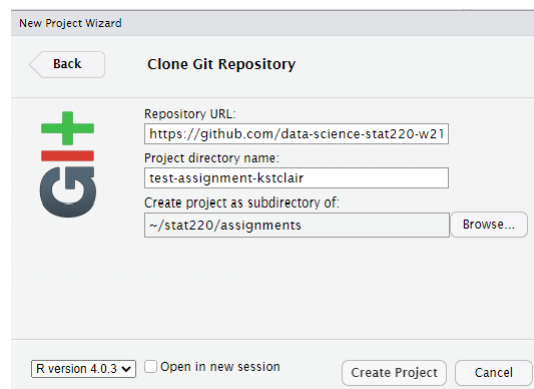
window and select **New Project...**



- Select **Version Control** and then **New Project**



- Paste the link you just copied into the Repository URL box. Leave the Project directory name blank (or keep the auto-filled name). Use the **Browse** button to find your **assignments** folder, then click **Create Project**



### 4.3.2 Working on your assignment

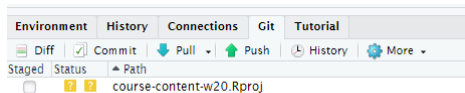
An RStudio project should now open, which will allow you to start working on your homework assignment. You should see the project assignment name in the top right side of RStudio. You will probably see a blank console screen when you open a new project. Look in the **Files** tab for your homework .Rmd file. Click on whatever file you want to edit (probably the .Rmd file) and edit away. Make sure that your current assignment's project is the one open and showing in the upper right project name. To **open** a project, click on the .Rproj file or use the **Open Project...** option available in the upper right project link.



### 4.3.2.1 Commits

After you make changes to the homework assignment, commit them. What are commits you ask? Commits are essentially taking a snapshot of your projects. Commits save this snapshot to your local version of Git (located on your hard drive or the maize server). For example, if I make changes to a code so that it prints “Hello world”, and then commit them with an informative message, I can look at the history of my commits and view the code that I wrote at that time. If I made some more changes to the function that resulted in an error, I could go back to the commit where the code was originally working. This prevents you from creating several versions of your homework (homework-v1, homework-v2, ...) or from trying to remember what your code originally looked like.

You can make commits in the Git tab in RStudio.



Click the **Commit** button in the Git tab. Check the boxes of the files that you want to commit, enter your commit message (briefly state what changes have been made), then hit **Commit**. You can read how to do this in RStudio in more detail here: <http://r-pkgs.had.co.nz/git.html#git-commit>.

Two things about committing.

- You should **commit somewhat frequently**. At minimum, if you’re doing a homework assignment, you should make a commit each time that you’ve finished a question.
- Leave **informative commit messages**. “Added stuff” will not help you if you’re looking at your commit history in a year. A message like “Added initial version of hello-world function” will be more useful.

### 4.3.2.2 Pushing changes to Github

At some point you’ll want to get the updated version of the assignment back onto GitHub, either so that we can help you with your code or so that it can be graded. You will also want to push work frequently when you have a shared GitHub repo for project collaborations (i.e. more than one person is working on a project and code). If you are ready to push, you can again click on the “Up” **Push** arrow in the Git tab or in the Commit pop-up window or in the Git tab (shown above).

To “turn in” an assignment, all you need to do is push all your relevant files to Github by the deadline.

## 4.4 Group work

Collaborative Github assignments are pretty similar to individual assignments.

### 4.4.1 Creating a group/partner assignment repo and project

Go to our course GitHub organization page(DataScienceSpring23) and find the repo for your group, for example if your group name is “team01” the you might find the `mp1-team01` repo. Clone this repo to your computer/maize account using the same steps done for an individual assignment (see steps 2-3).

#### 4.4.1.1 Working with collaborative repos

For group homework, I suggest that only the *recorder* edit the group-homework-x.Rmd file to avoid merge conflicts! Other group members can create a new Markdown doc to run and save commands. Only the recorder needs to **push** changes (answers) to the Github repo and all others can then **pull** these changes (i.e. the final answers) after the HW is submitted.

When you are working together on a Github project, you should commit and push your modifications frequently. You will also need to frequently **pull** updates from Github down to your local version of RStudio. These updates are changes that your teammates have made since your last pull. To pull in changes, click the “Down” **Pull** arrow in the Git tab (shown above).

If you get an error about conflict after pulling or pushing, don’t freak out! This can happen if you edit a file (usually an .Rmd or .R file) in a location that was also changed by a teammate. When this happens you should attempt to fix the **merge conflict**. Take a look at this resource site and try to fix the merge conflict in Rstudio.

## 4.5 Additional resources

- Happy Git and GitHub for the useR
- Rstudio, Git and GitHub
- Interactive learning guide for Git
- GitHub Guides
- Git setup for Windows (video)
- Git setup for Mac (video)
- How to clone, edit, and push homework assignments with GitHub Classroom (video)

## 4.6 Acknowledgements

Most of this content in this guide was taken from <https://github.com/jfiksiel/github-classroom-for-students>, edited for our classroom use by Katie St. Clair.

## 4.7 Reuse

This guide is licensed under the CC BY-NC 3.0 Creative Commons License.



## Chapter 5

# R Markdown Syntax

Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

### 5.0.1 Lists in R Markdown:

You can use asterisk mark to provide emphasis, such as *\*italics\** or **\*\*bold\*\***. You can create lists with a dash:

```
- Item 1
- Item 2
- Item 3
  + Subitem 1
* Item 4
```

to produce

- Item 1
- Item 2
- Item 3
  - Subitem 1
- Item 4

You can embed Latex equations in-line,  $\frac{1}{n} \sum_{i=1}^n x_i$  to produce  $\frac{1}{n} \sum_{i=1}^n x_i$  or in a new line as  $\text{Var}(X) = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$  to produce

$$\text{Var}(X) = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

### 5.0.2 Embed an R code chunk:

Use the following

```
```r
Use back ticks to
create a block of code
```
```

to produce:

```
Use back ticks to
create a block of code
```

You can also evaluate and display the results of R code. Each task can be accomplished in a suitably labeled chunk like the following:

```
summary(cars)
```

| speed   |       | dist    |         |
|---------|-------|---------|---------|
| Min.    | : 4.0 | Min.    | : 2.00  |
| 1st Qu. | :12.0 | 1st Qu. | : 26.00 |
| Median  | :15.0 | Median  | : 36.00 |
| Mean    | :15.4 | Mean    | : 42.98 |
| 3rd Qu. | :19.0 | 3rd Qu. | : 56.00 |
| Max.    | :25.0 | Max.    | :120.00 |

```
fit <- lm(dist ~ speed, data = cars)
fit
```

Call:

```
lm(formula = dist ~ speed, data = cars)
```

Coefficients:

|             |       |
|-------------|-------|
| (Intercept) | speed |
| -17.579     | 3.932 |

### 5.0.3 Including Plots:

You can also embed plots. See Figure 5.1 for example:

```
par(mar = c(0, 1, 0, 1))
pie(
  c(280, 60, 20),
  c('Sky', 'Sunny side of pyramid', 'Shady side of pyramid'),
  col = c('#0292D8', '#F7EA39', '#C4B632'),
  init.angle = -50, border = NA
)
```

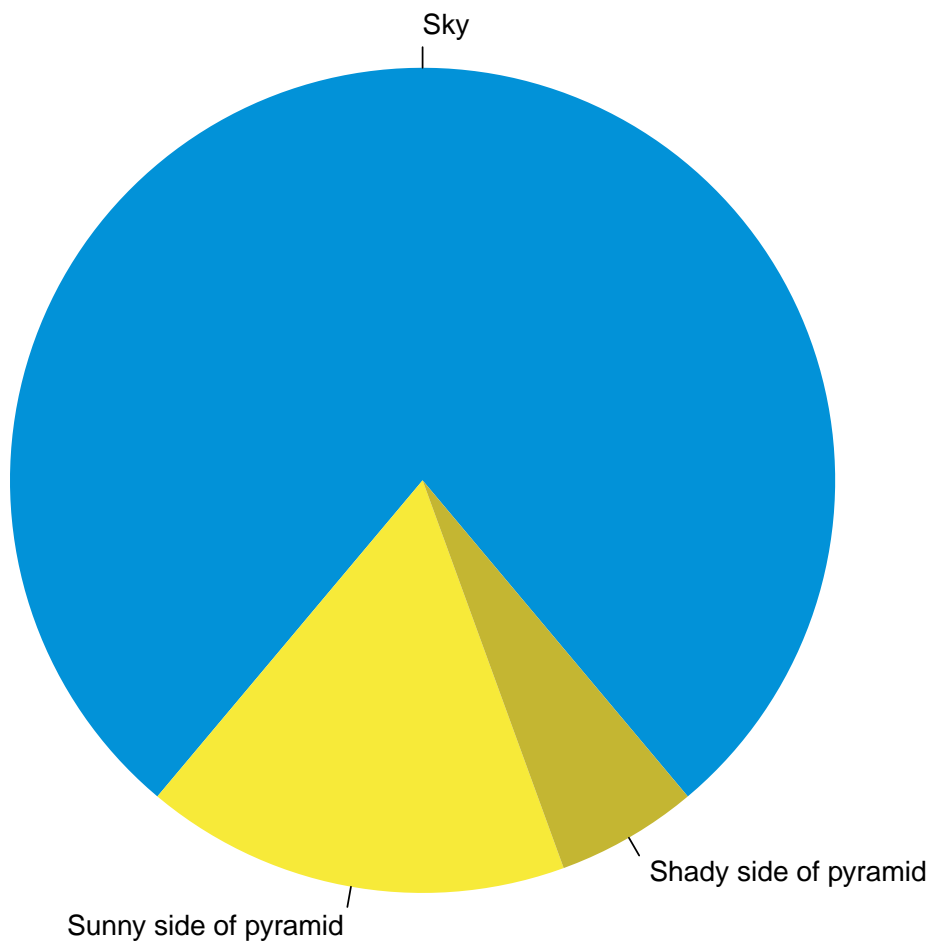


Figure 5.1: A fancy pie chart.

(Credit: Yihui Xie)

### 5.0.4 Read in data files:

```
simple_data <- read.csv("https://deepbas.io/data/simple-1.dat", )
summary(simple_data)
```

```

      initials      state      age
Length:3      Length:3      Min.   :45.0
Class :character Class :character 1st Qu.:47.5
Mode  :character Mode  :character Median :50.0
                                   Mean  :52.0
                                   3rd Qu.:55.5
                                   Max.   :61.0

      time
Length:3
Class :character
Mode  :character
```

```
knitr::kable(simple_data)
```

| initials | state | age | time |
|----------|-------|-----|------|
| vib      | MA    | 61  | 6:01 |
| adc      | TX    | 45  | 5:45 |
| kme      | CT    | 50  | 4:19 |

### 5.0.5 Hide the code:

If we enter the `echo = FALSE` option in the R chunk (see the .Rmd file). This prevents the R code from being printed to your document; you just see the results.

| initials | state | age | time |
|----------|-------|-----|------|
| vib      | MA    | 61  | 6:01 |
| adc      | TX    | 45  | 5:45 |
| kme      | CT    | 50  | 4:19 |



## Class Activities



## Chapter 6

# Class Activity 0

```
# load the required libraries
library(credentials) # to help with PAT access
library(gitcreds)
library(usethis)
```

```
# STEPS INVOLVED TO ESTABLISH GIT CREDENTIALS / PAT
```

```
# Step 1
```

```
# usethis::use_git_config(user.name = "deepbas", user.email = "deepbas99@gmail.com")
```

```
# Step 2
```

```
# usethis::create_github_token()
```

```
# Step 3
```

```
# if this is the second/subsequent iteration start from here
```

```
# gitcreds::gitcreds_set()
```

```
# Verify
```

```
# gitcreds::gitcreds_get()
```

In this worksheet, you will practice creating a GitHub repository using the `usethis::use_github()` function and cloning it back to your local machine using RStudio's menu options.

## 6.1 Tutorial 1: Creating and cloning a Repository starting from Github to RStudio

1. Visit the GitHub website at <https://github.com> and sign in using your GitHub account. If you don't have an account yet, you can create one for free.
2. Once logged in, click on the “+” icon in the top right corner of the webpage, then click on “New repository”.
3. Enter a name for your new repository in the “Repository name” field. You may also provide an optional description.
4. Choose the visibility of your repository by selecting either “Public” or “Private”. Public repositories are visible to anyone, while private repositories are only visible to you and any collaborators you invite.
5. (Optional) Check the box to initialize the repository with a README file.
6. Click on the “Create repository” button to create your new repository.

This will create a new GitHub repository on your Github account. Follow further to clone the repository to your local folder using RStudio.

1. Go to your GitHub repository webpage and click on the green “Code” button. This will display a dropdown menu with a URL for your repository. Click on the clipboard icon to copy the URL to your clipboard.
2. Open RStudio, and from the “File” menu, select “New Project”.
3. In the “New Project” dialog, choose “Version Control”.
4. Select “Git” as the version control system.
5. In the “Repository URL” field, paste the URL that you copied from your GitHub repository webpage.
6. Choose a local directory where you want to clone the repository by clicking on the “Browse” button and navigating to the desired folder on your computer.
7. Click on “Create Project” to clone the GitHub repository to your local computer.

## 6.2 Tutorial 2: Creating a new GitHub repository using usethis R package (RStudio to Github) (Works ONLY on local RStudio)

### 6.2.1 Prerequisites

1. Install the usethis package if you haven't already: `install.packages("usethis")`
2. Make sure you have a GitHub account, and you are logged in.
3. Configure Git with your name and email address if you haven't already. Run the following commands in the R console, replacing "Your Name" and "youremail@example.com" with your information:

```
usethis::use_git_config(user.name = "Your Name", user.email = "youremail@example.com")
```

4. Create a new R project in RStudio by clicking on "File" > "New Project" > "New Directory" > "New Project." Give your project a name and choose a location on your computer to save it. Click "Create Project."
5. Make a new file or copy and paste a .Rmd file that you want to have in your repo and save it to your requirement.
6. In the R console, load the usethis package:

```
library(usethis)
```

7. Initialize a Git repository for your project by running:

```
usethis::use_git()
```

8. Now, let's create a new GitHub repository using the `usethis::use_github()` function. Run the following command:

```
usethis::use_github()
```

9. Follow the instructions in the R console, and your GitHub repository will be created. Note the repository URL, as you will need it in the next activity.

### 6.3 (Optional) Tutorial 3: Creating a new GitHub repository using RStudio's Git terminal

1. Create a new R project in RStudio by clicking on “File” > “New Project” > “New Directory” > “New Project.” Give your project a name and choose a location on your computer to save it. Click “Create Project.”
2. Initialize a Git repository for your project. Click on the “Terminal” tab in the bottom right pane of RStudio and run the following command:

```
git init
```

3. Configure Git with your name and email address if you haven't already. Run the following commands in the terminal, replacing “Your Name” and “youremail@example.com” with your information:

```
git config user.name "Your Name"  
git config user.email "youremail@example.com"
```

4. Commit your project files to the Git repository. Run the following commands in the terminal:

```
git add .  
git commit -m "Initial commit"
```

5. Go to your GitHub account, click on the “+” icon in the upper right corner, and select “New repository.” Give your repository a name (it's recommended to use the same name as your R project), and click “Create repository.”
6. In the “...or push an existing repository from the command line” section of your new GitHub repository, copy the commands under this section. It should look similar to the following (replace and with your GitHub username and repository name):

```
git remote add origin https://github.com/<your-username>/<your-repo-name>.git  
git branch -M main  
git push -u origin main
```

7. Paste the copied commands into the RStudio terminal and execute them. This will link your local Git repository to the remote GitHub repository and push your initial commit to the GitHub repository.

## Chapter 7

# Class Activity 1

The R package `babynames` provides data about the popularity of individual baby names from the US Social Security Administration. Data includes all names used at least 5 times in a year beginning in 1880.

```
#install.packages("babynames") # uncomment to install  
library(babynames)
```

Below is the list for first few cases of baby names.

```
head(babynames)
```

```
# A tibble: 6 x 5  
  year sex  name      n  prop  
  <dbl> <chr> <chr>   <int> <dbl>  
1  1880 F    Mary    7065 0.0724  
2  1880 F    Anna    2604 0.0267  
3  1880 F    Emma    2003 0.0205  
4  1880 F  Elizabeth 1939 0.0199  
5  1880 F   Minnie   1746 0.0179  
6  1880 F  Margaret 1578 0.0162
```

1. How many cases and variables are in the dataset `babynames`?

**Answer:**

```
dim(babynames)
```

```
[1] 1924665      5
```

There are 1924665 cases and 5 variables in the dataset `babynames`.

Let's use the package `tidyverse` to do some exploratory data analysis.

```
#install.packages("tidyverse") # uncomment to install
library(tidyverse)
babynames %>% filter(name=='Aimee')
```

```
# A tibble: 150 x 5
   year sex  name      n      prop
  <dbl> <chr> <chr> <int>   <dbl>
1  1880 F    Aimee     13 0.000133
2  1881 F    Aimee     11 0.000111
3  1882 F    Aimee     13 0.000112
4  1883 F    Aimee     11 0.0000916
5  1884 F    Aimee     15 0.000109
6  1885 F    Aimee     17 0.000120
7  1886 F    Aimee     17 0.000111
8  1887 F    Aimee     18 0.000116
9  1888 F    Aimee     12 0.0000633
10 1889 F    Aimee     16 0.0000846
# ... with 140 more rows
```

```
filtered_names <- babynames %>% filter(name=='Aimee')
```

```
#install.packages("ggplot2") # uncomment to install
library(ggplot2)
```

```
ggplot(data=filtered_names, aes(x=year, y=prop)) +
  geom_line(aes(colour=sex)) +
  xlab('Year') +
  ylab('Prop. of Babies Named Aimee')
```

2. What do you see in the Figure 1? Explain in a few sentences.

[Click for answer](#)

### Answer:

In Figure 1, we can see the proportion of babies named Aimee by year for both males and females. We notice that the name Aimee has been more popular among females than males throughout the years. There is a peak in popularity around the 1970s for female babies, and then the popularity declines.



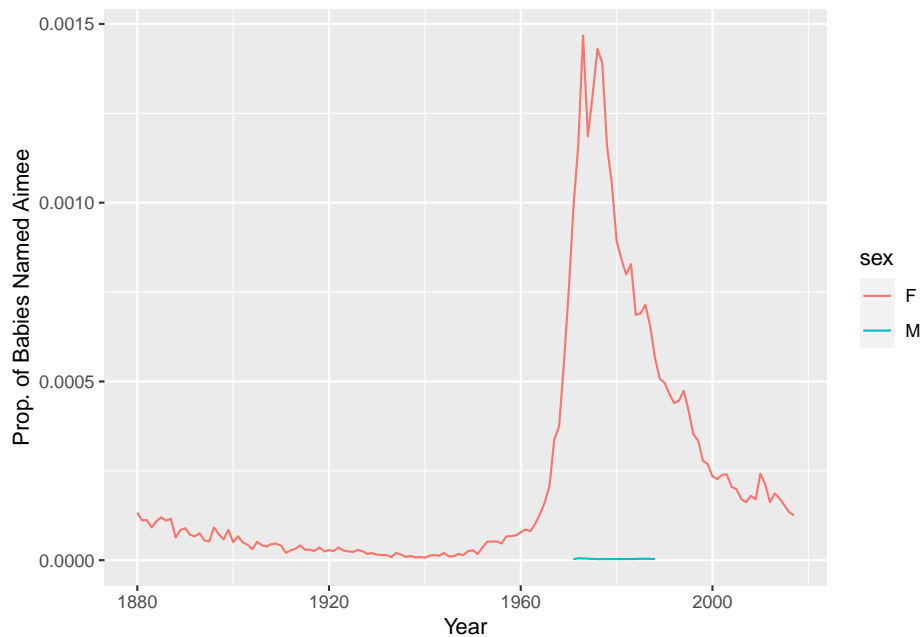


Figure 7.1: A trend chart

3. Repeat question 2 to infer how does the proportion of babies with your first name trend over time. Examine the generated plot and describe the trend of your name's popularity over time. Consider the following points:

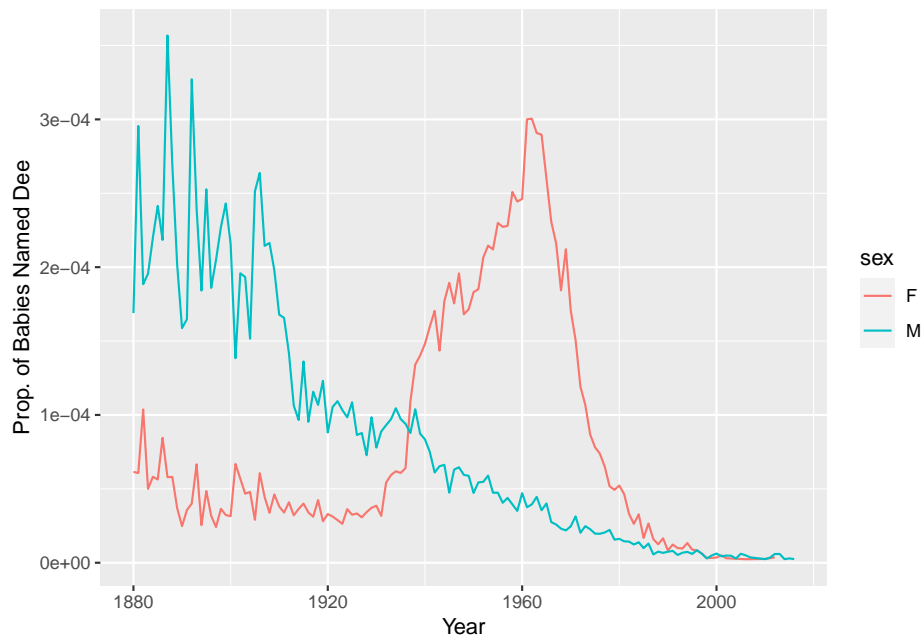
Has the popularity of your name increased, decreased, or remained stable over the years? Is there a noticeable difference in popularity between sexes? Are there any interesting patterns or trends, such as sudden increases or decreases in popularity?

