One of the greatest strengths of R, relative to other programming languages, is the ease with which we can create publication-quality graphics. In this lesson, you'll learn about base graphics in R.

We do not cover more advanced portions of graphics in R in this lesson. These include lattive, ggplot2 and ggvis.

There is a school of thought that this apprach is backwards, that we should teach ggplot2 first. See http://varianceexplained.org/r/teach_ggplot2_to_beginners/ for an outline of this view.

Load the included data frame cars with data(cars)

```
data(cars)
```

To fix ideas, we will work with simple data frames. Our main goal is to introduce various plotting functions and their arguments. All the output would look more interesting with larger, more complex data sets.

Pull up the help page for cars.

As you can see in the help page, the cars data set has only two variables: speed and stopping distance. Note that the data is from the 1920s.

Run head() on the cars data.

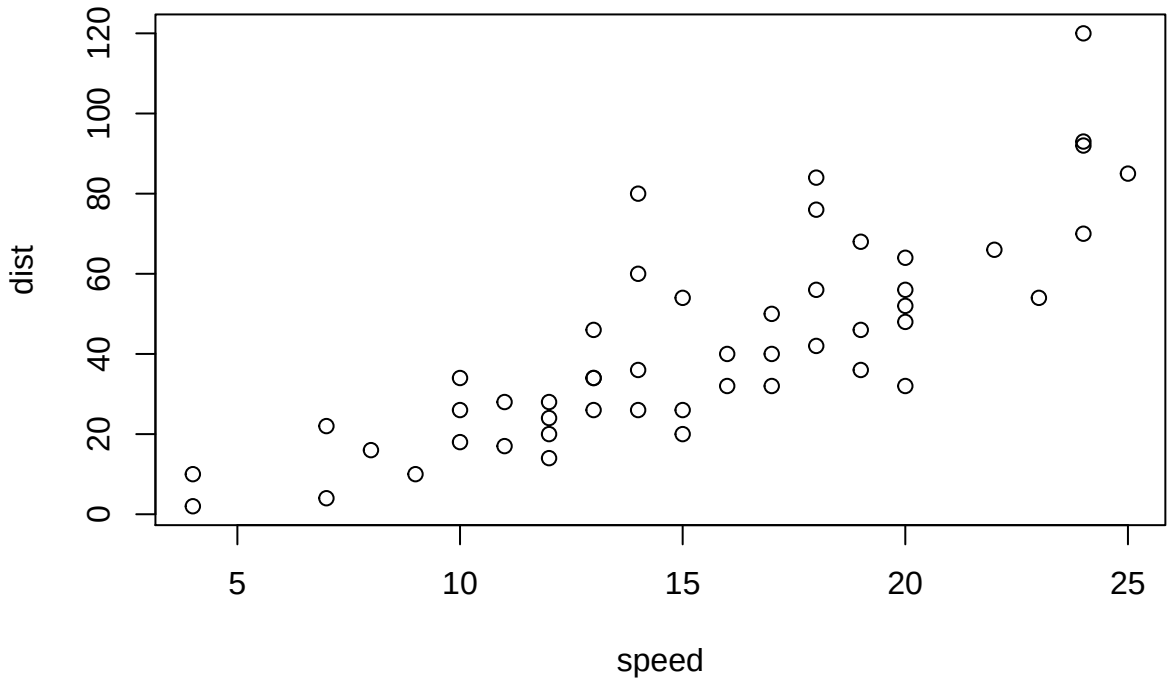
```
head(cars)
```

```
##   speed dist
## 1     4    2
## 2     4   10
## 3     7    4
## 4     7   22
## 5     8   16
## 6     9   10
```

Before plotting, it is always a good idea to get a sense of the data. Key R commands for doing so include, **dim(), names(), head(), tail()** and **summary()**.

Run the plot() command on the cars data frame.

```
plot(cars)
```



As always, R tries very hard to give you something sensible given the information that you have provided to it. First, R notes that the data frame you have given it has just two columns, so it assumes that you want to plot one column verses the other.