**Answer:** Answers will vary.

```
# Replace 'YourName' with your first name
your_name <- "Dee"

your_name_data <- babynames %>% filter(name == your_name)

ggplot(data=your_name_data, aes(x=year, y=prop)) +
  geom_line(aes(colour=sex)) +
  xlab('Year') +
  ylab(paste('Prop. of Babies Named', your_name))
```



4. Compare the popularity of your first name with a randomly chosen name from the dataset. Examine the generated plot and compare the popularity of your first name with the randomly chosen name. Consider the following points:

Are there differences in popularity trends between the two names? Is one name consistently more popular than the other, or do their popularity levels change over time? Are there any interesting patterns or trends in the data, such as periods of rapid increase or decrease in popularity?

**Answer** Answers will vary

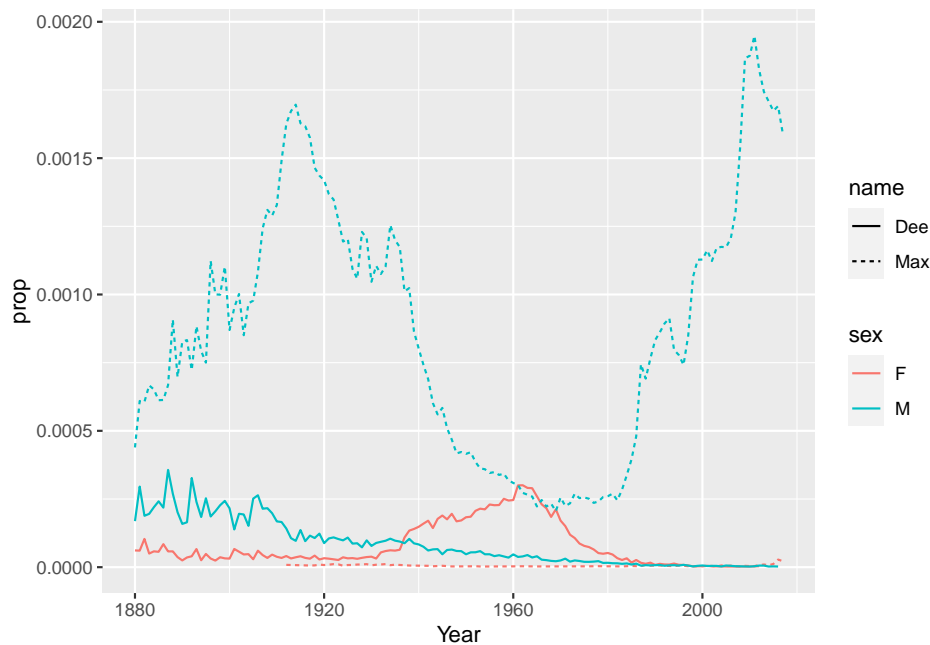
```
# Replace 'YourName' with your first name
your_name_data <- babynames %>% filter(name == 'Dee')

# Replace 'RandomName' with a randomly chosen name from the dataset
random_name_data <- babynames %>% filter(name == 'Max')

# Combine the two datasets
combined_data <- bind_rows(your_name_data, random_name_data)

# Plot the data
ggplot(data=combined_data, aes(x=year, y=prop)) +
```

```
geom_line(aes(colour=sex, linetype=name)) +  
xlab('Year')
```



## 7.1 Extras (optional)

### 7.1.1 Part 1: Setting Working Directory and Loading Data

1. Set your working directory to a folder on your computer where you would like to save your R scripts and data files.

```
# Replace 'your_directory_path' with the path to your desired folder  
# setwd("your_directory_path")
```

2. Load the mtcars dataset which comes preloaded with R. This dataset consists of various car features and their corresponding miles per gallon (mpg) values.

```
data(mtcars)  
head(mtcars)
```

|                   | mpg  | cyl | disp | hp  | drat | wt    | qsec  | vs | am |
|-------------------|------|-----|------|-----|------|-------|-------|----|----|
| Mazda RX4         | 21.0 | 6   | 160  | 110 | 3.90 | 2.620 | 16.46 | 0  | 1  |
| Mazda RX4 Wag     | 21.0 | 6   | 160  | 110 | 3.90 | 2.875 | 17.02 | 0  | 1  |
| Datsun 710        | 22.8 | 4   | 108  | 93  | 3.85 | 2.320 | 18.61 | 1  | 1  |
| Hornet 4 Drive    | 21.4 | 6   | 258  | 110 | 3.08 | 3.215 | 19.44 | 1  | 0  |
| Hornet Sportabout | 18.7 | 8   | 360  | 175 | 3.15 | 3.440 | 17.02 | 0  | 0  |
| Valiant           | 18.1 | 6   | 225  | 105 | 2.76 | 3.460 | 20.22 | 1  | 0  |

|                   | gear | carb |
|-------------------|------|------|
| Mazda RX4         | 4    | 4    |
| Mazda RX4 Wag     | 4    | 4    |
| Datsun 710        | 4    | 1    |
| Hornet 4 Drive    | 3    | 1    |
| Hornet Sportabout | 3    | 2    |
| Valiant           | 3    | 1    |

### 7.1.2 Part 2: Downloading Packages

1. Install the “tidyverse” package, which is a collection of useful R packages for data manipulation, exploration, and visualization.

```
# Uncomment the line below to install the package
# install.packages("tidyverse")
```

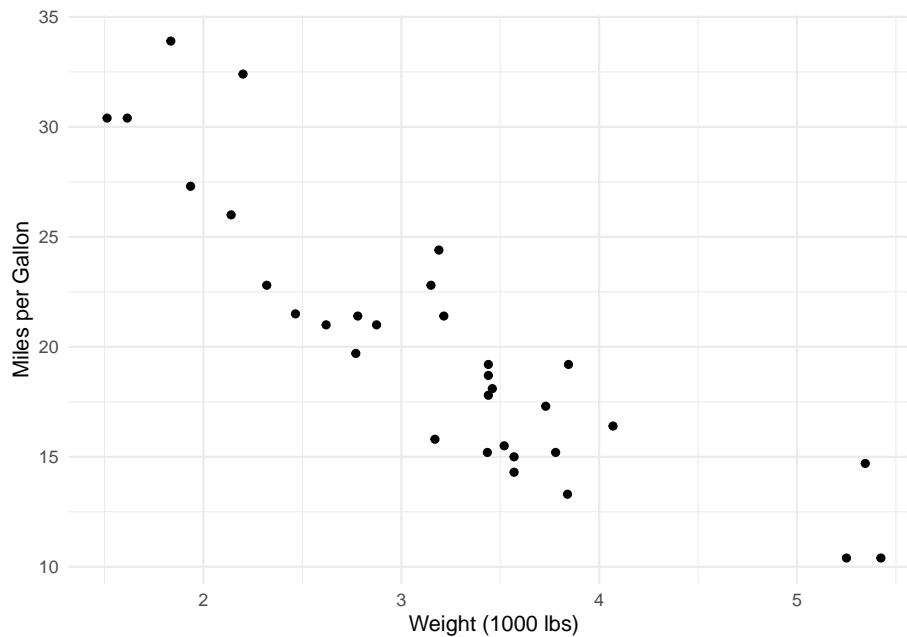
2. Load the “tidyverse” package into your R session.

```
library(tidyverse)
```

### 7.1.3 Part 3: Creating and Compiling an R Markdown File

1. Create a new R Markdown file in RStudio by clicking on “File” > “New File” > “R Markdown...”. Save the file in your working directory.
2. Add the following code to your R Markdown file to create a scatter plot of the mtcars dataset, showing the relationship between miles per gallon (mpg) and the weight of the car (wt).

```
# Create a scatter plot
ggplot(data = mtcars, aes(x = wt, y = mpg)) +
  geom_point() +
  xlab("Weight (1000 lbs)") +
  ylab("Miles per Gallon") +
  theme_minimal()
```



3. Knit your R Markdown file to create an output document. Click the “Knit” button at the top of the RStudio script editor, and choose the output format you prefer (e.g., HTML, PDF, or Word).

## 7.2 Questions

### 7.2.1 1. How does the weight of a car (wt) affect its miles per gallon (mpg) based on the scatter plot you created?

[Click for answer](#)

**Answer:**

Based on the scatter plot, there appears to be a negative relationship between the weight of a car (wt) and its miles per gallon (mpg). As the weight of a car increases, its fuel efficiency (mpg) tends to decrease.

### 7.2.2 2. What is the importance of setting a working directory in R?

Click for answer

**Answer:**

Setting a working directory in R is important because it determines the default location where R will read from or write to when loading or saving files. This makes it easier to keep your files organized and ensures that your R scripts can access the necessary files without needing to specify the full file paths. It also simplifies sharing your R projects with others since the file paths within your scripts will be relative to the working directory.

### 7.2.3 3. Explain the role of R Markdown in creating reproducible research documents.

Click for answer

**Answer:**

R Markdown plays a crucial role in creating reproducible research documents by allowing you to combine text, code, and output (e.g., tables, figures) within a single document. This integration of narrative, data, and results makes it easier to document your data analysis process, ensuring that others can easily understand, reproduce, and build upon your work. R Markdown also supports various output formats (e.g., HTML, PDF, Word) to make it easy to share your research findings with others.

## Chapter 8

# Class Activity 2

Let's practice some common data assignments and manipulations in R.

- a. Create a vector of all integers from 4 to 10, and save it as **a1**.

Click for answer

```
a1 <- 4:10  
a1
```

```
[1] 4 5 6 7 8 9 10
```

- b. Create a vector of *even* integers from 4 to 10, and save it as **a2**.

Click for answer

```
a2 <- seq(4, 10, by=2)  
a2
```

```
[1] 4 6 8 10
```

- c. What do you get when you add **a1** to **a2**?

Click for answer

```
a1_plus_a2 <- a1 + a2  
a1_plus_a2
```

```
[1] 8 11 14 17 12 15 18
```

**Answer:** When you add `a1` to `a2`, you get a vector containing the element-wise sum: 8, 11, 14, 17, 12, 15, 18.

d. What does the command `sum(a1)` do?

Click for answer

```
sum_a1 <- sum(a1)
sum_a1
```

```
[1] 49
```

**Answer:** The command `sum(a1)` calculates the sum of all elements in the vector `a1`. In this case, it returns 49.

e. What does the command `length(a1)` do?

Click for answer

```
length_a1 <- length(a1)
length_a1
```

```
[1] 7
```

**Answer:** The command `length(a1)` returns the number of elements in the vector `a1`. In this case, there are 7 elements.

f. Use the `sum` and `length` commands to calculate the average of the values in `a1`.

Click for answer

```
average_a1 <- sum(a1) / length(a1)
average_a1
```

```
[1] 7
```

**Answer:** The average of the values in `a1` is 7.



## 8.1 Extras (Optional)

In this worksheet, you will learn how to use the `write_csv()` function from the `readr` package to save a data object from your R session to a file in your working directory.

First, let's load the necessary package.

```
library(readr)
```

Suppose we have a simple data frame called `my_data`, with three columns: `Name`, `Age`, and `City`.

```
my_data <- data.frame(Name = c("Alice", "Bob", "Charlie", "David"),
                      Age = c(25, 30, 22, 35),
                      City = c("New York", "Los Angeles", "Chicago", "San Francisco"))
my_data
```

|   | Name    | Age | City          |
|---|---------|-----|---------------|
| 1 | Alice   | 25  | New York      |
| 2 | Bob     | 30  | Los Angeles   |
| 3 | Charlie | 22  | Chicago       |
| 4 | David   | 35  | San Francisco |

Now we want to save this data frame as a CSV file in our working directory. To do this, we will use the `write_csv()` function. The first argument is the data object you want to save, and the second argument is the file name (including the `.csv` extension).

```
write_csv(my_data, "my_data.csv")
```

This command will save `my_data` as a file called `my_data.csv` in your working directory.

**Question 1:** What is the purpose of the `write_csv()` function?

Click for answer

**Answer:**

The `write_csv()` function is used to save a data object from an R session to a CSV file in your working directory.

**Question 2:** How do you save a data frame called `my_data` as a file named "example\_data.csv"?

```
# Your code here
```

Click for answer

**Answer:**

```
write_csv(my_data, "example_data.csv")
```

**Question 3:** If you want to save a data frame called `students` as a file named “student\_data.csv”, what would be the appropriate command?

```
# Your code here
```

Click for answer

**Answer:**

```
write_csv(students, "student_data.csv")
```

## Chapter 9

### Class Activity 3

```
# some interesting data objects
x <- c(3,6,9,5,10)
x.mat <- cbind(x, 2*x)
x.df <- data.frame(x=x,double.x=x*2)
my.list <- list(myVec=x, myDf=x.df, myString=c("hi","bye"))
```

#### 9.1 Question 1: data types

- What data type is x?

Click for answer

*Answer:*

```
# code
typeof(x)
```

```
[1] "double"
```

- What data type is c(x, x/2)?

Click for answer

*Answer:*

```
# code
typeof(c(x, x/2))
```

```
[1] "double"
```

- What data type is `c(x,NA)`? What data type is `c(x,"NA")`?

Click for answer

*Answer:*

```
# code
typeof(c(x, NA))
```

```
[1] "double"
```

```
typeof(c(x, "NA"))
```

```
[1] "character"
```

## 9.2 Question 2: Subsetting and coercion

- How can we reverse the order of entries in `x`?

Click for answer

*Answer:*

```
# code
rev(x)
```

```
[1] 10  5  9  6  3
```

```
x[length(x):1]
```

```
[1] 10  5  9  6  3
```

- What does `which(x < 5)` equal?

Click for answer

*Answer:*

```
# code  
which(x<5)
```

```
[1] 1
```

- Extract the element of x that corresponds to the location in the preceding question.

Click for answer

Answer:

```
# code  
x[which(x<5)]
```

```
[1] 3
```

- What does `sum(c(TRUE,FALSE,TRUE,FALSE))` equal?

Click for answer

Answer:

```
# code  
sum(c(TRUE,FALSE,TRUE,FALSE))
```

```
[1] 2
```

- What does `sum(x[c(TRUE,FALSE,TRUE,FALSE)])` equal?

Click for answer

Answer:

```
# code  
sum(x[c(TRUE,FALSE,TRUE,FALSE, TRUE)])
```

```
[1] 22
```

- What does `sum(x < 5)` equal?

Click for answer

Answer:

```
# code  
sum(x < 5)
```

```
[1] 1
```

- What does `sum(x[x < 5])` equal?

Click for answer

*Answer:*

```
# code  
sum(x[x < 5])
```

```
[1] 3
```

- Why `dim(x.mat[1:2,1])` return NULL while `dim(x.mat[1:2,1:2])` returns a dimension?

Click for answer

*Answer:*

```
# code  
dim(x.mat[1:2,1])
```

```
NULL
```

```
dim(x.mat[1:2,1:2])
```

```
[1] 2 2
```

### 9.3 Question 3: Lists

- Using `my.list`, show three ways to write one command that gives the 3rd entry of variable `x` in data frame `myDf`

Click for answer

*Answer:*

```
# code  
my.list[[1]][3]
```

```
[1] 9
```

```
my.list[["myVec"]][3]
```

```
[1] 9
```

```
my.list[1]$myVec[3]
```

```
[1] 9
```

```
my.list$myVec[3]
```

```
[1] 9
```

- What class of object does the command `my.list[3]` return?

Click for answer

*Answer:*

```
# code  
class(my.list[3])
```

```
[1] "list"
```

- What class of object does the command `my.list[[3]]` return?

Click for answer

*Answer:*

```
# code  
class(my.list[[3]])
```

```
[1] "character"
```

- What class of object does the command `unlist(my.list)` return? Why are all the entries **characters**?

Click for answer

*Answer:*

```
# code  
class(unlist(my.list))
```

```
[1] "character"
```



## Chapter 10

# Class Activity 4

```
# Load the required libraries
library(tidyverse)
library(ggplot2)
library(datasauRus)
```

### 10.1 Your turn 1

This worksheet will guide you through creating various plots using the **ggplot2** package in R. We will be using the **datasaurus\_dozen** dataset from the **datasauRus** package for demonstration purposes. The dataset contains 13 different datasets, and we'll use them to create a variety of plots.

#### 10.1.1 Scatterplot

- a. Run the following code.

```
ggplot(data = dino_data, mapping = aes(x = x, y = y)) +
  geom_point()
```



- b. You *must* remember to put the aesthetic mappings in the `aes()` function! What happens if you forget?

[Click for answer](#)

*Answer:*

If you forget to put the aesthetic mappings inside the `aes()` function, `ggplot2` will not be able to map the variables to the aesthetics correctly, and you might encounter an error or unexpected behavior in your plot.

```
# Add a layer and see what happens
ggplot(data = dino_data , x = x , y = y)
```

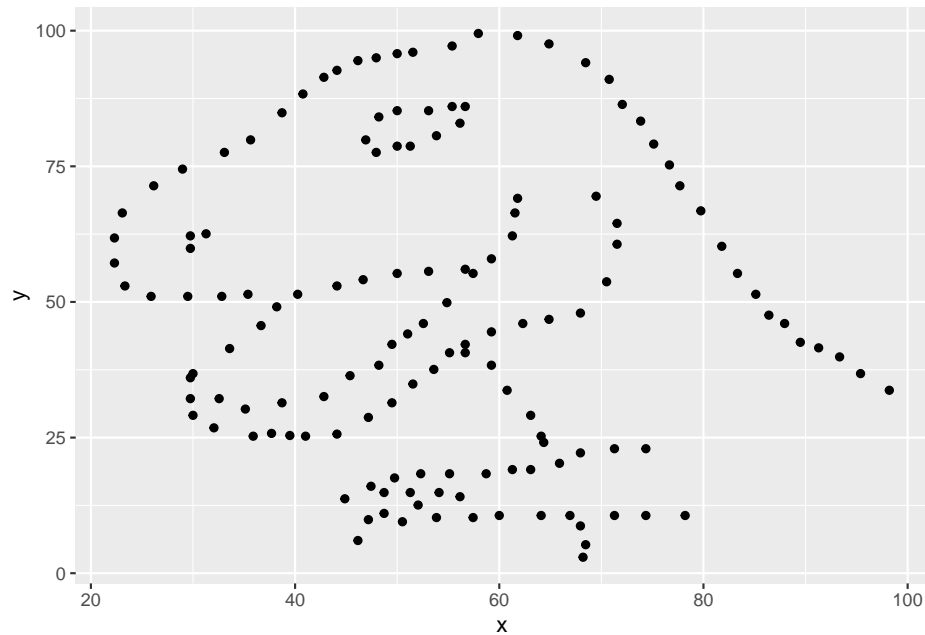


- c. The aesthetic mappings can be specified in the geom layer if you prefer, instead of the main `ggplot()` call. Give it a try:

Click for answer

*Answer:*

```
# Rebuild the scatterplot with your aesthetic mapping in the geom layer
ggplot(data = dino_data) +
  geom_point(aes(x = x, y = y))
```



### 10.1.2 Bar Plot

In this problem, we'll explore creating a bar plot using the `datasaurus_dozen` dataset.

- Create a new data frame containing the count of observations in each dataset.

[Click for answer](#)

*Answer:*

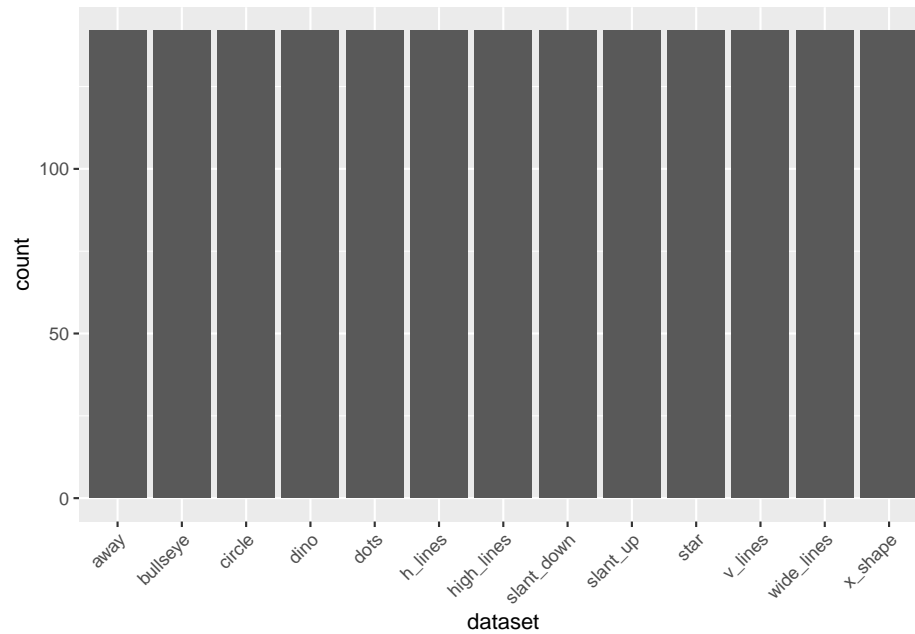
```
dataset_counts <- datasaurus_dozen %>%  
  group_by(dataset) %>%  
  summarise(count = n())
```

- Create a bar plot showing the number of observations in each dataset.

[Click for answer](#)

*Answer:*

```
ggplot(data = dataset_counts, aes(x = dataset, y = count)) +  
  geom_bar(stat = "identity") +  
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



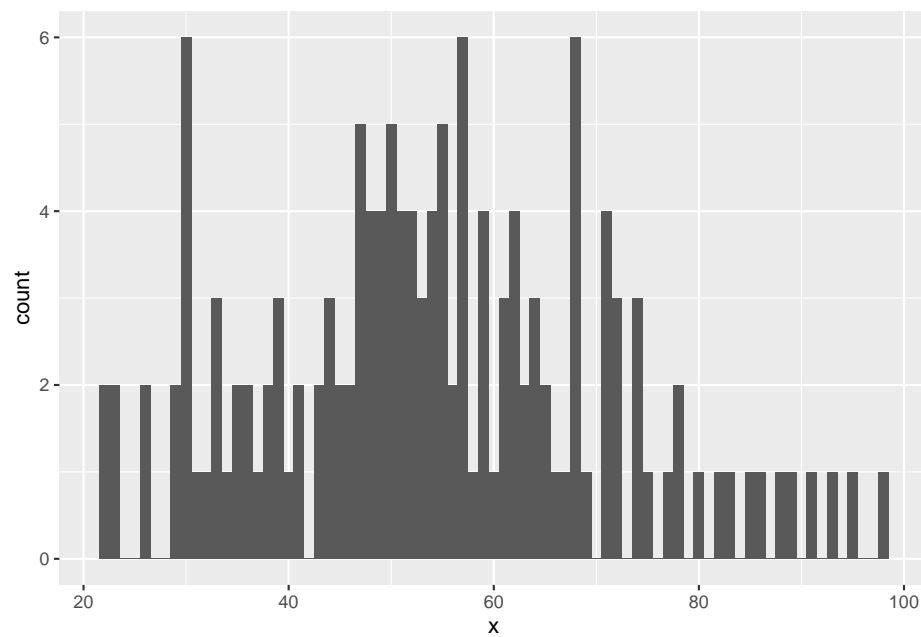
### 10.1.3 Histogram

- Create a histogram of the `x` variable for the `dino` dataset.

Click for answer

*Answer:*

```
ggplot(data = dino_data, aes(x = x)) +  
  geom_histogram(binwidth = 1)
```



b. Overlay a density curve on the histogram.

[Click for answer](#)

*Answer:*

```
ggplot(data = dino_data, aes(x = x)) +
  geom_histogram(aes(y = after_stat(density)), binwidth = 2, fill = "lightblue") +
  geom_density(color = "red")
```



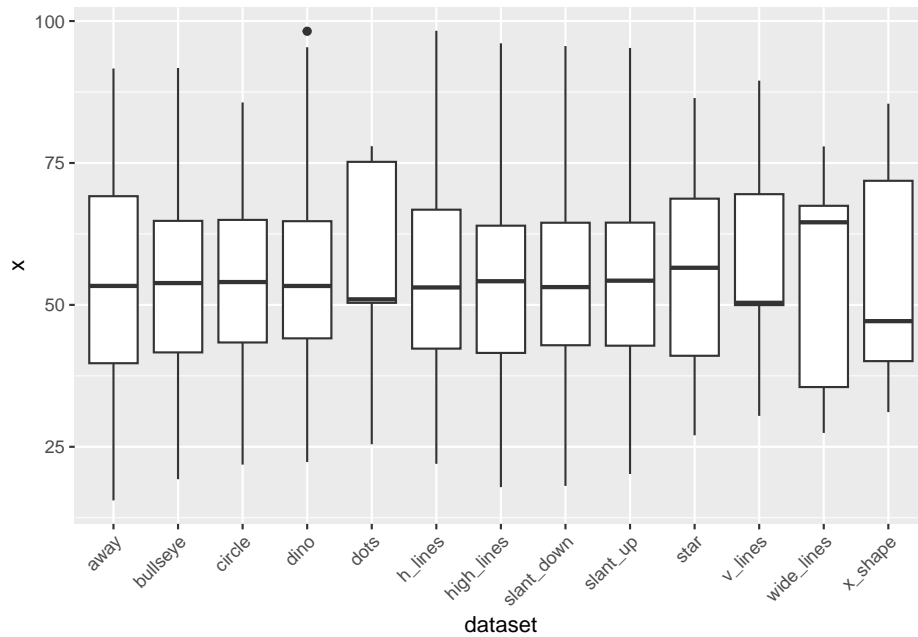
### 10.1.4 Boxplot

- a. Create a boxplot of the x variable for each dataset in `datasaurus_dozen`.

Click for answer

*Answer:*

```
ggplot(data = datasaurus_dozen, aes(x = dataset, y = x)) +  
  geom_boxplot() +  
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



### 10.1.5 Faceting

[Click for answer](#)

*Answer:*

- Create a scatterplot of `x` vs. `y` for each dataset in `datasaurus_dozen` using `facet_wrap()`.

```
ggplot(data = datasaurus_dozen, aes(x = x, y = y)) +  
  geom_point() +  
  facet_wrap(~ dataset) +  
  theme_minimal()
```





### 10.1.6 Variable Transformation

- a. The scatterplot of the `dino` dataset without any transformations is given below.

Click for answer

Answer:

```
ggplot(data = dino_data, aes(x = x, y = y)) +
  geom_point() +
  theme_minimal() -> p1
```

- b. Now, apply the square root transformation to both the `x` and `y` axes using the `scale_x_sqrt()` and `scale_y_sqrt()` functions in the `dino` dataset.

Click for answer

Answer:

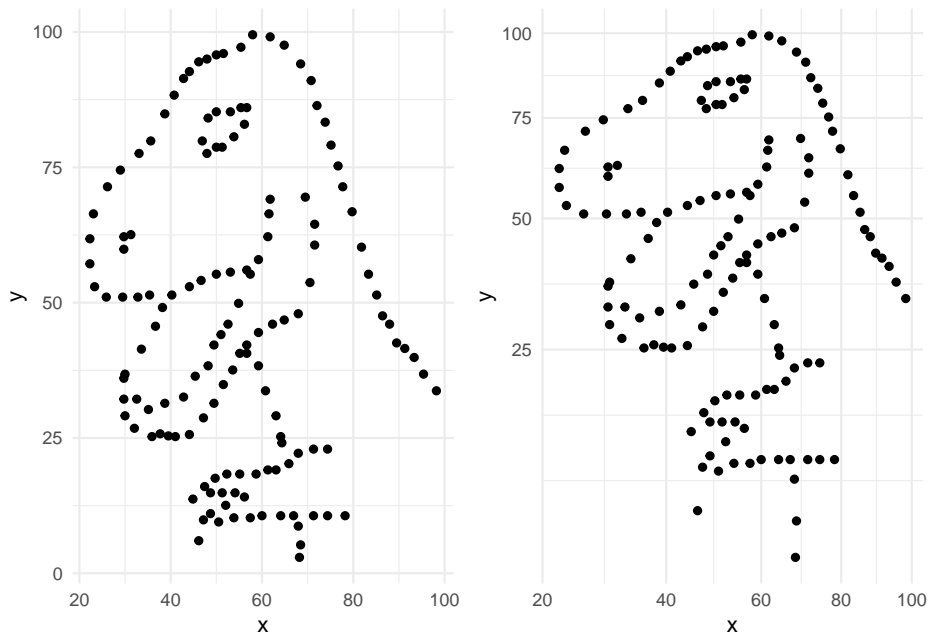
```
ggplot(data = dino_data, aes(x = x, y = y)) +
  geom_point() +
  scale_x_sqrt() +
  scale_y_sqrt() +
  theme_minimal() -> p2
```

- c. Finally, use `grid.arrange()` function from `gridExtra` package to plot the above two plots side-by-side. Which plot do you prefer and why?

Click for answer

*Answer:* The second plot is more revealing of a dinosaur than the first plot.

```
library(gridExtra)
grid.arrange(p1, p2, nrow = 1)
```



### 10.1.7 (Optional) Lne plot

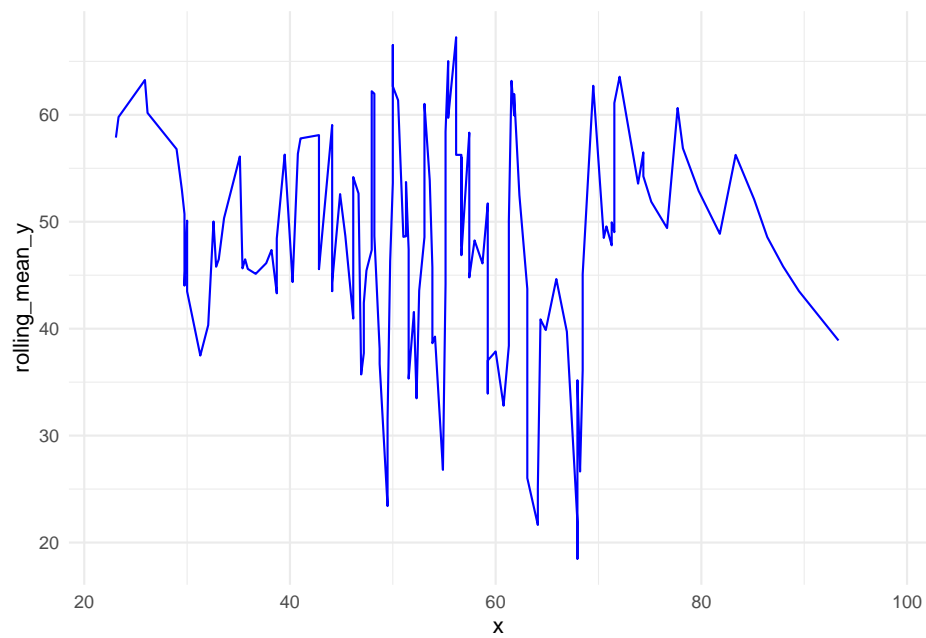
- a. Create a line plot of the `x` variable over the `y` variable for the `dino` dataset. To make it more interesting, let's first calculate the rolling mean of the `y` variable.

Click for answer

*Answer:*

```
dino_data <- dino_data %>%
  arrange(x) %>%
  mutate(rolling_mean_y = zoo::rollmean(y, k = 5, fill = NA))
```

```
# Line plot  
ggplot(data = dino_data, aes(x = x, y = rolling_mean_y)) +  
  geom_line(color = "blue") +  
  theme_minimal()
```





# Chapter 11

## Class Activity 5

```
# Load the required libraries
library(tidyverse)
library(ggplot2)
library(ggthemes)
```

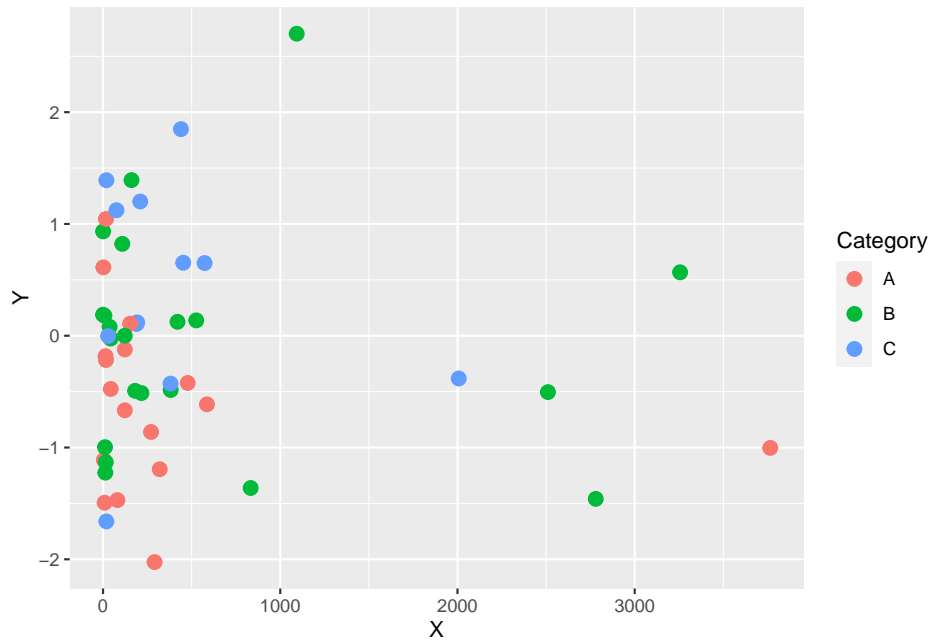
### 11.1 Problem 1: Changing color and shape scales

In this problem, you will learn about the effects of changing colors, scales, and shapes in `ggplot2` for both gradient and discrete color choices. You will be given a series of questions and examples to enhance your understanding. Consider the following scatter plot

```
# Generate sample data
set.seed(42)
data <- data.frame(
  Category = factor(sample(1:3, 50, replace = TRUE), labels = c("A", "B", "C")),
  X = 10 ^ rnorm(50, mean = 2, sd = 1),
  Y = rnorm(50, mean = 0, sd = 1)
)

p <- ggplot(data, aes(x = X, y = Y, color = Category)) +
  geom_point(size = 3)

p
```

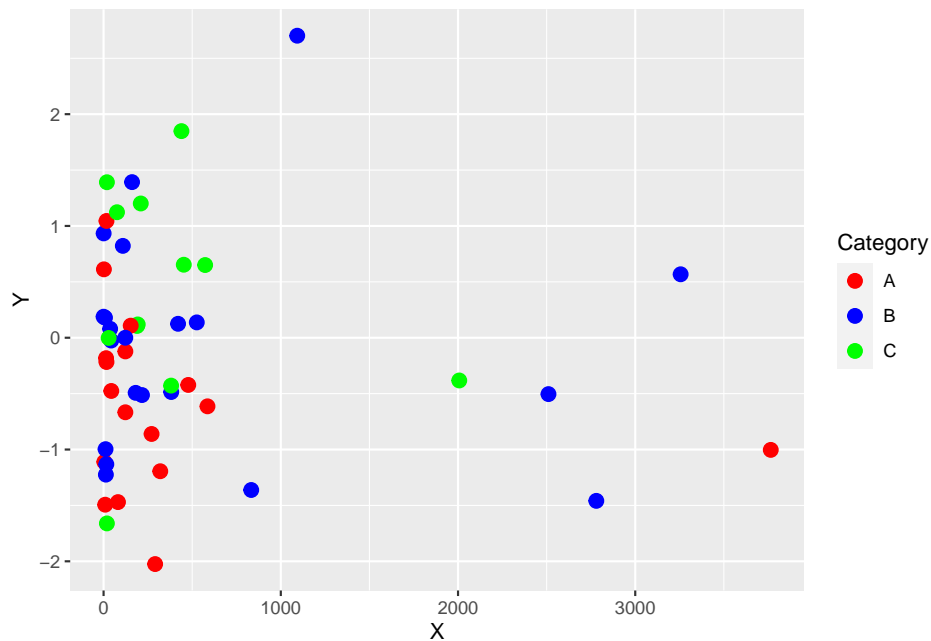


- a. Modify the scatter plot to use custom colors for each category using `scale_color_manual()`. What is the effect of changing the colors on the plot's readability?

Click for answer

*Answer:* Changing colors using `scale_color_manual()` allows for better distinction between categories and enhances the plot's readability.

```
p <- ggplot(data, aes(x = X, y = Y, color = Category)) +
  geom_point(size = 3) +
  scale_color_manual(values = c("A" = "red", "B" = "blue", "C" = "green"))
p
```

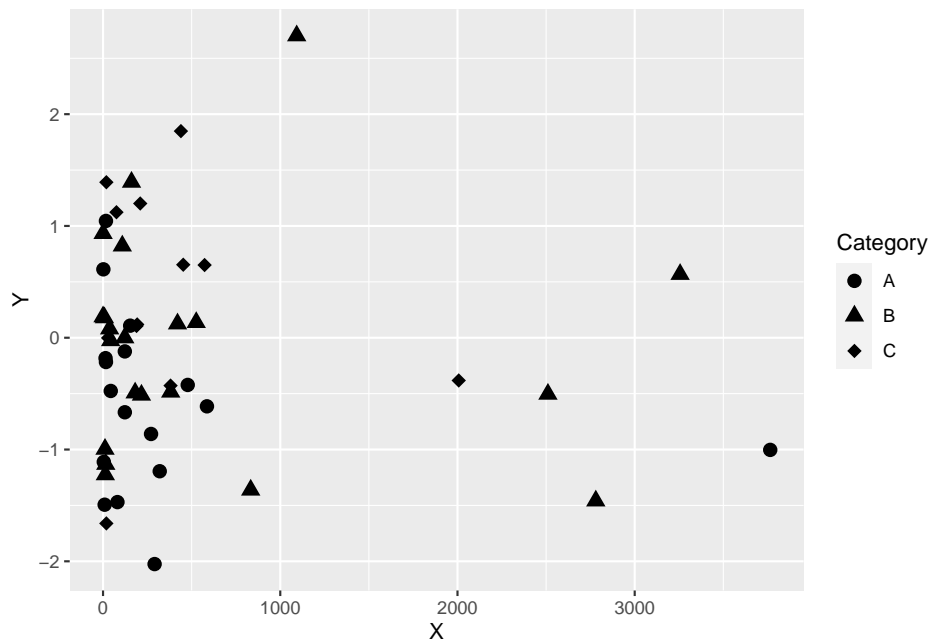


- b. Modify the scatter plot to use custom shapes for each category using `scale_shape_manual()`. What is the effect of changing the shapes on the plot's readability?

Click for answer

*Answer:* Changing the shapes using `scale_shape_manual()` helps to distinguish between categories and improves the plot's readability

```
p <- ggplot(data, aes(x = X, y = Y, shape = Category)) +
  geom_point(size = 3) +
  scale_shape_manual(values = c("A" = 16, "B" = 17, "C" = 18))
p
```



## 11.2 Problem 2: US maps

Now, let's learn about the effect of changing various coordinate systems in `ggplot2` using a map example from the `usmap` package. We will explore the different types of coordinate systems available in `ggplot2` and how they can be applied to the map visualization.

```
#install.packages("usmap") #uncomment to install
library(usmap)
```

### 11.2.1 a. Plot a simple map of the United States using `ggplot2` and the `usmap` package.

Click for answer

*Answer:*

```
us <- plot_usmap()
us
```





11.2.2 b. Apply the `coord_flip()` function to the map to flip the x and y axes.

[Click for answer](#)

*Answer:*

```
us_flipped <- us + coord_flip()  
us_flipped
```

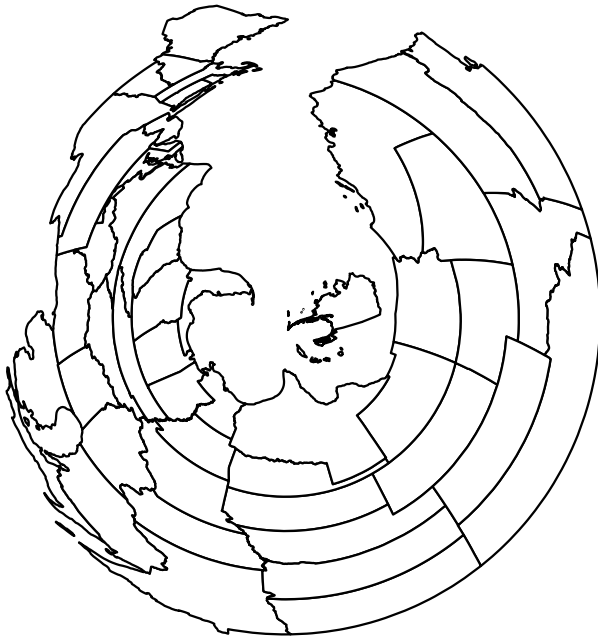


11.2.3 c. Apply the `coord_polar()` function to the map to transform the plot to a polar coordinate system

[Click for answer](#)

*Answer:*

```
us_polar <- us + coord_polar()  
us_polar
```



11.2.4 d. Apply the `coord_quickmap()` function to the map to provide an approximation for a map projection.

Click for answer

*Answer:*

```
us_quickmap <- us + coord_quickmap()  
us_quickmap
```



## 11.3 Problem 3: Choropleth map

In today's class we created choropleth maps of states in the US based on ACS data.

```
states <- map_data("state")
ACS <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/ACS")
ACS <- dplyr::filter(ACS, !(region %in% c("Alaska", "Hawaii"))) # only 48+D.C.
ACS$region <- tolower(ACS$region) # lower case (match states regions)
```

### 11.3.1 (a) Mapping median income

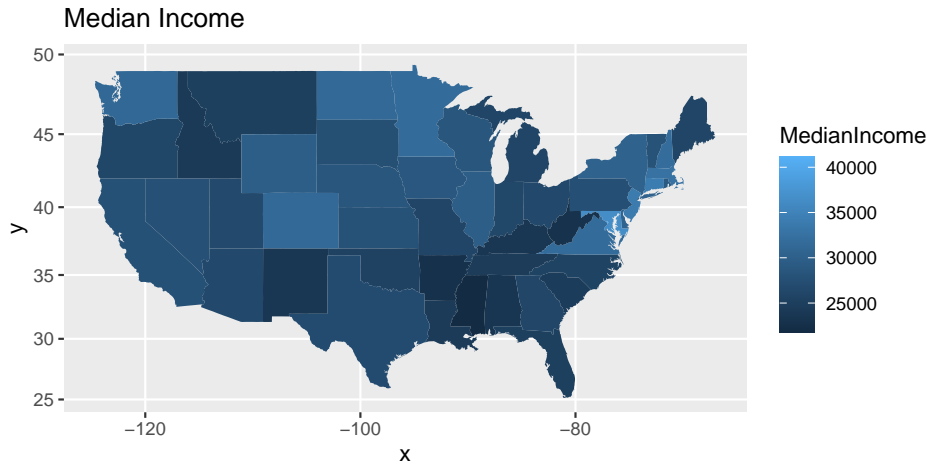
Create a choropleth plot that uses color to create a MedianIncome map of the US.

Click for answer

*Answer:*

```
# map median income
ggplot(data=ACS) + coord_map() +
```

```
geom_map(aes(map_id = region, fill = MedianIncome), map = states) +
  expand_limits(x=states$long, y=states$lat) + ggtitle("Median Income")
```



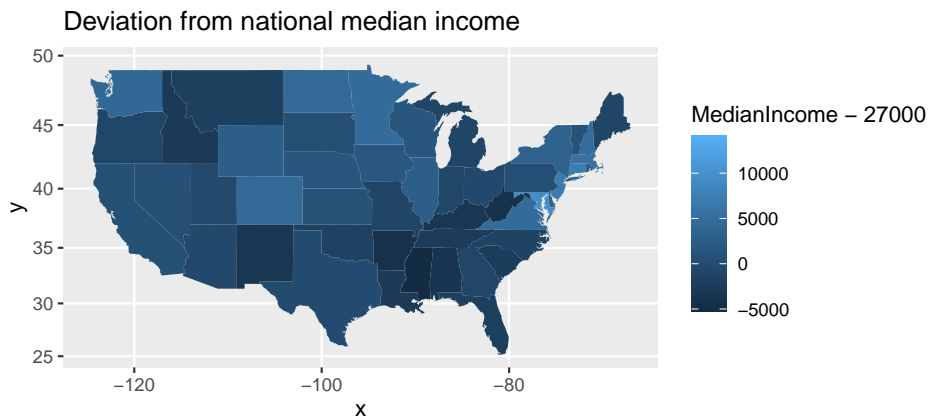
### 11.3.2 (b) Mapping deviations from national median income

The median income in the US in 2016 was estimated to be \$27,000. Redraw your map in (a) to visualize each state's deviation from national median income.