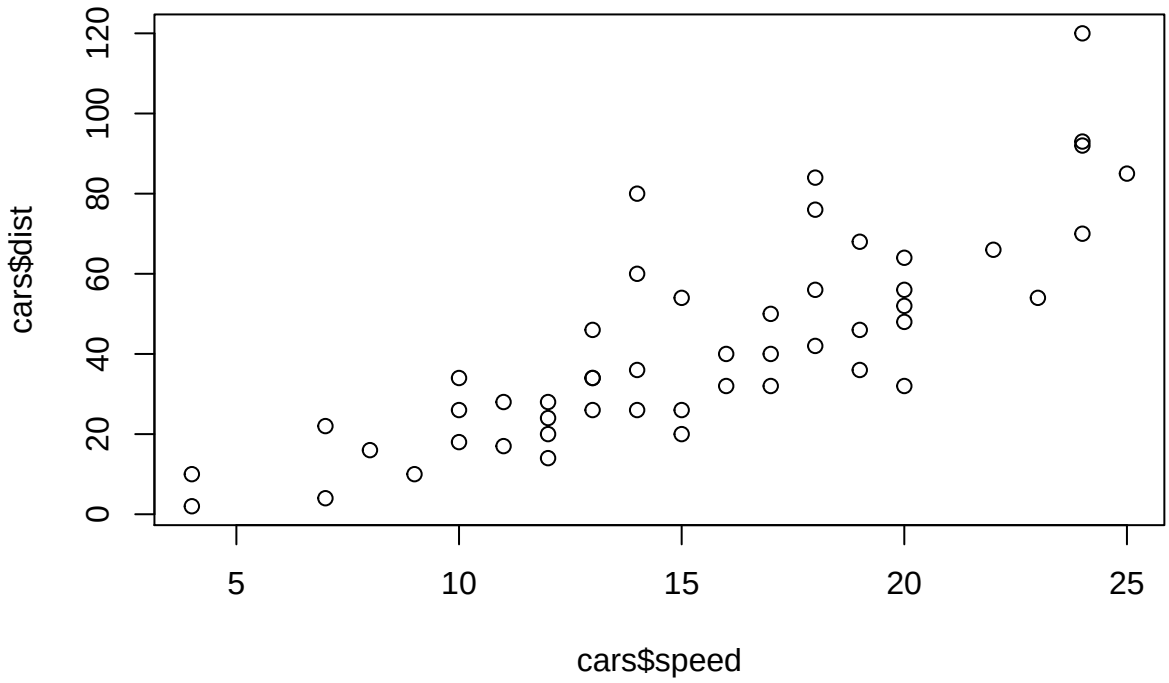
Second, since we do not provide labels for either axis, R uses the names of the columns. Third, it creates axis tick marks at nice round numbers and labels them accordingly. Forth, it uses the other defaults supplied in plot().

We will now spend some time exploring plot, but many of the topics covered here will apply to most other R graphics functions. Note that **plot** is short for scatterplot.

Look up the help page for plot.

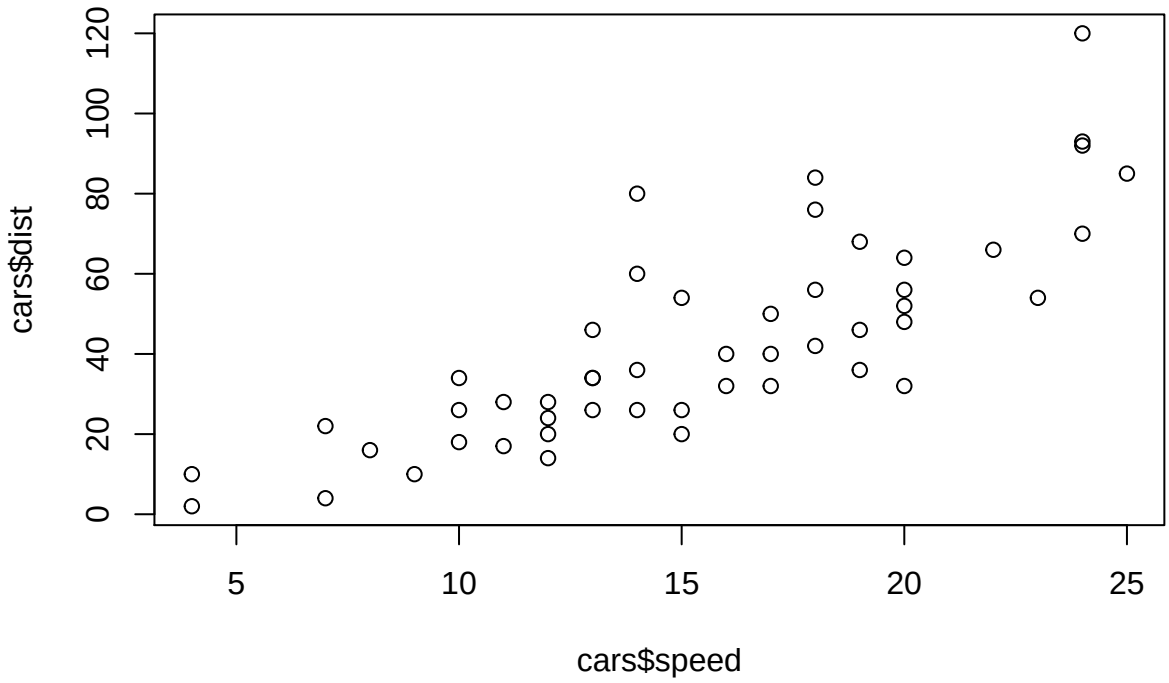
The help page for plot() highlights the different arguments that the function can take. The two most important are x and y, the variables that will be plotted. FOr the next set of questions, include the argument names in your answers. That is, do not type plot(cars$speed, cars$dist), although that will work. Instead, use plot(x = cars$speed, y = cars$dist).

```
plot(x = cars$speed, y = cars$dist)
```