Click for answer

*Answer:*

```
# compare state income to national income
ggplot(data=ACS) + coord_map() +
  geom_map(aes(map_id = region, fill = MedianIncome - 27000), map = states) +
  expand_limits(x=states$long, y=states$lat) + ggtitle("Deviation from national median income")
```



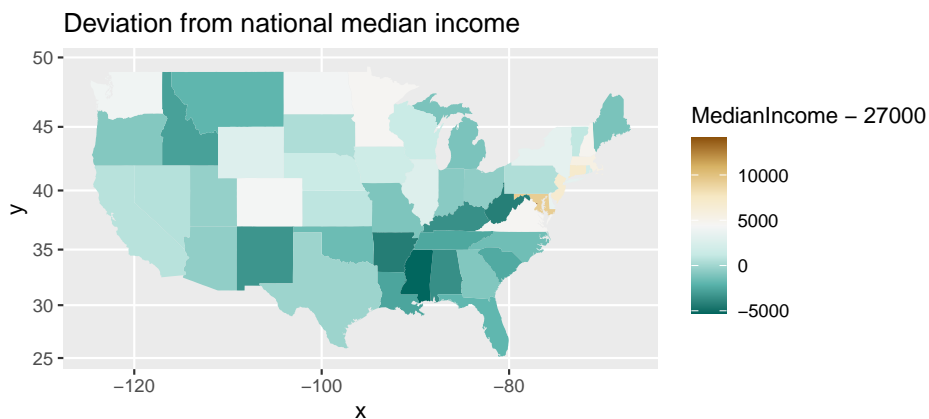
### 11.3.3 (c) Changing numerically scaled color

You should use a *diverging* color for (b) to highlight larger deviations from the national median. Add `scale_fill_distiller` to the map from (b) and select a diverging palette.

Click for answer

Answer:

```
# change to a diverging color
ggplot(data=ACS) + coord_map() +
  geom_map(aes(map_id = region, fill = MedianIncome - 27000), map = states) +
  expand_limits(x=states$long, y=states$lat) + ggtitle("Deviation from national median") +
  scale_fill_distiller(type = "div")
```



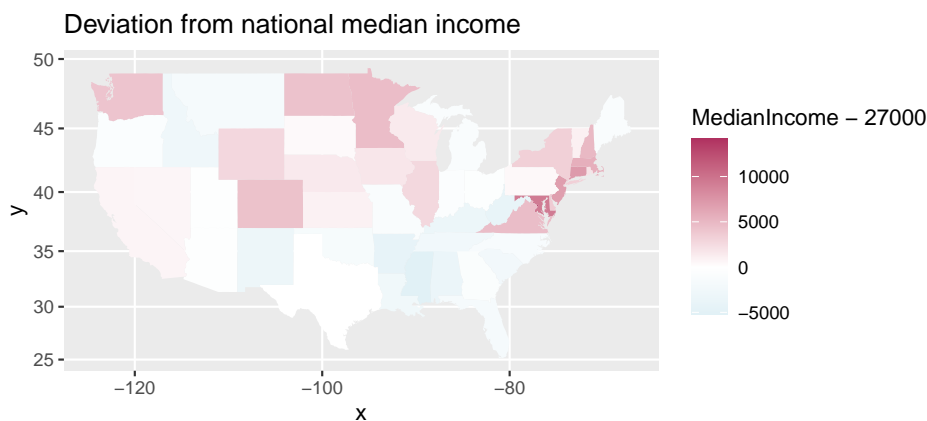
### 11.3.4 (d) Fixing a midpoint on a diverging scale

Use `scale_fill_gradient2` to fix a midpoint scale value at white color, with diverging colors for larger positive and negative values. Apply these colors to your map in (b) and fix the midpoint at an appropriate value.

Click for answer

Answer:

```
# change to a gradient fill color
ggplot(data=ACS) + coord_map() +
  geom_map(aes(map_id = region, fill = MedianIncome - 27000), map = states) +
  expand_limits(x=states$long, y=states$lat) + ggtitle("Deviation from national median income") +
  scale_fill_gradient2(
    low = "lightblue",    # Set the low color to red
    mid = "white",        # Set the mid color to yellow
    high = "maroon",      # Set the high color to green
    midpoint = 0
  )
```



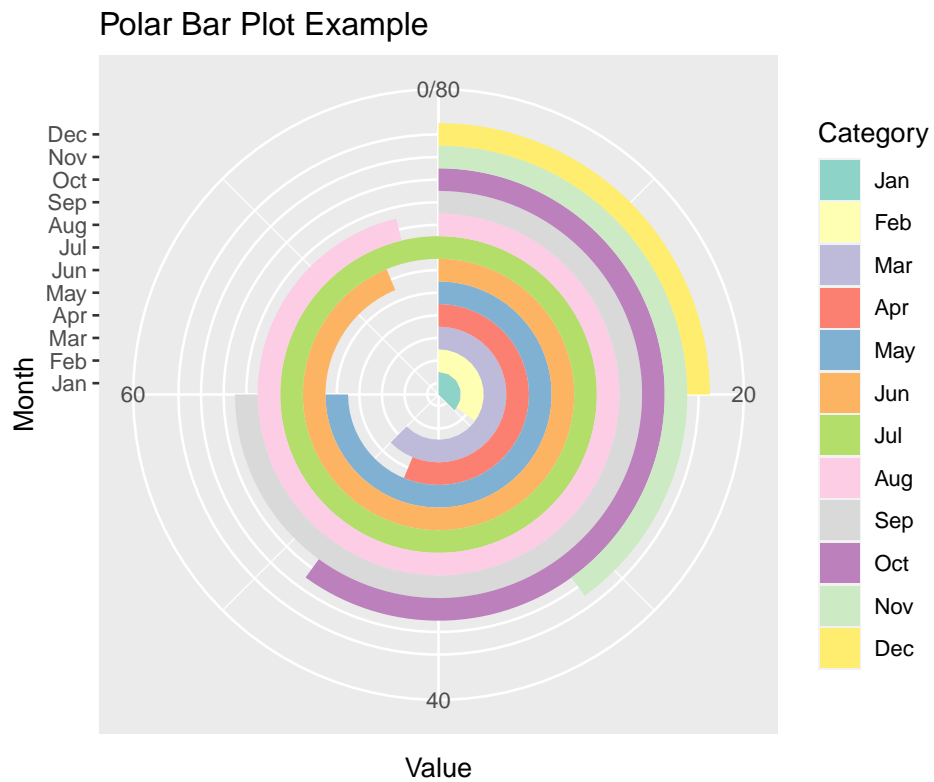
## 11.4 (Optional)

Let's learn how to create a polar bar plot with custom colors.

```
data <- data.frame(
  Category = factor(1:12, labels = month.abb),
  Value = c(30, 28, 50, 45, 60, 75, 80, 77, 60, 48, 32, 20)
)
```

Click for answer

```
p <- ggplot(data, aes(x = Category, y = Value, fill = Category)) +
  geom_bar(stat = "identity", width = 1) +
  coord_polar(theta = "y") +
  scale_fill_brewer(palette = "Set3") +
  labs(title = "Polar Bar Plot Example", x = "Month", y = "Value")
p
```





## Chapter 12

# Class Activity 6

```
# load the necessary libraries
library(dplyr)
library(ggplot2)
library(babynames)
```

We will work with the **babynames** dataset again in this class activity. The header of the dataset looks like this:

```
knitr::kable(head(babynames))
```

| year | sex | name      | n    | prop      |
|------|-----|-----------|------|-----------|
| 1880 | F   | Mary      | 7065 | 0.0723836 |
| 1880 | F   | Anna      | 2604 | 0.0266790 |
| 1880 | F   | Emma      | 2003 | 0.0205215 |
| 1880 | F   | Elizabeth | 1939 | 0.0198658 |
| 1880 | F   | Minnie    | 1746 | 0.0178884 |
| 1880 | F   | Margaret  | 1578 | 0.0161672 |

In this tutorial, we will learn about the five main verbs of dplyr and how to use them to manipulate data:

- **select()**: Choose columns from a data frame
- **filter()**: Choose rows based on a condition
- **arrange()**: Sort the rows of a data frame
- **mutate()**: Add new columns based on existing columns
- **summarise()**: Aggregate data and compute summary statistics

## 12.1 Problem 1: `select()`

Which of these is NOT a way to select the `name` and `n` columns together?

```
select(babynames, -c(year, sex, prop)) #1
select(babynames, name:n) #2
select(babynames, starts_with("n")) #3
select(babynames, ends_with("n")) #4
```

Click for answer

*Answer:* 4 is not the way to select the `name` and `n` columns together

## 12.2 Problem 2: `filter()`

Use `filter()` with the logical operators to extract:

### 12.2.1 a. All of the names where `prop` is greater than or equal to 0.08

Click for answer

```
filter(babynames, prop >= 0.08)
```

```
# A tibble: 3 x 5
  year sex  name      n prop
  <dbl> <chr> <chr>   <int> <dbl>
1  1880 M    John   9655 0.0815
2  1880 M   William 9532 0.0805
3  1881 M    John   8769 0.0810
```

```
# alternate
babynames %>% filter(prop >= 0.08)
```

```
# A tibble: 3 x 5
  year sex  name      n prop
  <dbl> <chr> <chr>   <int> <dbl>
1  1880 M    John   9655 0.0815
2  1880 M   William 9532 0.0805
3  1881 M    John   8769 0.0810
```

### 12.2.2 b. All of the babies named “Rose”

[Click for answer](#)

```
babynames %>% filter(name == "Rose")
```

```
# A tibble: 247 x 5
  year sex  name      n    prop
  <dbl> <chr> <chr> <int> <dbl>
1  1880 F    Rose    700 0.00717
2  1880 M    Rose     7 0.0000591
3  1881 F    Rose   734 0.00743
4  1882 F    Rose   886 0.00766
5  1883 F    Rose   877 0.00730
6  1883 M    Rose     5 0.0000445
7  1884 F    Rose  1060 0.00770
8  1884 M    Rose     5 0.0000407
9  1885 F    Rose  1164 0.00820
10 1885 M    Rose     9 0.0000776
# ... with 237 more rows
```

### 12.2.3 c. Use filter() to choose all rows where name is “John” and sex is “M”.

[Click for answer](#)

```
babynames %>% filter(name == "John", sex == "M")
```

```
# A tibble: 138 x 5
  year sex  name      n    prop
  <dbl> <chr> <chr> <int> <dbl>
1  1880 M    John  9655 0.0815
2  1881 M    John  8769 0.0810
3  1882 M    John  9557 0.0783
4  1883 M    John  8894 0.0791
5  1884 M    John  9388 0.0765
6  1885 M    John  8756 0.0755
7  1886 M    John  9026 0.0758
8  1887 M    John  8110 0.0742
9  1888 M    John  9247 0.0712
10 1889 M    John  8548 0.0718
# ... with 128 more rows
```

## 12.3 Problem 3: `arrange()`

### 12.3.1 a. Use `arrange()` to sort the `babynames` dataset by the `prop` column in descending order.

[Click for answer](#)

```
babynames %>% arrange(desc(prop))
```

```
# A tibble: 1,924,665 x 5
   year sex  name      n  prop
  <dbl> <chr> <chr>  <int> <dbl>
1  1880 M    John   9655 0.0815
2  1881 M    John   8769 0.0810
3  1880 M   William 9532 0.0805
4  1883 M    John   8894 0.0791
5  1881 M   William 8524 0.0787
6  1882 M    John   9557 0.0783
7  1884 M    John   9388 0.0765
8  1882 M   William 9298 0.0762
9  1886 M    John   9026 0.0758
10 1885 M    John   8756 0.0755
# ... with 1,924,655 more rows
```

### 12.3.2 b. Use `arrange()` to sort the `babynames` dataset by year (ascending) and then by `prop` (descending).

[Click for answer](#)

```
babynames %>% arrange(year, desc(prop))
```

```
# A tibble: 1,924,665 x 5
   year sex  name      n  prop
  <dbl> <chr> <chr>  <int> <dbl>
1  1880 M    John   9655 0.0815
2  1880 M   William 9532 0.0805
3  1880 F    Mary   7065 0.0724
4  1880 M    James  5927 0.0501
5  1880 M   Charles 5348 0.0452
6  1880 M   George 5126 0.0433
7  1880 M    Frank  3242 0.0274
8  1880 F    Anna   2604 0.0267
9  1880 M   Joseph  2632 0.0222
```

```
10 1880 M      Thomas    2534 0.0214
# ... with 1,924,655 more rows
```

## 12.4 Problem 4: `mutate()`

12.4.1 a. Use `mutate()` to create a new column called `decade` which contains the decade the record is in (e.g., 1990 for the years 1990-1999).

[Click for answer](#)

```
babynames %>% mutate(decade = (year %/% 10) * 10)
```

```
# A tibble: 1,924,665 x 6
   year sex  name      n  prop decade
  <dbl> <chr> <chr>   <int> <dbl> <dbl>
1  1880 F    Mary    7065 0.0724  1880
2  1880 F    Anna    2604 0.0267  1880
3  1880 F    Emma    2003 0.0205  1880
4  1880 F  Elizabeth  1939 0.0199  1880
5  1880 F   Minnie   1746 0.0179  1880
6  1880 F  Margaret   1578 0.0162  1880
7  1880 F     Ida    1472 0.0151  1880
8  1880 F    Alice   1414 0.0145  1880
9  1880 F   Bertha   1320 0.0135  1880
10 1880 F    Sarah   1288 0.0132  1880
# ... with 1,924,655 more rows
```

## 12.5 Problem 5: `summarize()` or `summarise()`

Use the codes mentioned so far to compute three statistics:

- the total number of children who ever had your name
- the maximum number of children given your name in a single year
- the mean number of children given your name per year/decade (optional)

[Click for answer](#)

```
babynames %>%
  filter(name == "Dee", sex == "M")
```

```
# A tibble: 136 x 5
  year sex   name     n   prop
  <dbl> <chr> <chr> <int> <dbl>
1  1880 M    Dee     20 0.000169
2  1881 M    Dee     32 0.000296
3  1882 M    Dee     23 0.000188
4  1883 M    Dee     22 0.000196
5  1884 M    Dee     27 0.000220
6  1885 M    Dee     28 0.000241
7  1886 M    Dee     26 0.000218
8  1887 M    Dee     39 0.000357
9  1888 M    Dee     35 0.000269
10 1889 M    Dee     24 0.000202
# ... with 126 more rows
```

```
babynames %>%
  filter(name == "Dee", sex == "M") %>%
  summarise(max_number = max(n))
```

```
# A tibble: 1 x 1
  max_number
  <int>
1       125
```

```
babynames %>%
  filter(name == "Dee", sex == "M") %>%
  mutate(decade = (year %/% 10) * 10) %>%
  group_by(decade) %>%
  summarise(total = sum(n),
            max = max(n),
            mean = mean(n))
```

```
# A tibble: 14 x 4
  decade total   max   mean
  <dbl> <int> <int> <dbl>
1  1880   276    39  27.6
2  1890   271    43  27.1
3  1900   302    38  30.2
4  1910   818   125  81.8
5  1920  1090   125 109
6  1930  1010   118 101
7  1940   967   120  96.7
8  1950   957   118  95.7
9  1960   683   102  68.3
```

```

10  1970    380    57  38
11  1980    217    30 21.7
12  1990    130    17  13
13  2000     87    13  9.67
14  2010     52    12  7.43

```

## 12.6 Problem 6

12.6.1 a. Use `min_rank()` and `mutate()` to rank each row in `babynames` from largest prop to smallest prop.

Click for answer

```
babynames %>% mutate(rank = min_rank(desc(prop))) %>% arrange(rank)
```

```

# A tibble: 1,924,665 x 6
   year sex  name      n  prop rank
  <dbl> <chr> <chr>   <int> <dbl> <int>
1  1880 M    John    9655 0.0815     1
2  1881 M    John    8769 0.0810     2
3  1880 M   William  9532 0.0805     3
4  1883 M    John    8894 0.0791     4
5  1881 M   William  8524 0.0787     5
6  1882 M    John    9557 0.0783     6
7  1884 M    John    9388 0.0765     7
8  1882 M   William  9298 0.0762     8
9  1886 M    John    9026 0.0758     9
10 1885 M    John    8756 0.0755    10
# ... with 1,924,655 more rows

```

12.6.2 b. Compute each name's rank within its year and sex.

Click for answer

```
babynames %>% group_by(year, sex) %>% mutate(rank = min_rank(desc(prop)))
```

```

# A tibble: 1,924,665 x 6
# Groups:   year, sex [276]
   year sex  name      n  prop rank
  <dbl> <chr> <chr>   <int> <dbl> <int>

```

```

1 1880 F Mary 7065 0.0724 1
2 1880 F Anna 2604 0.0267 2
3 1880 F Emma 2003 0.0205 3
4 1880 F Elizabeth 1939 0.0199 4
5 1880 F Minnie 1746 0.0179 5
6 1880 F Margaret 1578 0.0162 6
7 1880 F Ida 1472 0.0151 7
8 1880 F Alice 1414 0.0145 8
9 1880 F Bertha 1320 0.0135 9
10 1880 F Sarah 1288 0.0132 10
# ... with 1,924,655 more rows

```

**12.6.3 c.** Then compute the median rank for each combination of name and sex, and arrange the results from highest median rank to lowest.

Click for answer

```

babynames %>%
  group_by(year, sex) %>%
  mutate(rank = min_rank(desc(prop))) %>%
  group_by(name, sex) %>%
  summarize(score = median(rank)) %>%
  arrange(score)

```

```

# A tibble: 107,973 x 3
# Groups:   name [97,310]
   name      sex  score
   <chr>    <chr> <dbl>
1 Mary     F         1
2 James    M         3
3 John     M         3
4 William  M         4
5 Robert   M         6
6 Michael  M        7.5
7 Charles  M         9
8 Elizabeth F        10
9 Joseph   M        10
10 Thomas  M        11
# ... with 107,963 more rows

```



## Chapter 13

### Class Activity 7

```
# load the necessary libraries
library(tidyverse)
library(babynames)
```

#### 13.1 Problem 1: Boolean Operators

Use Boolean operators to alter the code below to return only the rows that contain:

##### 13.1.1 a. Girls named Rhea

Click for answer

```
filter(babynames, name == "Rhea", sex == "F")
```

```
# A tibble: 136 x 5
  year sex  name      n    prop
  <dbl> <chr> <chr> <int>  <dbl>
1  1882 F    Rhea      7 0.0000605
2  1883 F    Rhea      8 0.0000666
3  1884 F    Rhea     13 0.0000945
4  1885 F    Rhea     11 0.0000775
5  1886 F    Rhea     13 0.0000846
6  1887 F    Rhea     14 0.0000901
7  1888 F    Rhea     20 0.000106
```

```

8 1889 F    Rhea      31 0.000164
9 1890 F    Rhea      39 0.000193
10 1891 F    Rhea      24 0.000122
# ... with 126 more rows

```

```
babynames %>% filter(name == "Rhea", sex == "F")
```

```

# A tibble: 136 x 5
  year sex  name      n    prop
  <dbl> <chr> <chr> <int>  <dbl>
1  1882 F    Rhea      7 0.0000605
2  1883 F    Rhea      8 0.0000666
3  1884 F    Rhea     13 0.0000945
4  1885 F    Rhea     11 0.0000775
5  1886 F    Rhea     13 0.0000846
6  1887 F    Rhea     14 0.0000901
7  1888 F    Rhea     20 0.000106
8  1889 F    Rhea     31 0.000164
9  1890 F    Rhea     39 0.000193
10 1891 F    Rhea     24 0.000122
# ... with 126 more rows

```

### 13.1.2 b. Names that were used by exactly 5 or 6 children in 1990

Click for answer

```
filter(babynames, year == 1990, n == 5 | n == 6)
```

```

# A tibble: 6,144 x 5
  year sex  name      n    prop
  <dbl> <chr> <chr> <int>  <dbl>
1  1990 F    Aariel      6 0.00000292
2  1990 F    Aarion      6 0.00000292
3  1990 F    Abagael     6 0.00000292
4  1990 F    Abbye       6 0.00000292
5  1990 F    Abiola      6 0.00000292
6  1990 F    Abreanna    6 0.00000292
7  1990 F    Abygail     6 0.00000292
8  1990 F    Acadia      6 0.00000292
9  1990 F    Adilenne    6 0.00000292
10 1990 F    Adriena     6 0.00000292
# ... with 6,134 more rows

```

```
babynames %>% filter(year == "1990", n == 5 | n == 6)
```

```
# A tibble: 6,144 x 5
   year sex  name      n      prop
  <dbl> <chr> <chr>   <int>   <dbl>
1  1990 F    Aariel     6 0.00000292
2  1990 F    Aarion     6 0.00000292
3  1990 F   Abagael     6 0.00000292
4  1990 F   Abbye      6 0.00000292
5  1990 F   Abiola     6 0.00000292
6  1990 F  Abreanna     6 0.00000292
7  1990 F  Abygail     6 0.00000292
8  1990 F   Acadia     6 0.00000292
9  1990 F  Adilenne     6 0.00000292
10 1990 F   Adriena     6 0.00000292
# ... with 6,134 more rows
```

### 13.1.3 c. Names that are one of Apple, Yoroi, Ada

Click for answer

```
filter(babynames, name == "Apple" | name == "Yoroi" | name == "Ada")
```

```
# A tibble: 200 x 5
   year sex  name      n      prop
  <dbl> <chr> <chr>   <int>   <dbl>
1  1880 F    Ada     652 0.00668
2  1881 F    Ada     628 0.00635
3  1882 F    Ada     689 0.00596
4  1883 F    Ada     778 0.00648
5  1884 F    Ada     854 0.00621
6  1885 F    Ada     876 0.00617
7  1885 M    Ada       5 0.0000431
8  1886 F    Ada     915 0.00595
9  1886 M    Ada       6 0.0000504
10 1887 F    Ada     910 0.00586
# ... with 190 more rows
```

### 13.1.4 d. Store the data tibble in part c into a new tibble and change all the character columns to upper case. Also, rename the n variable to count.

Click for answer

```
aya <- babynames %>% filter(name == "Apple" | name == "Yoroi" | name == "Ada")
aya %>% mutate_if(is.character, toupper)
```

```
# A tibble: 200 x 5
  year sex  name      n      prop
  <dbl> <chr> <chr> <int>   <dbl>
1  1880 F    ADA     652 0.00668
2  1881 F    ADA     628 0.00635
3  1882 F    ADA     689 0.00596
4  1883 F    ADA     778 0.00648
5  1884 F    ADA     854 0.00621
6  1885 F    ADA     876 0.00617
7  1885 M    ADA       5 0.0000431
8  1886 F    ADA     915 0.00595
9  1886 M    ADA       6 0.0000504
10 1887 F    ADA     910 0.00586
# ... with 190 more rows
```

```
aya %>% mutate_at(vars(name), toupper)
```

```
# A tibble: 200 x 5
  year sex  name      n      prop
  <dbl> <chr> <chr> <int>   <dbl>
1  1880 F    ADA     652 0.00668
2  1881 F    ADA     628 0.00635
3  1882 F    ADA     689 0.00596
4  1883 F    ADA     778 0.00648
5  1884 F    ADA     854 0.00621
6  1885 F    ADA     876 0.00617
7  1885 M    ADA       5 0.0000431
8  1886 F    ADA     915 0.00595
9  1886 M    ADA       6 0.0000504
10 1887 F    ADA     910 0.00586
# ... with 190 more rows
```

```
aya %>% rename(count = n)
```

```
# A tibble: 200 x 5
  year sex  name  count      prop
  <dbl> <chr> <chr> <int>   <dbl>
1  1880 F    Ada     652 0.00668
2  1881 F    Ada     628 0.00635
3  1882 F    Ada     689 0.00596
```

```

4 1883 F      Ada      778 0.00648
5 1884 F      Ada      854 0.00621
6 1885 F      Ada      876 0.00617
7 1885 M      Ada       5 0.0000431
8 1886 F      Ada     915 0.00595
9 1886 M      Ada       6 0.0000504
10 1887 F     Ada     910 0.00586
# ... with 190 more rows

```

### 13.1.5 e. Change all the column names to upper case in the previous problem.

Click for answer

```
aya %>% rename_at(vars(year:prop), toupper)
```

```

# A tibble: 200 x 5
   YEAR SEX  NAME      N      PROP
  <dbl> <chr> <chr> <int>   <dbl>
1  1880 F    Ada    652 0.00668
2  1881 F    Ada    628 0.00635
3  1882 F    Ada    689 0.00596
4  1883 F    Ada    778 0.00648
5  1884 F    Ada    854 0.00621
6  1885 F    Ada    876 0.00617
7  1885 M    Ada      5 0.0000431
8  1886 F    Ada   915 0.00595
9  1886 M    Ada      6 0.0000504
10 1887 F    Ada   910 0.00586
# ... with 190 more rows

```

### 13.1.6 f. What do these commands do?

```

polluted_cities <- tribble(
  ~city, ~size, ~amount,
  "New York", "large", 23,
  "New York", "small", 14,
  "London", "large", 22,
  "London", "small", 16,
  "Beijing", "large", 121,
  "Beijing", "small", 56
)

```

```
polluted_cities
```

```
# A tibble: 6 x 3
  city      size amount
  <chr>    <chr> <dbl>
1 New York large    23
2 New York small    14
3 London   large    22
4 London   small    16
5 Beijing  large   121
6 Beijing  small    56
```

```
polluted_cities %>% select_if(is.numeric) #1
polluted_cities %>% rename_all(toupper) #2
polluted_cities %>% rename_if(is.character, toupper) #3
polluted_cities %>% rename_at(vars(contains("it")), toupper) #4
```

Click for answer

*answer:*

1. Selects all numeric columns from the polluted\_cities dataset.
2. Renames all column names in the polluted\_cities dataset to uppercase.
3. Renames column names with character data type in the polluted\_cities dataset to uppercase.
4. Renames column names containing “it” in the polluted\_cities dataset to uppercase.

```
polluted_cities %>% select_if(is.numeric) #1
```

```
# A tibble: 6 x 1
  amount
  <dbl>
1     23
2     14
3     22
4     16
5    121
6     56
```

```
polluted_cities %>% rename_all(toupper) #2
```

```
# A tibble: 6 x 3
  CITY      SIZE AMOUNT
  <chr>    <chr> <dbl>
1 New York large    23
2 New York small    14
3 London   large    22
4 London   small    16
5 Beijing  large   121
6 Beijing  small    56
```

```
polluted_cities %>% rename_if(is.character, toupper) #3
```

```
# A tibble: 6 x 3
  CITY      SIZE amount
  <chr>    <chr> <dbl>
1 New York large    23
2 New York small    14
3 London   large    22
4 London   small    16
5 Beijing  large   121
6 Beijing  small    56
```

```
polluted_cities %>% rename_at(vars(contains("it")), toupper) #4
```

```
# A tibble: 6 x 3
  CITY      size amount
  <chr>    <chr> <dbl>
1 New York large    23
2 New York small    14
3 London   large    22
4 London   small    16
5 Beijing  large   121
6 Beijing  small    56
```

---

Let's look at an interesting example on how to join related information on various artists, bands, songs, and their labels.

```
artists <- tibble(first = c("Jimmy", "George", "Mick", "Tom", "Davy", "John",
                           "Paul", "Jimmy", "Joe", "Elvis", "Keith", "Paul",
                           "Ringo", "Joe", "Brian", "Nancy"),
                  last = c("Buffett", "Harrison", "Jagger", "Jones", "Jones",
```





```
$ last      <chr> "Buffett", "Harrison", "Jagger", "Jones~
$ instrument <chr> "Guitar", "Guitar", "Vocals", "Vocals",~
```

```
glimpse(bands)
```

```
Rows: 13
Columns: 3
$ first <chr> "John", "John Paul", "Jimmy", "Robert", "Geo~
$ last  <chr> "Bonham", "Jones", "Page", "Plant", "Harriso~
$ band  <chr> "Led Zeppelin", "Led Zeppelin", "Led Zeppeli~
```

```
glimpse(albums)
```

```
Rows: 9
Columns: 3
$ album <chr> "A Hard Day's Night", "Magical Mystery Tour"~
$ band  <chr> "The Beatles", "The Beatles", "The Rolling S~
$ year  <dbl> 1964, 1967, 1968, 1969, 1971, 1973, 1973, 19~
```

```
glimpse(songs)
```

```
Rows: 4
Columns: 4
$ song <chr> "Come Together", "Dream On", "Hello, Goodbye~
$ album <chr> "Abbey Road", "Aerosmith", "Magical Mystery ~
$ first <chr> "John", "Steven", "Paul", "Tom"
$ last  <chr> "Lennon", "Tyler", "McCartney", "Jones"
```

```
glimpse(labels)
```

```
Rows: 9
Columns: 2
$ album <chr> "Abbey Road", "A Hard Days Night", "Magical ~
$ label <chr> "Apple", "Parlophone", "Parlophone", "Atlant~
```

## 13.2 Problem 2: Joining artists and bands data

13.2.1 a. Join the artists and bands tibbles using `left_join()`, `right_join()`, and `full_join()`. Verify that the datasets obtained from `left_join()` and `right_join()` are the same using `setequal()`.

Click for answer

```
bands2 <- left_join(bands, artists, by = c("first", "last"))
bands3 <- right_join(artists, bands, by = c("first", "last"))
full_bands <- full_join(artists, bands, by = c("first", "last"))

# Check if the datasets are the same
setequal(bands2, bands3)
```

```
[1] TRUE
```

**13.2.2 b.** Use the pipe operator, `%>%`, to create one table that combines all information from artists, bands, albums, songs, and labels.

Click for answer

```
all_info <- artists %>%
  full_join(bands, by = c("first", "last")) %>%
  full_join(songs, by = c("first", "last")) %>%
  full_join(albums, by = c("album", "band")) %>%
  full_join(labels, by = c("album"))
all_info
```

```
# A tibble: 30 x 8
  first last instrument band song album year label
  <chr> <chr> <chr> <chr> <chr> <chr> <dbl> <chr>
1 Jimmy Buffett Guitar The ~ <NA> <NA> NA <NA>
2 George Harrison Guitar The ~ <NA> <NA> NA <NA>
3 Mick Jagger Vocals The ~ <NA> <NA> NA <NA>
4 Tom Jones Vocals <NA> It's~ Alon~ NA <NA>
5 Davy Jones Vocals <NA> <NA> <NA> NA <NA>
6 John Lennon Guitar The ~ Come~ Abbe~ 1969 Apple
7 Paul McCartney Bass The ~ Hell~ Magi~ 1967 Parl~
8 Jimmy Page Guitar Led ~ <NA> <NA> NA <NA>
9 Joe Perry Guitar <NA> <NA> <NA> NA <NA>
10 Elvis Presley Vocals <NA> <NA> <NA> NA <NA>
# ... with 20 more rows
```

## 13.3 Problem 3: Filtering and counting rows in the data

### 13.3.1 a. Collect artists that have songs provided, and return rows of artists that don't have bands info.

Click for answer

```
# Artists with songs
artists_with_songs <- artists %>%
  semi_join(songs, by = c("first", "last"))

# Artists without bands info
artists_without_bands <- artists %>%
  anti_join(bands, by = c("first", "last"))

artists_with_songs
```

```
# A tibble: 3 x 3
  first last      instrument
  <chr> <chr>    <chr>
1 Tom   Jones    Vocals
2 John  Lennon    Guitar
3 Paul  McCartney Bass
```

```
artists_without_bands
```

```
# A tibble: 8 x 3
  first last      instrument
  <chr> <chr>    <chr>
1 Tom   Jones    Vocals
2 Davy  Jones    Vocals
3 Joe   Perry    Guitar
4 Elvis Presley Vocals
5 Paul  Simon    Guitar
6 Joe   Walsh    Guitar
7 Brian Wilson  Vocals
8 Nancy Wilson  Vocals
```

### 13.3.2 b. Collect the albums made by a band, count the number of rows, find the rows of songs that match a row in labels, and count the number of rows.

Click for answer

```
# Albums made by a band
albums_by_band <- albums %>% semi_join(bands, by = "band")
n_albums_by_band <- nrow(albums_by_band)

# Rows of songs that match a row in labels
songs_with_labels <- songs %>% semi_join(labels, by = "album")
n_songs_with_labels <- nrow(songs_with_labels)

n_albums_by_band
```

```
[1] 5
```

```
n_songs_with_labels
```

```
[1] 3
```

## Chapter 14

# Class Activity 8

```
# load the necessary libraries
library(tidyverse)
library(lubridate)
```

### 14.1 Your turn 1

The following code chunks create the data objects used in this exercise. Please run the chunks and answer the questions.

```
DBP_wide <- tibble(id = letters[1:4],
  sex = c("F", "M", "M", "F"),
  v1.DBP = c(88, 84, 102, 70),
  v2.DBP = c(78, 78, 96, 76),
  v3.DBP = c(94, 82, 94, 74),
  age=c(23, 56, 41, 38)
)
DBP_wide
```

```
# A tibble: 4 x 6
  id    sex  v1.DBP v2.DBP v3.DBP  age
<chr> <chr>  <dbl>  <dbl>  <dbl> <dbl>
1 a     F      88     78     94    23
2 b     M      84     78     82    56
3 c     M     102     96     94    41
4 d     F      70     76     74    38
```

```
BP_wide <- tibble(id = letters[1:4],
                 sex = c("F", "M", "M", "F"),
                 SBP_v1 = c(130, 120, 130, 119),
                 SBP_v2 = c(110, 116, 136, 106),
                 SBP_v3 = c(112, 122, 138, 118))

BP_wide
```

```
# A tibble: 4 x 5
  id    sex  SBP_v1 SBP_v2 SBP_v3
<chr> <chr>  <dbl>  <dbl>  <dbl>
1 a      F      130     110     112
2 b      M      120     116     122
3 c      M      130     136     138
4 d      F      119     106     118
```

```
BP_long <- BP_wide %>%
  pivot_longer(names_to = "visit", values_to = "SBP", SBP_v1:SBP_v3) %>%
  mutate(visit = parse_number(visit))

BP_long
```

```
# A tibble: 12 x 4
  id    sex  visit  SBP
<chr> <chr>  <dbl> <dbl>
1 a      F      1     130
2 a      F      2     110
3 a      F      3     112
4 b      M      1     120
5 b      M      2     116
6 b      M      3     122
7 c      M      1     130
8 c      M      2     136
9 c      M      3     138
10 d     F      1     119
11 d     F      2     106
12 d     F      3     118
```

#### 14.1.1 a. Create a long dataframe from DBP\_wide based on the repeated DBP columns and save it as DBP\_long.

Click for answer

*Answer:*

```
DBP_long <- DBP_wide %>%
  pivot_longer(names_to = "visit",
               values_to = "DBP",
               cols = v1.DBP:v3.DBP)
DBP_long
```

```
# A tibble: 12 x 5
   id    sex    age visit    DBP
  <chr> <chr> <dbl> <chr>  <dbl>
1 a     F      23 v1.DBP   88
2 a     F      23 v2.DBP   78
3 a     F      23 v3.DBP   94
4 b     M      56 v1.DBP   84
5 b     M      56 v2.DBP   78
6 b     M      56 v3.DBP   82
7 c     M      41 v1.DBP  102
8 c     M      41 v2.DBP   96
9 c     M      41 v3.DBP   94
10 d    F      38 v1.DBP   70
11 d    F      38 v2.DBP   76
12 d    F      38 v3.DBP   74
```

#### 14.1.2 b. Clean up the visit column of DBP\_long so that the values are 1, 2, 3, and save it as DBP\_long.

Click for answer

*Answer:*

```
DBP_long <- DBP_long %>%
  mutate(visit = parse_number(visit))
DBP_long
```

```
# A tibble: 12 x 5
   id    sex    age visit    DBP
  <chr> <chr> <dbl> <dbl>  <dbl>
1 a     F      23     1   88
2 a     F      23     2   78
3 a     F      23     3   94
4 b     M      56     1   84
5 b     M      56     2   78
6 b     M      56     3   82
7 c     M      41     1  102
8 c     M      41     2   96
```

|    |   |   |    |   |    |
|----|---|---|----|---|----|
| 9  | c | M | 41 | 3 | 94 |
| 10 | d | F | 38 | 1 | 70 |
| 11 | d | F | 38 | 2 | 76 |
| 12 | d | F | 38 | 3 | 74 |

**14.1.3 c.** Make `DBP_long` wide with column names `visit.1`, `visit.2`, `visit.3` for the DBP values, and save it as `DBP_wide2`

Click for answer

*Answer:*

```
DBP_wide2 <- DBP_long %>%
  pivot_wider(names_from = "visit",
              values_from = "DBP",
              names_prefix = "visit.")
DBP_wide2
```

```
# A tibble: 4 x 6
  id    sex    age visit.1 visit.2 visit.3
<chr> <chr> <dbl>   <dbl>   <dbl>   <dbl>
1 a     F      23      88      78      94
2 b     M      56      84      78      82
3 c     M      41     102      96      94
4 d     F      38      70      76      74
```

**14.1.4 d.** Join `DBP_long` with `BP_long2` to create a single data frame with columns `id`, `sex`, `visit`, `SBP`, `DBP`, and `age`. Save this as `BP_both_long`.

Click for answer

*Answer:*

```
BP_both_long <- left_join(BP_long, DBP_long, by = c("id", "sex", "visit"))
BP_both_long
```

```
# A tibble: 12 x 6
  id    sex  visit  SBP  age  DBP
<chr> <chr> <dbl> <dbl> <dbl> <dbl>
1 a     F      1   130   23   88
2 a     F      2   110   23   78
```



|    |   |   |   |     |    |     |
|----|---|---|---|-----|----|-----|
| 3  | a | F | 3 | 112 | 23 | 94  |
| 4  | b | M | 1 | 120 | 56 | 84  |
| 5  | b | M | 2 | 116 | 56 | 78  |
| 6  | b | M | 3 | 122 | 56 | 82  |
| 7  | c | M | 1 | 130 | 41 | 102 |
| 8  | c | M | 2 | 136 | 41 | 96  |
| 9  | c | M | 3 | 138 | 41 | 94  |
| 10 | d | F | 1 | 119 | 38 | 70  |
| 11 | d | F | 2 | 106 | 38 | 76  |
| 12 | d | F | 3 | 118 | 38 | 74  |

**14.1.5 e.** Calculate the mean SBP and DBP for each visit and save the result as `mean_BP_by_visit`.

Click for answer

*Answer:*

```
mean_BP_by_visit <- BP_both_long %>%
  group_by(visit) %>%
  summarize(mean_SBP = mean(SBP),
             mean_DBP = mean(DBP))
mean_BP_by_visit
```

```
# A tibble: 3 x 3
  visit mean_SBP mean_DBP
  <dbl>   <dbl>   <dbl>
1     1    125.     86
2     2    117     82
3     3    122     86
```

## 14.2 Your turn 2

**14.2.1 a.** Parsing Complex Dates: Use `dmy_hms()` to parse the following date-time string: “25-Dec-2020 17:30:00”

Click for answer

*Answer:*

```
parsed_date <- dmy_hms("25-Dec-2020 17:30:00")
parsed_date
```

```
[1] "2020-12-25 17:30:00 UTC"
```

**14.2.2 b. Advanced Date Arithmetic: Calculate the exact age in years for someone born on “1995-05-15 09:30:00”.**

Click for answer

*Answer:*

```
dob <- ymd_hms("1995-05-15 09:30:00")
exact_age <- as.duration(interval(dob, now())) / dyears(1)
exact_age
```

```
[1] 27.96645
```

**14.2.3 c. Creating Date-Time Objects: Create a date-time object for March 15, 2020, 13:30:00 using `make_datetime()`.**

Click for answer

*Answer:*

```
new_date_time <- make_datetime(2020, 3, 15, 13, 30, 0)
new_date_time
```

```
[1] "2020-03-15 13:30:00 UTC"
```

**14.2.4 d. Extracting Components from Date-Time Objects: Extract the year, month (as a number), day, hour, and minute from “2022-07-01 14:45:00”.**

Click for answer

*Answer:*

```
example_date_time <- ymd_hms("2022-07-01 14:45:00")
extracted_components <- tibble(
  year = year(example_date_time),
  month = month(example_date_time),
  day = day(example_date_time),
  hour = hour(example_date_time),
  minute = minute(example_date_time)
)
extracted_components
```

```
# A tibble: 1 x 5
  year month   day hour minute
  <dbl> <dbl> <int> <int> <int>
1  2022     7     1    14     45
```

#### 14.2.5 e. Advanced Date-Time Arithmetic with Periods: Add 2 months and 15 days to “2021-08-01”.

Click for answer

*Answer:*

```
initial_date <- ymd("2021-08-01")
new_date <- initial_date + months(2) + days(15)
new_date
```

```
[1] "2021-10-16"
```

#### 14.2.6 f. Duration and Time Differences: Calculate the duration in days, weeks, months, and years between “2019-04-01” and “2022-04-01”.

Click for answer

*Answer:*

```
start_date <- ymd("2019-04-01")
end_date <- ymd("2022-04-01")
time_diff <- end_date - start_date
duration_days <- as.duration(time_diff)
duration_weeks <- duration_days / dweeks(1)
duration_months <- duration_days / dmonths(1)
duration_years <- duration_days / dyears(1)
```

```
duration_results <- tibble(  
  days = duration_days,  
  weeks = duration_weeks,  
  months = duration_months,  
  years = duration_years  
)  
duration_results
```

```
# A tibble: 1 x 4  
  days                weeks months years  
  <Duration>          <dbl>  <dbl> <dbl>  
1 94694400s (~3 years)  157.   36.0  3.00
```

## Chapter 15

### Class Activity 9

```
# load the necessary libraries
library(tidyverse)
```

#### 15.1 Your Turn 1

##### 15.1.1 a) read\_csv()

Use `read_csv()` to import the `desserts` data set from <https://raw.githubusercontent.com/deepbas/statdatasets/main/desserts.csv>. Use `glimpse` to see if the data import is alright.

```
url <- "https://raw.githubusercontent.com/deepbas/statdatasets/main/desserts.csv"
desserts <- read_csv(url)
glimpse(desserts)
```

```
Rows: 549
Columns: 16
$ series      <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1~
$ episode     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1~
$ baker       <chr> "Annetha", "David", "Edd", "~
$ technical   <chr> "2nd", "3rd", "1st", "N/A", ~
$ result      <chr> "IN", "IN", "IN", "IN", "IN"~
$ uk_airdate   <chr> "17 August 2010", "17 August~
$ us_season   <dbl> NA, NA, NA, NA, NA, NA, NA, ~
$ us_airdate   <date> NA, NA, NA, NA, NA, NA, NA, ~
$ showstopper_chocolate <chr> "chocolate", "chocolate", "n~
```

```

$ showstopper_dessert    <chr> "other", "other", "other", "~
$ showstopper_fruit     <chr> "no fruit", "no fruit", "no ~
$ showstopper_nut       <chr> "no nut", "no nut", "no nut"~
$ signature_chocolate   <chr> "no chocolate", "chocolate",~
$ signature_dessert      <chr> "cake", "cake", "cake", "cak~
$ signature_fruit        <chr> "no fruit", "fruit", "fruit"~
$ signature_nut          <chr> "no nut", "no nut", "no nut"~

```

### 15.1.2 b) Are there any issues with the data import? If so, what are they?

Click for answer

*Answer:* Based on the output of glimpse, we can see that the ‘technical’ column should be a numeric column and the ‘uk\_airstate’ column should be a date column. We can also identify any issues with missing values.

*# your r-code*

```

desserts <- read_csv(url,
  col_types = list(
    technical = col_number(),
    uk_airstate = col_date()
  )
)

problems(desserts)

```

```

# A tibble: 556 x 5
   row   col expected      actual      file
  <int> <int> <chr>         <chr>    <chr>
1     2     6 date in ISO8601 17 August 2010 ""
2     3     6 date in ISO8601 17 August 2010 ""
3     4     6 date in ISO8601 17 August 2010 ""
4     5     4 a number      N/A      ""
5     5     6 date in ISO8601 17 August 2010 ""
6     6     6 date in ISO8601 17 August 2010 ""
7     7     4 a number      N/A      ""
8     7     6 date in ISO8601 17 August 2010 ""
9     8     6 date in ISO8601 17 August 2010 ""
10    9     4 a number      N/A      ""
# ... with 546 more rows

```

### 15.1.3 c) Import the dataset with correct data types, if needed. Fix the problems, if any.

Click for answer

```
desserts <- read_csv(url,
  col_types = list(
    technical = col_number(),
    uk_airdate = col_date()
  )
)

problems(desserts)
```

# A tibble: 556 x 5

|    | row   | col   | expected        | actual         | file  |
|----|-------|-------|-----------------|----------------|-------|
|    | <int> | <int> | <chr>           | <chr>          | <chr> |
| 1  | 2     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 2  | 3     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 3  | 4     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 4  | 5     | 4     | a number        | N/A            | ""    |
| 5  | 5     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 6  | 6     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 7  | 7     | 4     | a number        | N/A            | ""    |
| 8  | 7     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 9  | 8     | 6     | date in ISO8601 | 17 August 2010 | ""    |
| 10 | 9     | 4     | a number        | N/A            | ""    |

# ... with 546 more rows

```
desserts <- read_csv(url,
  col_types = list(
    technical = col_number(),
    uk_airdate = col_date(format = "%d %B %Y")
  )
)

problems(desserts)
```

# A tibble: 7 x 5

|   | row   | col   | expected | actual | file  |
|---|-------|-------|----------|--------|-------|
|   | <int> | <int> | <chr>    | <chr>  | <chr> |
| 1 | 5     | 4     | a number | N/A    | ""    |
| 2 | 7     | 4     | a number | N/A    | ""    |
| 3 | 9     | 4     | a number | N/A    | ""    |

```

4   11      4 a number N/A    ""
5   35      4 a number N/A    ""
6   36      4 a number N/A    ""
7   37      4 a number N/A    ""

```

```

desserts <- read_csv(url,
  col_types = list(
    technical = col_number(),
    uk_airdate = col_date(format = "%d %B %Y")
  ),
  na = c("", "NA", "N/A")
)

problems(desserts)

```

```

# A tibble: 0 x 5
# ... with 5 variables: row <int>, col <int>,
#   expected <chr>, actual <chr>, file <chr>

```

## 15.2 Your Turn 2

Use the appropriate `read_<type>()` function to import the following data sets:

- <https://deepbas.io/data/simple-1.dat>
- <https://deepbas.io/data/mild-1.csv>
- <https://deepbas.io/data/tricky-1.csv>
- <https://deepbas.io/data/tricky-2.csv>

Identify and fix any issues you encounter.

### 15.2.1 a) Importing simple data:

Click for answer

```

simple1 <- readr::read_csv("https://deepbas.io/data/simple-1.dat")
problems(simple1)

```

```

# A tibble: 0 x 5
# ... with 5 variables: row <int>, col <int>,
#   expected <chr>, actual <chr>, file <chr>

```



### 15.2.2 b) Importing mildly tricky data:

Click for answer

```
mild1 <- readr::read_delim("https://deepbas.io/data/mild-1.csv", delim = "|")
problems(mild1)
```

```
# A tibble: 0 x 5
# ... with 5 variables: row <int>, col <int>,
#   expected <chr>, actual <chr>, file <chr>
```

### 15.2.3 c) Importing tricky data 1:

Click for answer

```
tricky1 <- read_csv("https://deepbas.io/data/tricky-1.csv")
problems(tricky1)
```

```
# A tibble: 2 x 5
   row   col expected actual   file
  <int> <int> <chr>      <chr>   <chr>
1     4     4 5 columns 4 columns ""
2     7     4 5 columns 4 columns ""
```

*# Fix missing values*

```
tricky1[3, ] <- c(tricky1[3, 1:2], NA, tricky1[3, 3:4])
tricky1[6, ] <- c(tricky1[4, 1], NA, tricky1[4, 3:5])
```

### 15.2.4 d) Importing tricky data 2:

Click for answer

```
tricky2 <- read_csv("https://deepbas.io/data/tricky-2.csv")
problems(tricky2)
```

```
# A tibble: 0 x 5
# ... with 5 variables: row <int>, col <int>,
#   expected <chr>, actual <chr>, file <chr>
```

```
# Fix missing values
tricky2_part1 <- read_csv("https://deepbas.io/data/tricky-2.csv", n_max = 7) %>%
  separate(city, c("city", "state"), sep = ",") %>%
  select(-c(7))

tricky2_part2 <- read_csv(
  "https://deepbas.io/data/tricky-2.csv",
  skip = 8,
  col_names = c("iata", "airport", "city", "state", "latitude", "longitude")
)

# Combine parts
data_combined <- full_join(tricky2_part1, tricky2_part2)
```

## Chapter 16

# Class Activity 10

```
# load the necessary libraries
library(tidyverse)
library(tidyr)
```

### 16.1 Your Turn 1

```
students <- tibble(
  id = 1:24,
  grade = sample(c("9th", "10th", "11th"), 24, replace = TRUE),
  region = sample(c("North America", "Europe", "Asia", "South America", "Middle East", "Africa"),
  score = round(runif(24,50, 100))
)
```

- 16.1.1 a. Create a new column `grade_fac` by converting the `grade` column into a factor. Reorder the levels of `grade_fac` to be “9th”, “10th”, and “11th”. Sort the dataset based on the `grade_fac` column.

Click for answer

*Answer:*

```
students_a <- students %>%
  mutate(grade_fac = factor(grade)) %>%
```

```
mutate(grade_fac = fct_relevel(grade_fac, c("9th", "10th", "11th"))) %>%
  arrange(grade_fac)
print(students_a, n = 24)
```

```
# A tibble: 24 x 5
   id grade region      score grade_fac
  <int> <chr> <chr>      <dbl> <fct>
1     6 9th   Africa      67 9th
2     7 9th   Middle East  84 9th
3    10 9th   Asia       77 9th
4    20 9th   Europe      80 9th
5     2 10th  South America 87 10th
6     4 10th  Asia       74 10th
7     5 10th  North America 65 10th
8     9 10th  Asia       80 10th
9    12 10th  Middle East  86 10th
10    13 10th  Africa      55 10th
11    14 10th  South America 60 10th
12    15 10th  Africa      60 10th
13    17 10th  Europe      86 10th
14    18 10th  Africa      64 10th
15    22 10th  Asia       86 10th
16    24 10th  Africa      53 10th
17     1 11th  Africa      57 11th
18     3 11th  North America 79 11th
19     8 11th  Asia       59 11th
20    11 11th  North America 86 11th
21    16 11th  Asia       96 11th
22    19 11th  Middle East  83 11th
23    21 11th  Middle East  68 11th
24    23 11th  North America 62 11th
```

**16.1.2 b.** Create a new column `region_fac` by converting the `region` column into a factor. Collapse the `region_fac` levels into three categories: “Americas”, “EMEA” and “Asia”. Count the number of students in each collapsed region category.

Click for answer

*Answer:*

```
students_b <- students_a %>%
  mutate(region_fac = factor(region)) %>%
  mutate(region_collapsed = fct_collapse(region_fac,
                                          Americas = c("North America", "South America"),
                                          EMEA = c("Europe", "Middle East", "Africa"),
                                          Asia = "Asia")) %>%
  count(region_collapsed)
print(students_b)
```

```
# A tibble: 3 x 2
  region_collapsed    n
  <fct>            <int>
1 EMEA              12
2 Asia               6
3 Americas          6
```

**16.1.3 c.** Create a new column `grade_infreq` that is a copy of the `grade_fac` column. Reorder the levels of `grade_infreq` based on their frequency in the dataset. Print the levels of `grade_infreq` to check the ordering.

Click for answer

*Answer:*

```
students_c <- students_a %>%
  mutate(grade_infreq = grade_fac) %>%
  mutate(grade_infreq = fct_infreq(grade_infreq))

levels(students_c$grade_infreq)
```

```
[1] "10th" "11th" "9th"
```

**16.1.4 d.** Create a new column `grade_lumped` by lumping the least frequent level of the `grade_fac` column into an ‘Others’ category. Count the number of students in each of the categories of the `grade_lumped` column.

Click for answer

*Answer:*

```
students_d <- students_a %>%
  mutate(grade_lumped = fct_lump(grade_fac, n = 1, other_level = "Others")) %>%
  count(grade_lumped)
students_d
```

```
# A tibble: 2 x 2
  grade_lumped     n
  <fct>         <int>
1 10th             12
2 Others           12
```

## 16.2 Your Turn 2

Lets import the `gss_cat` dataset from the `forcats` library. This datast contains a sample of categorical variables from the General Social survey.

```
# import gss_cat dataset from forcats library
forcats::gss_cat
```

```
# A tibble: 21,483 x 9
   year marital      age race  rincome partyid relig denom
  <int> <fct>      <int> <fct> <fct>   <fct>   <fct> <fct>
1  2000 Never marr~   26 White $8000 ~ Ind,ne~ Prot~ Sout~
2  2000 Divorced    48 White $8000 ~ Not st~ Prot~ Bapt~
3  2000 Widowed    67 White Not ap~ Indepe~ Prot~ No d~
4  2000 Never marr~   39 White Not ap~ Ind,ne~ Orth~ Not ~
5  2000 Divorced    25 White Not ap~ Not st~ None  Not ~
6  2000 Married    25 White $20000~ Strong~ Prot~ Sout~
7  2000 Never marr~   36 White $25000~ Not st~ Chri~ Not ~
8  2000 Divorced    44 White $7000 ~ Ind,ne~ Prot~ Luth~
9  2000 Married    44 White $25000~ Not st~ Prot~ Other
10 2000 Married    47 White $25000~ Strong~ Prot~ Sout~
# ... with 21,473 more rows, and 1 more variable:
#   tvhours <int>
```

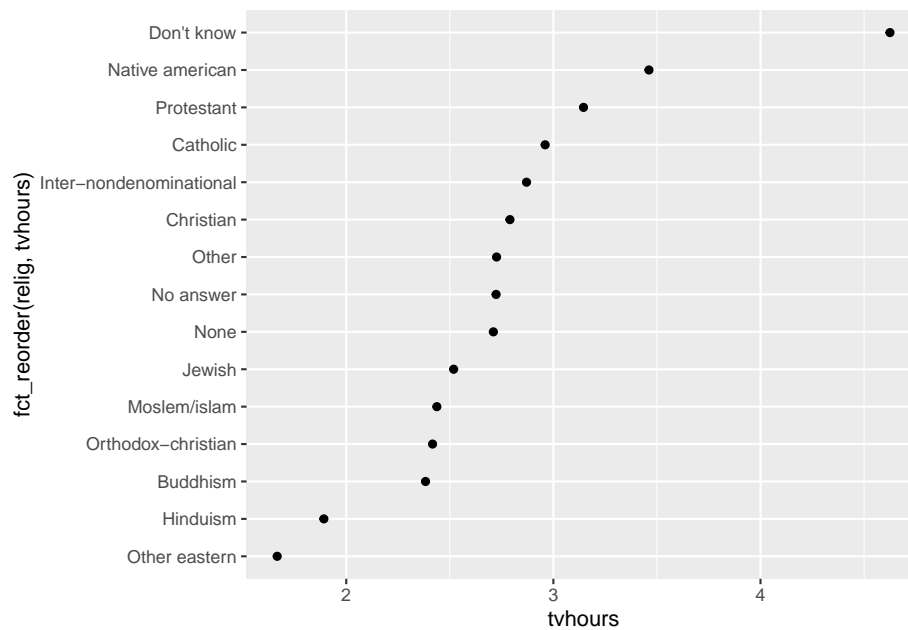
Use `gss_cat` to answer the following questions.

### 16.2.1 a. Which religions watch the least TV?

Click for answer

*Answer:*

```
# your r-code
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(relig) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(aes(tvhours, fct_reorder(relig, tvhours))) +
  geom_point()
```

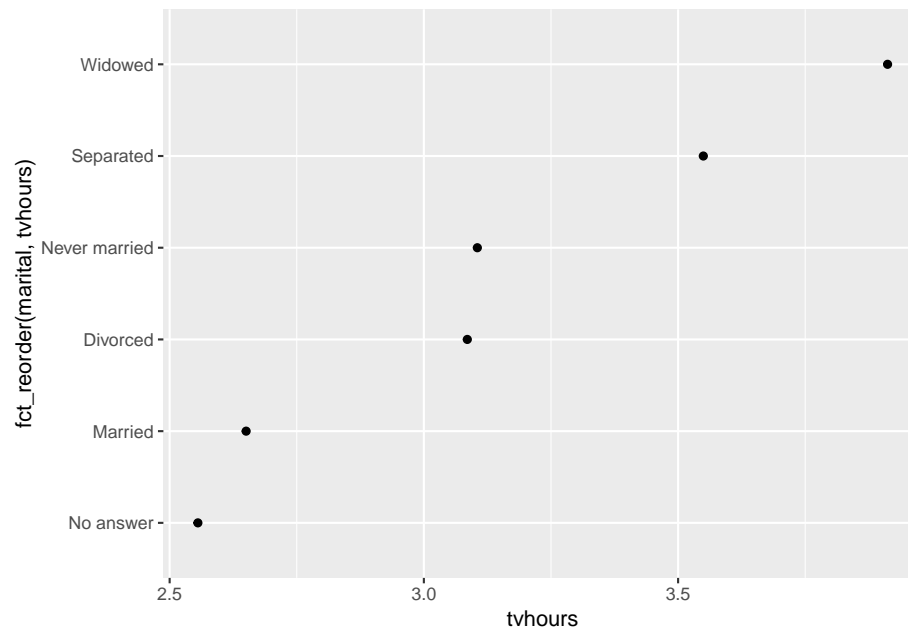


### 16.2.2 b. Do married people watch more or less TV than single people?

Click for answer

Answer:

```
# your r-code
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(marital) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(aes(tvhours, fct_reorder(marital, tvhours))) +
  geom_point()
```



**16.2.3 c.** Collapse the marital variable to have levels `married`, `not_married`, and `no_answer`. Include "Never married", "Divorced", and "Widowed" in `not_married`

Click for answer

Answer:

```
# your r-code
gss_cat %>%
  drop_na(tvhours) %>%
  select(marital, tvhours) %>%
  mutate(
    maritalStatus =
      fct_collapse(
        marital,
        married = c("Married",
                     "Separated"),
        not_married = c("Never married",
                        "Divorced",
                        "Widowed"),
        no_answer = c("No answer"))
  ) -> marital_c
```



```
levels(marital_c$maritalStatus)
```

```
[1] "no_answer" "not_married" "married"
```



## Chapter 17

# Class Activity 11

```
# load the necessary libraries
library(tidyverse)
library(stringr)
```

### 17.1 Problem 1

Let's learn about combining strings with different separators first.

```
place <- "Central Park"
activity <- "jogging"
activities <- c("jogging", "picnicking", "boating")
my_sentence <- str_c(place, " is great for ", activity, ".", sep = "")
my_sentence
```

```
[1] "Central Park is great for jogging."
```

- a. What happens when a `str_c` entry is a vector?

Click for answer

*Answer:* When an entry in `str_c` is a vector, it will combine the strings with each element of the vector, creating multiple combined strings.

```
my_sentences <- str_c(place, " is great for ", activities, ".", sep = "")
my_sentences
```

```
[1] "Central Park is great for jogging."  
[2] "Central Park is great for picnicking."  
[3] "Central Park is great for boating."
```

b. How do you combine strings with `str_glue`?

Click for answer

*Answer:* You can combine strings with `str_glue` using curly braces `{}` to insert variables directly into the string.

```
my_sentence <- str_glue("{place} is great for {activity}.")  
my_sentence
```

Central Park is great for jogging.

```
my_sentences1 <- str_glue("{place} is great for {activities}.")  
my_sentences1
```

Central Park is great for jogging.  
Central Park is great for picnicking.  
Central Park is great for boating.

c. What does `str_flatten` do?

Click for answer

*Answer:* `str_flatten` collapses a character vector into a single string by concatenating the elements with a specified separator.

```
str_flatten(my_sentences, collapse = " and ")
```

```
[1] "Central Park is great for jogging. and Central Park is great for picnicking. and C
```

d. What will using a `\n` separator do in the command below?

Click for answer

*Answer:* Using a `\n` separator in the command will insert a newline character between the strings being combined, making them display on separate lines when printed.

```
p <- str_c(place, " is great for ", activity, sep = "\n")
writeLines(p)
```

```
Central Park
  is great for
jogging
```

e. Does `str_length` count spaces and special characters??

[Click for answer](#)

*Answer:* Yes, `str_length` counts spaces and special characters as part of the string's length.

```
p
```

```
[1] "Central Park\n is great for \njogging"
```

```
str_length(p)
```

```
[1] 35
```

f. How do you count the number of `e`'s in a string?

[Click for answer](#)

*Answer:* You can count the number of `e`'s in a string using `str_count` with a pattern that matches the character `'e'`.

```
text <- "The quick brown fox jumps over the lazy dog."
pattern <- "e"
vowel_count <- str_count(text, pattern)
vowel_count
```

```
[1] 3
```

g. What happens with negative positions?

[Click for answer](#)

*Answer:* Negative positions in `str_sub` count the positions from the end of the string rather than from the beginning.

```
str_sub(my_sentence, start = -3, end = -1)
```

```
[1] "ng."
```

- h. How do you extract a **substring** with positive and negative positions?

Click for answer

*Answer:* You can extract a **substring** with positive and negative positions using `str_sub` and specifying the start and end positions with either positive or negative numbers.

```
my_sentence <- "Central Park is great for jogging."
positive_substr <- str_sub(my_sentence, start = 1, end = 12)
negative_substr <- str_sub(my_sentence, start = -8, end = -1)
positive_substr
```

```
[1] "Central Park"
```

```
negative_substr
```

```
[1] "jogging."
```

- i. With a vector of positions?

Click for answer

*Answer:* Using a vector of positions with `str_sub` will extract **substrings** starting and ending at the specified positions in the vector.

```
str_sub(my_sentence, start = c(1, 9), end = c(4, 15))
```

```
[1] "Cent"      "Park is"
```

- j. How do you extract multiple **substrings** using a vector of positions?

Click for answer

*Answer:* You can extract multiple **substrings** using a vector of positions with `str_sub` by specifying the start and end positions in separate vectors.

```
my_sentence <- "Central Park is great for jogging."
substrs <- str_sub(my_sentence, start = c(1, 14, 24), end = c(12, 19, 30))
substrs
```

```
[1] "Central Park" "is gre"      "or jogg"
```

---

## 17.2 Problem 2

- a. Use the string parsing functions that you learned today to do tasks described in the comments below:

```
s1 <- "12%" # remove %
s2 <- "New Jersey_*" # remove _*
s3 <- "2,150" # remove comma(,)
s4 <- "Learning #datascience is fun!" # extract #datascience
s5 <- "123 Main St, Springfield, MA, 01101" # separate info
```

Click for answer

```
# Cleaning steps
s1_clean <- str_replace(s1, "%", "")
s2_clean <- str_replace(s2, "_\\*", "")
s3_clean <- str_replace(s3, ",", "")
s4_clean <- str_extract(s4, "#\\w+")
s5_clean <- str_split(s5, ",\\s?")

# Print cleaned strings
s1_clean
```

```
[1] "12"
```

```
s2_clean
```

```
[1] "New Jersey"
```

```
s3_clean
```

```
[1] "2150"
```

```
s4_clean
```

```
[1] "#datascience"
```

```
s5_clean
```

```
[[1]]
```

```
[1] "123 Main St" "Springfield" "MA" "01101"
```

### 17.3 Problem 3

- a. Use the string parsing functions that you learned today to do tasks described in the comments below:

```
s1 <- "25%" # remove %
s2 <- "Los Angeles_#" # remove _#
s3 <- "1,250" # remove comma(,)
s4 <- "Discover #machinelearning today!" # extract #machinelearning
s5 <- "456 Main St, San Francisco, CA, 94107" # separate info
```

Click for answer

```
# Cleaning steps
s1_clean <- str_replace(s1, "%", "")
s2_clean <- str_replace(s2, "_#", "")
s3_clean <- str_replace(s3, ",", "")
s4_clean <- str_extract(s4, "#\\w+")
s5_clean <- str_split(s5, ",\\s?")

# Print cleaned strings
s1_clean
```

```
[1] "25"
```

```
s2_clean
```

```
[1] "Los Angeles"
```

```
s3_clean
```

```
[1] "1250"
```



```
s4_clean
```

```
[1] "#machinelearning"
```

```
s5_clean
```

```
[[1]]
[1] "456 Main St"   "San Francisco" "CA"
[4] "94107"
```

## 17.4 Problem 4

- a. Let's look at the following dataset containing information about movies and their release years. We'll extract the release year from the movie title, create a new column with decades, and count the number of movies in each decade.

```
# Sample dataset
movies <- tibble(
  title = c(
    "The Godfather (1972)", "Pulp Fiction (1994)", "The Dark Knight (2008)",
    "Forrest Gump (1994)", "The Shawshank Redemption (1994)", "The Matrix (1999)",
    "Inception (2010)", "Interstellar (2014)", "Parasite (2019)", "Fight Club (1999)"
  )
)
movies
```

```
# A tibble: 10 x 1
  title
<chr>
1 The Godfather (1972)
2 Pulp Fiction (1994)
3 The Dark Knight (2008)
4 Forrest Gump (1994)
5 The Shawshank Redemption (1994)
6 The Matrix (1999)
7 Inception (2010)
8 Interstellar (2014)
9 Parasite (2019)
10 Fight Club (1999)
```

[Click for answer](#)

```
# Processing the dataset
movies_processed <- movies %>%
  mutate(
    release_year = as.integer(str_extract(title, "\\d{4}")),
    decade = floor(release_year / 10) * 10
  ) %>%
  count(decade) %>%
  rename(num_movies = n)

# Print the processed dataset
movies_processed
```

```
# A tibble: 4 x 2
  decade num_movies
  <dbl>     <int>
1  1970         1
2  1990         5
3  2000         1
4  2010         3
```

## Chapter 18

# Class Activity 12

In-class midterm!



## Chapter 19

# Class Activity 13

```
# load the necessary libraries
library(stringr)
library(dplyr)
library(readr)
```

In this tutorial, we will learn about string manipulations using regular expressions and the `stringr` library in R. We will cover different examples and use cases to help you understand the concepts and functions related to string manipulation.

### 19.1 Group Activity 1

```
x <- "My SSN is 593-29-9502 and my age is 55"
y <- "My phone number is 612-643-1539"
z <- "My old SSN number is 39532 9423."
out <- str_flatten(c(x,y,z), collapse = ". ")
```

19.1.1 a. What characters in `x` will `str_view_all(x, "-..-")` find?

Click for answer

*answer:*

The pattern searches for a dash, followed by any two characters, followed by another dash. In `x`, it finds “-29-” which is a part of the SSN.

```
str_view_all(x, "-.-")
```

```
[1] | My SSN is 593<-29->9502 and my age is 55
```

### 19.1.2 b. What pattern will `str_view_all(x, "-\\d{2}-")` find?

Click for answer

*answer:*

The pattern searches for a dash, followed by two digits, followed by another dash. In `x`, it finds the same “-29-” as in the previous example, which is a part of the SSN.

```
str_view_all(x, "-\\d{2}-") # "-" then 2 digits then "-"
```

```
[1] | My SSN is 593<-29->9502 and my age is 55
```

### 19.1.3 c. What pattern will `str_view_all(out, "\\d{2}\\.*")` find?

Click for answer

*answer:*

The pattern searches for two digits followed by an optional period. In `out`, it finds “55” and “55.”, which represent the age in the first sentence.

```
str_view_all(out, "\\s\\d{2}\\.*") # 2 digits then "."
```

```
[1] | My SSN is 593-29-9502 and my age is< 55.> My phone number is 612-643-1539. My ol
```

### 19.1.4 d. Use `str_view_all` to determine the correct regex pattern to identify all SSN in `out`

We can get the SSN with the usual format (###-##-####) with a regex that has 3, 2, and 4 digits separated by a dash.

```
str_view_all(out,"([0-8]\\d{2})-(\\d{2})-(\\d{4})")
```

```
[1] | My SSN is <593-29-9502> and my age is 55. My phone number is 612-643-1539. My ol
```

This misses the oddly formatted SSN in the third entry. Rather than use a dash, we can specify the divider as `[-\\s]?` which allows either 0 or 1 occurrences of either a dash or space divider:

```
str_view_all(out, "([0-8]\\d{2})[-\\s]?(\\d{2})[-\\s]?(\\d{4})")
```

```
[1] | My SSN is <593-29-9502> and my age is 55. My phone number is 612-643-1539. My old SSN number
```

Click for answer

*answer:*

The first pattern finds the SSNs in the standard format (###-##-####) by searching for 3 digits, a dash, 2 digits, another dash, and 4 digits. The second pattern does the same but allows for a space instead of a dash as a divider. It finds all SSNs in out, including the oddly formatted one in the third sentence.

### 19.1.5 e. Write a regular expression to extract dates in the format YYYY-MM-DD from a given text.

```
date_pattern <- "\\d{4}-\\d{2}-\\d{2}"
text <- "The event will take place on 2023-07-20 and end on 2023-07-22."
str_extract_all(text, date_pattern)
```

```
[[1]]
[1] "2023-07-20" "2023-07-22"
```

Click for answer

*Answer:* The pattern searches for 4 digits, a dash, 2 digits, another dash, and 2 digits. In the given text, it finds the dates “2023-07-20” and “2023-07-22”.

### 19.1.6 f. Write a regular expression to extract all words that start with a capital letter in a given text.

```
capital_pattern <- "\\b[A-Z][a-zA-Z]*\\b"
text <- "Alice and Bob went to the Market to buy some Groceries."
str_extract_all(text, capital_pattern)
```

```
[[1]]
[1] "Alice"      "Bob"        "Market"     "Groceries"
```

Click for answer

*Answer:* The pattern searches for a word boundary, followed by an uppercase letter, and then any sequence of letters. In the given text, it finds the words “Alice”, “Bob”, “Market”, and “Groceries”.

### 19.1.7 g (Optional) Create a regular expression to match URLs, considering both http and https protocols.

```
url_pattern <- "https?://(?:[a-zA-Z0-9-]+\\.)+[a-zA-Z]{2,}(?:\\d+)?(?:/\\S*)?"
urls <- c("https://www.example.com", "http://example.org/resource?query=123", "invalid")
str_view(urls, url_pattern)
```

```
[1] | <https://www.example.com>
[2] | <http://example.org/resource?query=123>
```

Click for answer

*Answer:* The pattern searches for either “http://” or “https://”, followed by one or more domain segments separated by periods, an optional port number, and an optional path. In the given urls, it matches the first two valid URLs but not the invalid one.

**https?://:** This part matches the URL protocol (http or https). The ? means that the preceding character “s” is optional. **(?:[a-zA-Z0-9-]+\\.)+:** This part matches the domain name. The (?: ) is a non-capturing group, and [a-zA-Z0-9-]+ matches one or more alphanumeric characters or hyphens. The \\. matches a period (dot), and the + outside the group means that the pattern inside the group should occur one or more times. **[a-zA-Z]{2,}:** This part matches the top-level domain (TLD), such as .com or .org, which has at least two alphabetic characters. **(?:\\d+)?:** This part is an optional group that matches a colon followed by one or more digits. It is used to specify a port number in the URL. The ? outside the group makes it optional. **(?:/\\S\*)?:** This part is another optional group that matches a forward slash followed by zero or more non-whitespace characters (representing the URL path). Again, the ? outside the group makes it optional.

---



## 19.2 Group Activity 2

### 19.2.1 a. Let's deal with a number string that is longer than 9 digits.

```
ssn <- "([0-8]\\d{2})[-\\s]?(\\d{2})[-\\s]?(\\d{4})"
test <- c("123-45-67890", "1123 45 6789")
str_view_all(test, ssn)
```

```
[1] | <123-45-6789>0
[2] | 1<123 45 6789>
```

This example captures a 9-digit string as an SSN, but these strings are longer than 9 digits and may not represent an SSN. One way to deal with this is to use the negative lookbehind `?<!` and negative lookahead `?!` operators to ensure that the identified 9-digit string does not have a leading 0 or does not contain more digits.

If we “look behind” from the start of the SSN, we should not see another digit:

```
str_view_all(test, "(?<!(\\d)([0-8]\\d{2})[-\\.\\s]?(\\d{2})[-\\.\\s]?(\\d{4})")
```

```
[1] | <123-45-6789>0
[2] | 1123 45 6789
```

And if we “look ahead” from the end of the SSN, we should not see another digit:

```
str_view_all(test, "(?<!(\\d)([0-8]\\d{2})[-\\.\\s]?(\\d{2})[-\\.\\s]?(\\d{4})(?!\\d)")
```

```
[1] | 123-45-67890
[2] | 1123 45 6789
```

For parts b and c, consider the following string.

```
string1 <- "100 dollars 100 pesos"
```

### 19.2.2 b. Explain why the following matches the first 100 and not the second.

Click for answer

*answer:* It looks for one or more digits followed by a space and `dollars`

```
str_view(string1, "\\d+(?= dollars)")
```

```
[1] | <100> dollars 100 pesos
```

### 19.2.3 c. Explain why the following matches the second 100 and not the first.

Click for answer

*answer:* It looks for one or more digits not followed by either a digit or space followed by dollars

```
str_view(string1, "\\d+(?!\\d| dollars)")
```

```
[1] | 100 dollars <100> pesos
```

For parts d and e, please take a look at `string2`.

```
string2 <- "USD100 PES0100"
```

### 19.2.4 d. Explain why the following matches the first 100 and not the second.

Click for answer

*answer:* It looks for exactly 3 digits preceded by USD

```
str_view(string2, "(?<=USD)\\d{3}")
```

```
[1] | USD<100> PES0100
```

### 19.2.5 e. Explain why the following matches the second 100 and not the first.

Click for answer

*answer:* It looks for exactly 3 digits that is not preceded by USD

```
str_view(string2, "(?!USD)\\d{3}")
```

```
[1] | USD100 PES0<100>
```

---

## 19.3 Group Activity 3

```
tweets<- read_csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/TrumpTweetData.csv")
```

**19.3.1 a.** What proportion of tweets (text) mention “America”?

```
tweets %>%  
  summarize(prop = mean(str_detect(str_to_title(text), "America")))
```

```
# A tibble: 1 x 1  
  prop  
  <dbl>  
1 0.0926
```

Click for answer

*Answer:* About 10% of tweets mention “America”.

**19.3.2 b.** What proportion of these tweets include “great”?

```
tweets %>% filter(str_detect(str_to_title(text), "America")) %>%  
  summarize(prop = mean(str_detect(str_to_lower(text), "great")))
```

```
# A tibble: 1 x 1  
  prop  
  <dbl>  
1 0.4
```

Click for answer

*Answer:* About 40% of tweets mention “great”.

**19.3.3 c.** What proportion of the tweets mention @?

```
tweets %>% mutate(ct = str_count(text, "@")) %>%
  select(text, ct) %>%
  summarize(prop = mean(ct>0))
```

```
# A tibble: 1 x 1
  prop
  <dbl>
1 0.317
```

Click for answer

*Answer:* About 32% of tweets mention @.

#### 19.3.4 d. Remove the tweets having mentions @.

```
Mentions <- c("@[^\\s]+")
```

```
tw_noMentions <- tweets %>% mutate(textNoMentions = str_replace_all(text, Mentions, ""))
tw_noMentions$text[38]
```

```
[1] "My daughter @IvankaTrump will be on @Greta tonight at 7pm. Enjoy! https://t.co/QySC5PLFMy"
```

```
tw_noMentions$textNoMentions[38]
```

```
[1] "My daughter  will be on  tonight at 7pm. Enjoy! https://t.co/QySC5PLFMy"
```

Click for answer

*Answer:* @: This part of the pattern matches the “@” symbol, which usually indicates the beginning of a mention in a tweet. `[^\\s]+`: This part of the pattern matches one or more characters that are NOT whitespaces. The `^` inside the square brackets `[ ]` negates the character class (meaning it matches any character that is NOT in the specified class). The double backslash `\\s` is used to escape the backslash in the R string, so the pattern `\\s` represents the whitespace character class `\\s`. Finally, the `+` indicates that the pattern should match one or more occurrences of the non-whitespace characters. Together, this regular expression pattern `@[^\\s]+` matches any mention in a tweet, which usually starts with “@” followed by one or more non-whitespace characters.

**19.3.5 e. What poportion of tweets originated from an iPhone?**

```
tweets %>% group_by(source) %>% summarize(count = n()) %>%  
  mutate(prop = count / sum(count)) %>% filter(source == "iPhone")
```

```
# A tibble: 1 x 3  
  source count  prop  
  <chr>  <int> <dbl>  
1 iPhone    628 0.415
```

Click for answer

*Answer:* About 42% of the tweets originated from an iPhone.



## Chapter 20

# Class Activity 14

```
# load the necessary libraries
library(wordcloud)
library(reshape2)
library(tidyverse)
library(tidyr)
library(tidytext)
library(dplyr)
```

### 20.1 Group Activity 1

#### 20.1.1 a. Variance and Skewness

The variance of a random variable  $x$  is defined as:

$$\text{Var}(x) = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

where  $x_i = (\sum_i^n x_i)/n$  is the sample mean. Also, the skewness of the random variable  $x$  is defined as:

$$\text{Skew}(x) = \frac{\frac{1}{n-2} \left( \sum_{i=1}^n (x_i - \bar{x})^3 \right)}{\text{Var}(x)^{3/2}}$$

Please write functions to calculate the variance and skewness of  $\{12, 45, 54, 34, 56, 30, 67, \text{NA}\}$ .

```
x <- c(12, 45, 54, 34, 56, 30, 67, NA)
```

Click for answer

```
# function to calculate the variance of a vector
var <- function(x){
  x <- na.omit(x) # omit NA values
  sum((x - mean(x)) ^ 2) / (length(x) - 1)
}
```

```
var(x)
```

```
[1] 346.619
```

```
# function to calculate the skewness of a vector
skewness <- function(x) {
  x <- na.omit(x) # omit NA values
  sum((x - mean(x)) ^ 3) / ((length(x) - 2) * var(x) ^ (3 / 2))
}
```

```
skewness(x)
```

```
[1] -0.3930586
```

### 20.1.2 b. Conditions and breaks

Create a function that iterates through a numeric vector and stops when it encounters the first negative number, returning the position of that negative number. If there are no negative numbers in the vector, the function should return a message stating that there are no negative numbers.

Click for answer

```
find_first_negative <- function(x) {
  negative_positions <- which(x < 0)

  if (length(negative_positions) > 0) {
    return(paste("The first negative number is at position", negative_positions[1]))
  } else {
    return("There are no negative numbers in the vector")
  }
}
```



```
test_vector <- c(5, 12, -7, 20, 15)
find_first_negative(test_vector)
```

```
[1] "The first negative number is at position 3"
```

---

## 20.2 Group Activity 2

```
musical_instr_reviews <- read_csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/musical_instr_reviews.csv")
rename(musical_instr_reviews, ratingOverall = overall)
glimpse(musical_instr_reviews)
```

```
Rows: 10,261
Columns: 3
$ reviewerName <chr> "cassandra tu \"Yeah, well, that's j~
$ reviewText <chr> "not much to write about here but it~
$ ratingOverall <dbl> 5, 5, 5, 5, 5, 5, 5, 3, 5, 5, 5, 4, ~
```

### 20.2.1 a. Write a function to filter the dataset based on the provided rating:

Click for answer

```
filter_reviews_by_rating <- function(data, rating) {
  data %>% filter(ratingOverall == rating)
}
```

### 20.2.2 b. Write a function to process the text and remove stop words:

Click for answer

```
process_text <- function(data) {
  data %>%
    select(reviewText) %>%
    unnest_tokens(output = word, input = reviewText) %>%
    anti_join(stop_words)
}
```

### 20.2.3 c. Write a function to join the processed text with sentiment data and create a word count table.

Click for answer

```
create_word_count_table <- function(data) {
  data %>%
    inner_join(get_sentiments("bing")) %>%
    count(word, sentiment, sort = TRUE) %>%
    reshape2::acast(word ~ sentiment, value.var = "n", fill = 0)
}
```

### 20.2.4 d. Create the final function that takes the rating and number of words as input arguments and returns a word cloud plot.

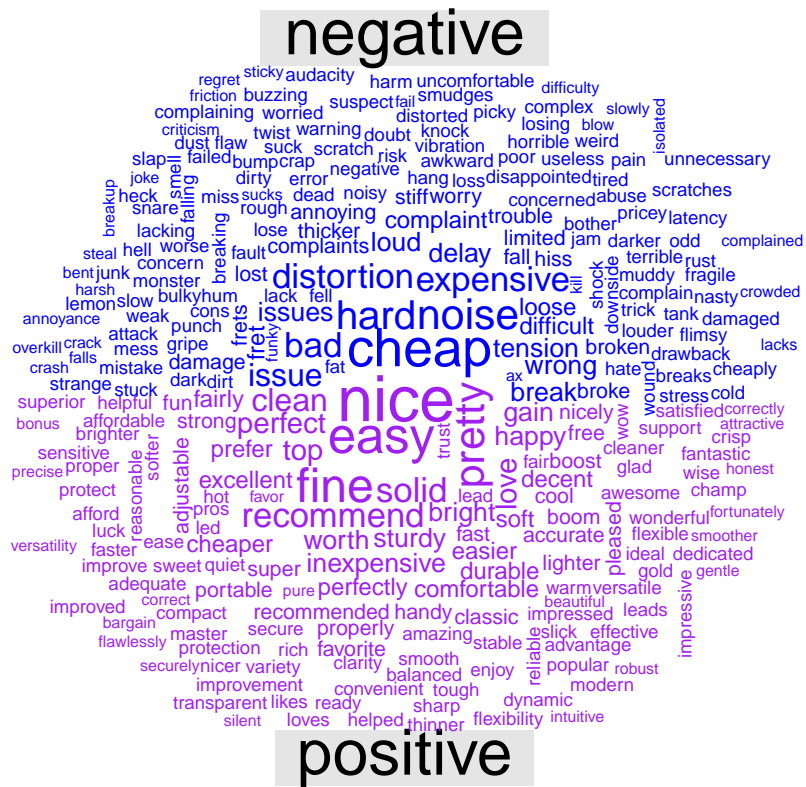
Click for answer

```
word_cloud <- function(rating, num.words) {
  rating <- as.numeric(rating)
  num.words <- as.numeric(num.words)

  if (rating >= 1 & rating <= 5) {
    filtered_reviews <- filter_reviews_by_rating(musical_instr_reviews, rating)
    processed_reviews <- process_text(filtered_reviews)
    word_count_table <- create_word_count_table(processed_reviews)

    comparison.cloud(
      word_count_table,
      colors = c("blue", "purple"),
      scale = c(2, 0.5),
      max.words = num.words,
      title.size = 2
    )
  } else {
    warning(" Please enter a rating from 1 to 5")
  }
}

word_cloud(rating = "4", num.words = 300)
```





## Chapter 21

### Class Activity 15

```
# load the necessary libraries
library(tidyverse)
library(dplyr)
library(stringr)

energy <- read_csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/energy.csv",
  col_type = cols(
    .default = col_double(),
    Timestamp = col_datetime(format = ""),
    dayWeek = col_factor(levels=c("Mon", "Tues", "Wed", "Thurs", "Fri", "Sat", "Sun"))
  )
)
```

#### 21.1 Group Activity 1

##### 21.1.1 a. if and for loop

Write a for loop to iterate over the columns of the ‘energy’ dataset and print the names of all columns containing the string “House”. Please use the function `colnames()` to extract the column names and store the results in a list.

Click for answer

*Answer:*

```
# Create an empty list to store the column names
house_columns <- list()
```

```
# Iterate over the columns of the 'energy' dataset
for (i in seq_along(colnames(energy))) {
  col_name <- colnames(energy)[i]

  # Check if the column name contains the string "House"
  if (str_detect(col_name, "House")) {
    # Add the column name to the list
    house_columns[[length(house_columns) + 1]] <- col_name
  }
}

# Print the list of house columns
house_columns <- unlist(house_columns)
house_columns
```

```
[1] "Allen_House"
[2] "Alumni_Guest_House/Johnson_House"
[3] "Benton_House"
[4] "Berg_House"
[5] "Bird_House"
[6] "Chaney_House"
[7] "Clader_House"
[8] "Dacie_Moses_House"
[9] "Douglas_House"
[10] "Farm_House"
[11] "Geffert_House"
[12] "Headley_House"
[13] "Henrickson_House"
[14] "Henry_House"
[15] "Hill_House"
[16] "Hilton_House"
[17] "Hoppin_House_(Alumni)"
[18] "Huntington_House"
[19] "Jewett_House"
[20] "Jones_House"
[21] "Nutting_House"
[22] "Page_House_West"
[23] "Parish_House_"
[24] "Parr_House"
[25] "Pollock_House"
[26] "Prentice_House"
[27] "Rayment_House"
[28] "Rice_House"
[29] "Rogers_House"
[30] "Ryberg_House"
```

```
[31] "Seccombe_House"  
[32] "Sperry_House"  
[33] "Stimson_House"  
[34] "Strong_House"  
[35] "Whittier_House"  
[36] "Wilson_House"
```

### 21.1.2 b. for loop and mean

Using a for loop, calculate and print the mean energy consumption of houses you identified in part a.

Click for answer

*Answer:*

```
# Assuming the house_columns vector from the previous step  
  
# Create an empty numeric vector to store the mean energy consumption  
mean_energy_consumption <- numeric()  
  
# Iterate over the house_columns vector  
for (house_col in house_columns) {  
  # Calculate the mean energy consumption for the current house column  
  mean_val <- mean(energy[[house_col]], na.rm = TRUE)  
  
  # Add the mean energy consumption to the vector  
  mean_energy_consumption <- c(mean_energy_consumption, mean_val)  
}  
  
# Combine the house names and mean energy consumption into a dataframe  
house_mean_energy <- bind_cols(House = house_columns, MeanEnergyConsumption = mean_energy_consumption)  
  
# Print the dataframe  
house_mean_energy %>% knitr::kable()
```

| House                            | MeanEnergyConsumption |
|----------------------------------|-----------------------|
| Allen_House                      | 0.9821865             |
| Alumni_Guest_House/Johnson_House | 20.2631152            |
| Benton_House                     | 1.8849290             |
| Berg_House                       | 1.3174340             |
| Bird_House                       | 2.3222680             |
| Chaney_House                     | 1.0715123             |
| Clader_House                     | 0.4646776             |
| Dacie_Moses_House                | 1.2776465             |
| Douglas_House                    | 0.7219500             |
| Farm_House                       | 5.0599020             |
| Geffert_House                    | 0.9360400             |
| Headley_House                    | 1.4555605             |
| Henrickson_House                 | 3.4407858             |
| Henry_House                      | 1.3639619             |
| Hill_House                       | 1.4735884             |
| Hilton_House                     | 0.4248030             |
| Hoppin_House_(Alumni)            | 1.8760474             |
| Huntington_House                 | 1.2395238             |
| Jewett_House                     | 0.8987697             |
| Jones_House                      | 0.8680271             |
| Nutting_House                    | 4.3967234             |
| Page_House_West                  | 1.8923490             |
| Parish_House__                   | 12.6793378            |
| Parr_House                       | 9.7210618             |
| Pollock_House                    | 1.1831426             |
| Prentice_House                   | 0.9089497             |
| Rayment_House                    | 0.8005664             |
| Rice_House                       | 1.1568457             |
| Rogers_House                     | 0.5634289             |
| Ryberg_House                     | 1.0729988             |
| Seccombe_House                   | 2.6874199             |
| Sperry_House                     | 0.7052983             |
| Stimson_House                    | 2.0659904             |
| Strong_House                     | 2.5410595             |
| Whittier_House                   | 1.0424369             |
| Wilson_House                     | 1.0435830             |

## 21.2 Group Activity 2

1. Make a data frame of quantiles for `energy` buildings in columns 9-90 (you will need `na.rm = TRUE`)



Click for answer

*Answer:*

```
qdf <- energy %>% select(9:90) %>%
  map_dfc(quantile, probs = seq(.1,.9,.1), na.rm = TRUE)
qdf
```

```
# A tibble: 9 x 82
  100_Neva~1 104_M~2 106_W~3 Allen~4 Alumn~5 Arbor~6 Art_S~7
    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>
1    0.0972    1.04    0.601    0.756    17.0     0.13     0.23
2    0.120     1.11    0.632    0.781    18.1     0.23     0.28
3    0.183     1.18    0.673    0.941    18.4     0.25     0.33
4    0.461     1.18    0.681    0.983    20.3     0.28     0.4
5    0.710     1.42    0.692    1.00     21.0     0.32     0.47
6    0.795     1.42    0.865    1.01     21.8     0.38     0.57
7    0.915     1.54    1.10     1.07     21.9     0.44     0.73
8    1.11      1.56    1.20     1.07     22      0.52     0.88
9    1.24      1.67    1.27     1.25     22.5     0.71     1.09
# ... with 75 more variables: Benton_House <dbl>,
#   Berg_House <dbl>, Bird_House <dbl>,
#   Boliou_Memorial_Art_Bldg. <dbl>, Burton_Hall <dbl>,
#   `Cassat_Hall_/James_Hall` <dbl>,
#   `Center_for_Mathematics_&Computing` <dbl>,
#   Chaney_House <dbl>, Clader_House <dbl>,
#   College_Warehouse <dbl>, Cowling_Gym <dbl>, ...
```

## 2. Add a variable to identify the quantile

Click for answer

*Answer:*

```
qdf <- energy %>% select(9:90) %>%
  map_dfc(quantile, probs = seq(.1,.9,.1), na.rm = TRUE) %>%
  mutate(stat = str_c("quantile_", seq(10,90,10)))
qdf
```

```
# A tibble: 9 x 83
  100_Neva~1 104_M~2 106_W~3 Allen~4 Alumn~5 Arbor~6 Art_S~7
    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>
1    0.0972    1.04    0.601    0.756    17.0     0.13     0.23
2    0.120     1.11    0.632    0.781    18.1     0.23     0.28
3    0.183     1.18    0.673    0.941    18.4     0.25     0.33
4    0.461     1.18    0.681    0.983    20.3     0.28     0.4
```

```

5      0.710      1.42  0.692  1.00      21.0      0.32  0.47
6      0.795      1.42  0.865  1.01      21.8      0.38  0.57
7      0.915      1.54  1.10   1.07      21.9      0.44  0.73
8      1.11      1.56  1.20   1.07      22        0.52  0.88
9      1.24      1.67  1.27   1.25      22.5      0.71  1.09
# ... with 76 more variables: Benton_House <dbl>,
#   Berg_House <dbl>, Bird_House <dbl>,
#   Boliou_Memorial_Art_Bldg. <dbl>, Burton_Hall <dbl>,
#   `Cassat_Hall/_James_Hall` <dbl>,
#   `Center_for_Mathematics_&Computing` <dbl>,
#   Chaney_House <dbl>, Clader_House <dbl>,
#   College_Warehouse <dbl>, Cowling_Gym <dbl>, ...

```

3. Reshape the data frame to make variables `stat` (describing the quantile), `building` and `quant` (quantile value)

Click for answer

*Answer:*

```

qdf <- energy %>% select(9:90) %>%
  map_dfc(quantile, probs = seq(.1,.9,.1), na.rm = TRUE) %>%
  mutate(stat = str_c("quantile_", seq(10,90,10))) %>%
  pivot_longer(names_to = "building", values_to = "quantiles", 1:82)
qdf

```

```

# A tibble: 738 x 3
   stat      building      quantiles
  <chr>      <chr>      <dbl>
1 quantile_10 100_Nevada_Street  0.0972
2 quantile_10 104_Maple_St.    1.04
3 quantile_10 106_Winona_St.    0.601
4 quantile_10 Allen_House  0.756
5 quantile_10 Alumni_Guest_House/Johnson_House 17.0
6 quantile_10 Arboretum_Office  0.13
7 quantile_10 Art_Studios    0.23
8 quantile_10 Benton_House   1.59
9 quantile_10 Berg_House     1.06
10 quantile_10 Bird_House    1.42
# ... with 728 more rows

```

4. Plot the KWH value for each quantile on the x-axis for the buildings Sayles-Hill, Language\_&\_Dining\_Center, Olin\_Hall\_of\_Science

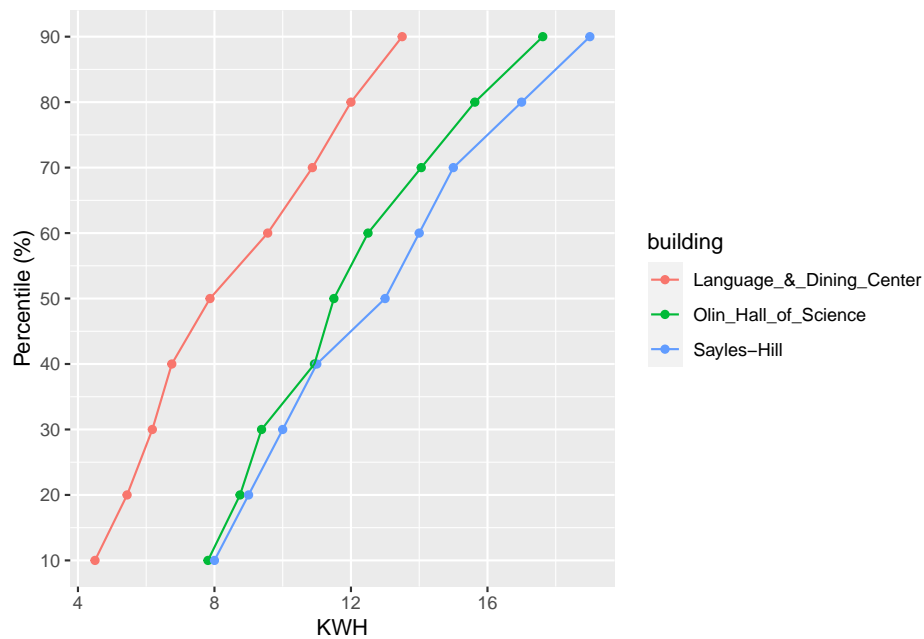
Click for answer

*Answer:*

```

qdf %>%
  filter(building %in% c("Sayles-Hill", "Language_&_Dining_Center", "Olin_Hall_of_Science")) %>%
  ggplot(aes(x=quantiles, y=parse_number(stat), color=building)) +
  geom_point() +
  geom_line(aes(group=building)) +
  labs(y="Percentile (%)", x="KWH") +
  scale_y_continuous(breaks=seq(10,90,by=10))

```





## Chapter 22

# Class Activity 16

```
# load the necessary libraries
library(tidyverse)
library(stringr)
library(polite)
library(rvest)
```

### 22.1 Group Activity 1

```
url <- 'https://www.imdb.com/search/title/?groups=best_picture_winner&sort=year,desc&count=100&vi
webpage <- bow(url) %>% scrape()
```

As seen in the slides, we can extract the movie titles using the `.lister-item-header` a css selector.

```
title_data <- webpage %>%
  html_nodes(css = ".lister-item-header a") %>%
  html_text()
```

Now, lets scrape other elements of the webpage one by one using the selector gadget tool.

#### 22.1.1 a. Use the selector gadget tool to find the CSS for extracting year the movie came out.

- Tidy the data

- Using `parse_number()`
- Using any regex

Click for answer

```
year_data <- webpage %>%
  html_nodes(css = '.text-muted.unbold') %>%
  html_text() %>%
  parse_number()

year_data1 <- webpage %>%
  html_nodes(css = '.text-muted.unbold') %>%
  html_text() %>%
  str_extract_all("[0-9]+") %>%
  unlist() %>%
  as.numeric()
```

**22.1.2 b.** Next, parse the webpage to produce a vector of the descriptions. Tidy the description by removing unwanted regexes.

Click for answer

```
description_data <- webpage %>%
  html_nodes('.ratings-bar+ .text-muted') %>%
  html_text() %>%
  str_trim()
head(description_data,3)
```

```
[1] "A middle-aged Chinese immigrant is swept up into an insane adventure in which she
[2] "As a CODA (Child of Deaf Adults) Ruby is the only hearing person in her deaf fami
[3] "A woman in her sixties, after losing everything in the Great Recession, embarks on
```

**22.1.3 c.** Now, parse the runtime data by following similar tools used for extracting year.

Click for answer

```
runtime_data <- webpage %>%
  html_nodes('.runtime') %>%
  html_text() %>%
  parse_number()
head(runtime_data)
```

```
[1] 139 111 107 132 130 123
```

#### 22.1.4 d. Do the same for getting the ratings data using an appropriate selector.

Click for answer

```
rating_data <- webpage %>%  
  html_nodes('.ratings-imdb-rating') %>%  
  html_text() %>%  
  as.numeric()
```

#### 22.1.5 e. Finally, get the number of votes following similar tools

Click for answer

```
votes_data <- webpage %>%  
  html_nodes('.sort-num_votes-visible span:nth-child(2)') %>%  
  html_text() %>%  
  parse_number()
```

We can combine all the information we scraped to produce a nice table that we can use for further analysis. Please run the following code, once you are done with the prior codes.

Click for answer

```
movies_df <- data.frame(Year = year_data,  
                        Title = title_data,  
                        Description = description_data,  
                        Runtime = runtime_data,  
                        Rating = rating_data,  
                        Votes = votes_data) %>% as_tibble()  
movies_df %>% knitr::kable()
```

| Year | Title   | Description  |
|------|---|--|
| 2022 | Everything Everywhere All at Once               | A middle-aged Chinese immigrant is swept up by an bizarre forces when an eccentric (Michelle Yeoh) turns up dead.  |
| 2021 | CODA  | As a CODA (Child of Deaf Adults) Ruby is the only hearing person in her deaf family.   |
| 2020 | Nomadland                                       | A woman in her sixties, after losing everything, finds a new way of life by working as a seasonal migrant worker.  |
| 2019 | Parasite  | Greed and class discrimination threaten the newly formed symbiotic relationship between the two parallel K-class societies.  |
| 2018 | Green Book                                      | A working-class Italian-American bouncer becomes the driver of an African-American pianist on a tour of southern America.  |
| 2017 | The Shape of Water                              | At a top secret research facility in the 1960s, a lonely janitor forms a unique connection with a non-verbal subject.  |
| 2016 | Moonlight                                       | A young African-American man grapples with his sexual orientation and his economic circumstances.  |
| 2015 | Spotlight                                       | The true story of how the Boston Globe uncovered the massive scandal of child molesters and cover-ups within the local Catholic Archdiocese.                                 |
| 2014 | Birdman or (The Unexpected Virtue of Ignorance) | A washed-up superhero actor attempts to revive his fading career by writing, directing, and starring in a new film about himself.  |
| 2013 | 12 Years a Slave                                | In the antebellum United States, Solomon, a free black man, is kidnapped and sold into slavery.  |
| 2012 | Argo  | Acting under the cover of a Hollywood producer, a CIA operative and a team of exiles rescue six Americans from Iran.   |
| 2011 | The Artist                                      | An egomaniacal film star develops a relationship with a silent movie newcomer.   |
| 2010 | The King's Speech                               | The story of King George VI, his impersonal speech therapist, and the personal sacrifices that allowed the King to lead his people through the darkest days of World War II. |
| 2008 | Slumdog Millionaire                             | A Mumbai teenager reflects on his life after winning the Indian version of the game show "Who Wants to Be a Millionaire?"  |
| 2008 | The Hurt Locker                                 | During the Iraq War, a Sergeant recently transferred to an elite bomb squad must learn to live and work with two other squad members.  |
| 2007 | No Country for Old Men                          | Violence and mayhem ensue after a hunter stumbles upon a drug deal gone bad and the brutal aftermath.  |
| 2006 | The Departed                                    | An undercover cop and a mole in the police attempt to identify each other while infiltrating an Irish gang in South Boston.  |
| 2004 | Crash   | Los Angeles citizens with vastly separate backgrounds are forced to interact under dire circumstances.   |
| 2004 | Million Dollar Baby                             | A determined woman works with a hardened boxing trainer to become a professional.  |
| 2003 | The Lord of the Rings: The Return of the King   | Gandalf and Aragorn lead the World of Men against Sauron, the dark lord of the Rings.  |
| 2002 | Chicago   | Two death-row murderesses develop a fierce rivalry while on trial.   |
| 2001 | A Beautiful Mind                                | After John Nash, a brilliant but asocial mathematician, accepts a position at Princeton University, he uncovers a secret of mental warfare.                                  |
| 2000 | Gladiator                                       | A former Roman General sets out to exact revenge on the corrupt and tyrannical emperor.  |
| 1999 | American Beauty                                 | A sexually frustrated suburban father has a mid-life crisis after his son is kicked out of school.   |
| 1998 | Shakespeare in Love                             | The world's greatest ever playwright, William Shakespeare, falls in love with a woman who is not even born yet.  |
| 1997 | Titanic   | A seventeen-year-old aristocrat falls in love with a kind but poor artist on the night of the ship's sinking.  |
| 1996 | The English Patient                             | At the close of World War II, a young nurse falls for a man who is a spy and a traitor.  |
| 1995 | Braveheart                                      | Scottish warrior William Wallace leads his fellow countrymen against the English king Edward I.  |
| 1994 | Forrest Gump                                    | The presidencies of Kennedy and Johnson; the height of the Cold War; and the 1960s civil rights movement.  |
| 1993 | Schindler's List                                | In German-occupied Poland during World War II, a Jewish businessman saves the lives of his Jewish workers.   |
| 1992 | Unforgiven                                      | Retired Old West gunslinger William Munny reluctantly takes on three bachelors aiming to kill the town's drunk.  |
| 1991 | The Silence of the Lambs                        | A young F.B.I. cadet must receive the help of an incarcerated and manipulative cannibal killer to help catch another serial killer.  |
| 1990 | Dances with Wolves                              | Lieutenant John Dunbar, assigned to a remote post, befriends and joins the band of a Sioux chief.  |
| 1989 | Driving Miss Daisy                              | An old Jewish woman and her African-American chauffeur form a bond while she outmaneuvers her grasping son.  |
| 1988 | Rain Man  | After a selfish L.A. yuppie learns his estranged father has a mentally disabled son, he takes him on a road trip.  |
| 1987 | The Last Emperor                                | Dramatization of China's last emperor, Puyi, who was forced to renounce his throne at a young age.   |
| 1986 | Platoon   | Chris Taylor, a neophyte recruit in Vietnam, witnesses the harrowing battlefield experiences of his platoon.   |
| 1985 | Out of Africa                                   | In 20th-century colonial Kenya, a Danish aristocrat falls in love with a local African man.  |
| 1984 | Amadeus   | The life, success and troubles of Wolfgang Amadeus Mozart, as told by Salieri, his bitter rival.   |
| 1983 | Terms of Endearment                             | Follows hard-to-please Aurora looking for love and happiness.  |
| 1982 | Gandhi  | The life of the lawyer who became the father of the Indian independence movement.  |
| 1981 | Chariots of Fire                                | Two British track athletes, one a determined underdog and the other a professional, compete for the 1924 Olympic Games.  |
| 1980 | Ordinary People                                 | The accidental death of the older son of a family of well-to-do people.  |
| 1979 | Kramer vs. Kramer                               | After his wife leaves him, a work-obsessed father must learn to raise their young son on his own.  |
| 1978 | The Deer Hunter                                 | An in-depth examination of the ways in which the Vietnam War affects the lives of a group of friends.  |
| 1977 | Annie Hall                                      | Alvy Singer, a divorced Jewish comedian, looks back on his relationship with Annie Hall.   |
| 1976 | Rocky   | A small-time Philadelphia boxer gets a sudden shot at the world title when he falls for a heavyweight champion's daughter.   |
| 1975 | One Flew Over the Cuckoo's Nest                 | In the Fall of 1963, a Korean War veteran is committed to a mental institution.  |
| 1974 | The Godfather Part II                           | The early life and career of Vito Corleone in 1920s New York City.   |
| 1973 | The Sting                                       | Two grifters team up to pull off the ultimate scam.  |
| 1972 | The Godfather                                   | The aging patriarch of an organized crime dynasty in post-war New York City.   |
| 1971 | The French Connection                           | A pair of NYPD detectives in the Narcotics Unit track down a heroin smuggler.  |
| 1970 | Patton  | The World War II phase of the career of General George S. Patton.  |



---

## 22.2 Group Activity 2

### 22.2.1 a. Scrape the names, scores, and years of most popular TV shows on IMDB:

`www.imdb.com/chart/tvmeter`. Create a data frame called `tvshows` with four variables (`rank`, `name`, `score`, `year`)

Note:

It's easier to use the `SelectorGadget` and choose the CSS selectors wisely. Otherwise, you'll have more cleaning to do after scraping.

---

## 22.3 Group Activity 3

### 22.3.1 a. Scrape the first table in `List_of_NASA_missions` wiki page. Additionally, use `janitor::clean_names()` to clean the column names and store the resulting table as `NASA_missions.csv` in your working folder.

### 22.3.2 b. Now, write a code snippet to scrape all the URLs from the anchor tags (`<a>`) on a given Wikipedia page, convert the relative URLs to absolute URLs, and store the results in a tibble and save it as `websites.csv` in your working folder.

Click for answer



# Extra Materials



## Chapter 23

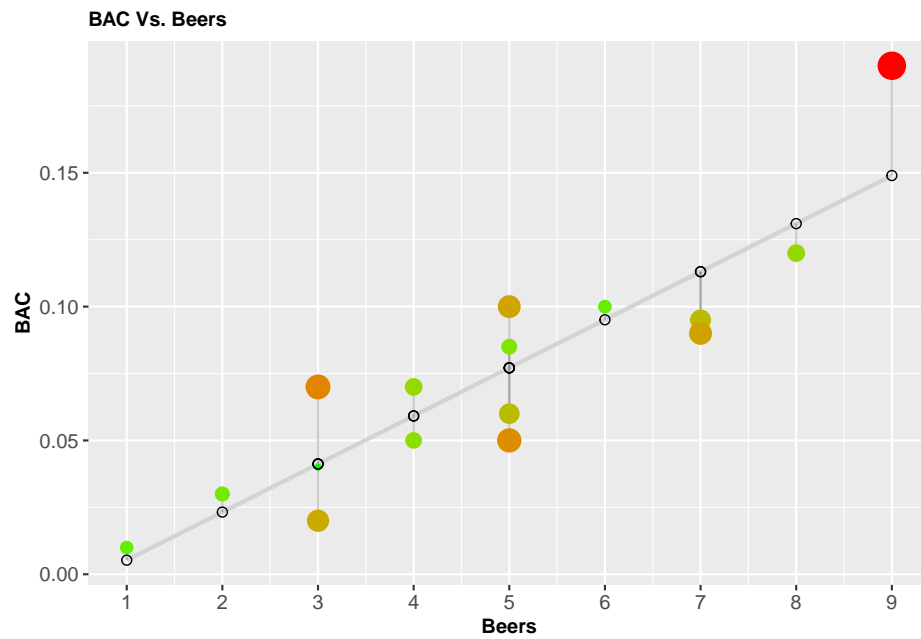
# Helpful R codes

### 23.1 Residual Plots in ggplot2

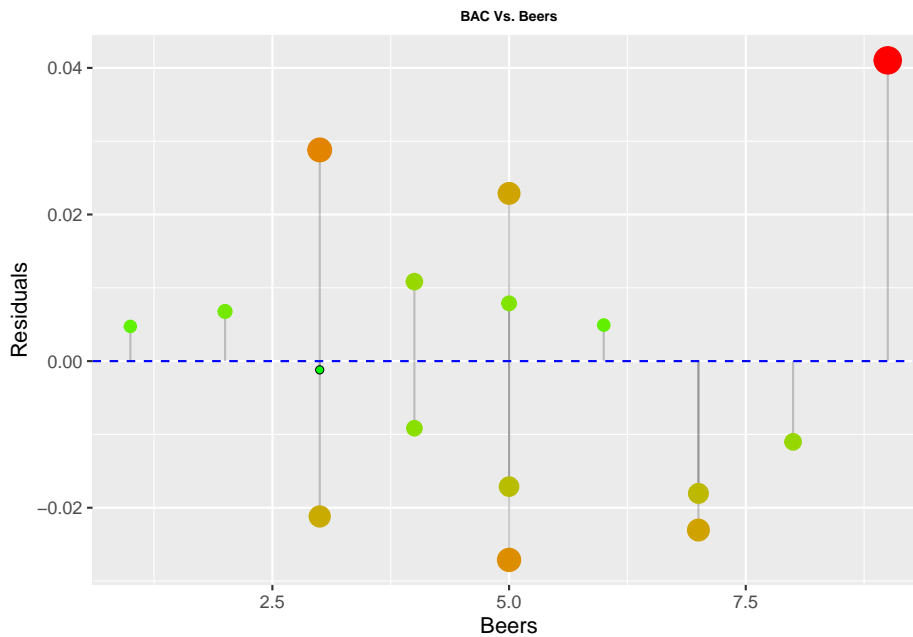
```
# residual size plot
library(ggplot2)
bac <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/BAC.csv")

fit <- lm(BAC ~ Beers, data = bac) # fit the model
bac$predicted <- predict(fit) # Save the predicted values
bac$residuals <- residuals(fit) # Save the residual values

ggplot(bac, aes(x = Beers, y = BAC)) +
  geom_smooth(method = "lm", se = FALSE, color = "lightgrey") + # regression line
  geom_segment(aes(xend = Beers, yend = predicted), alpha = .2) + # draw line from point to
  geom_point(aes(color = abs(residuals), size = abs(residuals))) + # size of the points
  scale_color_continuous(low = "green", high = "red") +
  labs(title = "BAC Vs. Beers") +# color of the points mapped to residual size - green smaller, red larger
  guides(color = FALSE, size = FALSE) + # Size legend removed
  geom_point(aes(y = predicted), shape = 1, size = 2) +
  scale_x_continuous(breaks=1:9)+
  theme(axis.text=element_text(size=10),
        axis.title=element_text(size=10,face="bold"),
        plot.title = element_text(size = 10, face = "bold"))
```



```
ggplot(bac, aes(x = Beers, y = residuals)) +
  geom_point() +
  theme(legend.position = "none") +
  geom_segment(aes(xend = Beers, yend = 0), alpha = .2) +
  scale_color_continuous(low = "green", high = "red") +
  geom_point(aes(color = abs(residuals), size = abs(residuals))) + # size of the point
  geom_hline(yintercept = 0, col = "blue", size = 0.5, linetype = "dashed") +
  labs(title = "BAC Vs. Beers",
       x = "Beers",
       y = "Residuals") +
  theme(plot.title = element_text(hjust=0.5, size=7, face='bold'))
```



## 23.2 Plotly codes

```
library(plotly)

cell_phone_data <- data.frame(
  Type = c("Android", "iPhone", "Blackberry", "Non Smartphone", "No Cell Phone"),
  Frequency = c(458, 437, 141, 924, 293)
)

data <- data.frame(
  Gender = c("Female", "Male"),
  In_a_relationship = c(32, 10),
  Its_complicated = c(12, 7),
  Single = c(63, 45)
)

plot_ly(cell_phone_data, labels = ~Type, values = ~Frequency, type = 'pie',
  textposition = 'inside', hoverinfo = 'label+value+percent',
  textinfo = 'label', insidetextfont = list(color = '#FFFFFF')) %>%
  layout(title = 'Cell Phone Usage',
    xaxis = list(showgrid = FALSE, zeroline = FALSE, showticklabels = FALSE),
    yaxis = list(showgrid = FALSE, zeroline = FALSE, showticklabels = FALSE))
```

```
plot_ly(data, x = ~Gender, y = ~In_a_relationship, type = 'bar', name = 'In a relationship')
add_trace(y = ~Its_complicated, name = 'It\'s complicated') %>%
add_trace(y = ~Single, name = 'Single') %>%
layout(yaxis = list(title = 'Number of People'), barmode = 'group')
```