Use plot() command to show speed on the x-axis and dist on the y-axis form the cars data frame. Use the form of the plot command in which vectors are explicitly passed in as arguments for x and y.

```
plot(x = cars$speed, y = cars$dist)
```

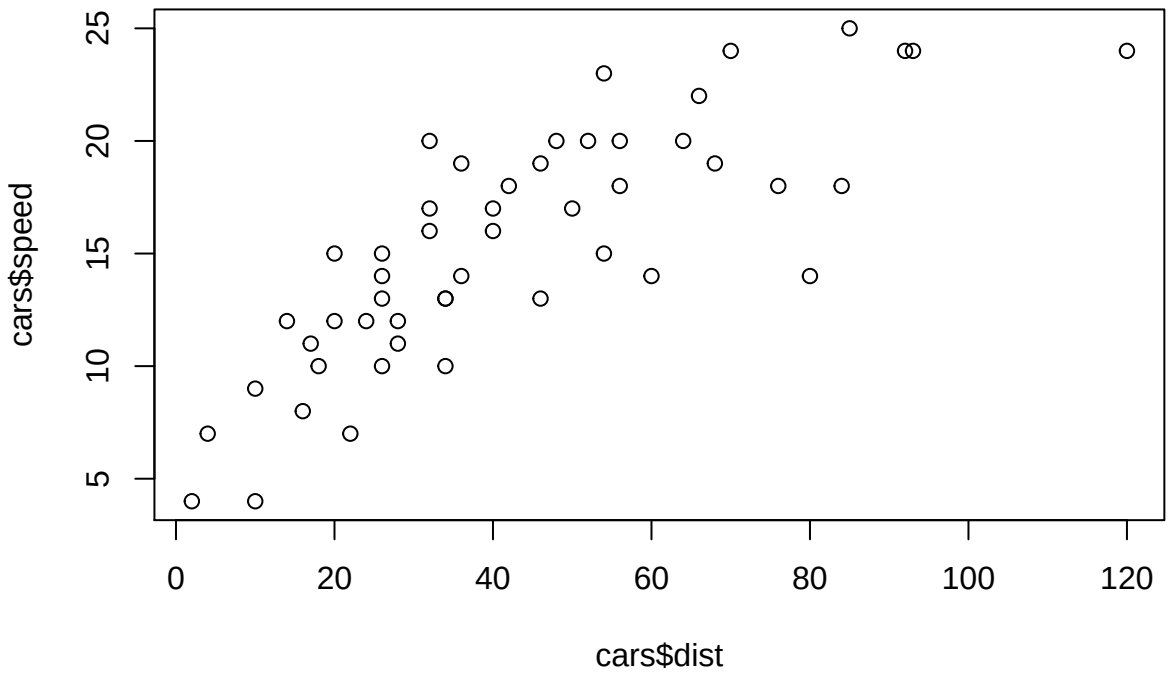


Note that this prodices a slighlty different anser than plot(cars). In this case, R is not sure what you want to use as labels on the axes, so it just uses the arguments which you pass in, data frame name and dollar signs included.

Note that there are other ways to call the plot command, i.e., using the **formula** interface. For example, we get a similar plot to the above with plot(dist ~ speed, cars). However, we will wait until later in the lesson before using the formula interface.

Use plot() command to show dist on the x-axis and speed on the y-axis from the cars dat frame. This is the opposite of what we did above.

```
plot(x = cars$dist, y = cars$speed)
```

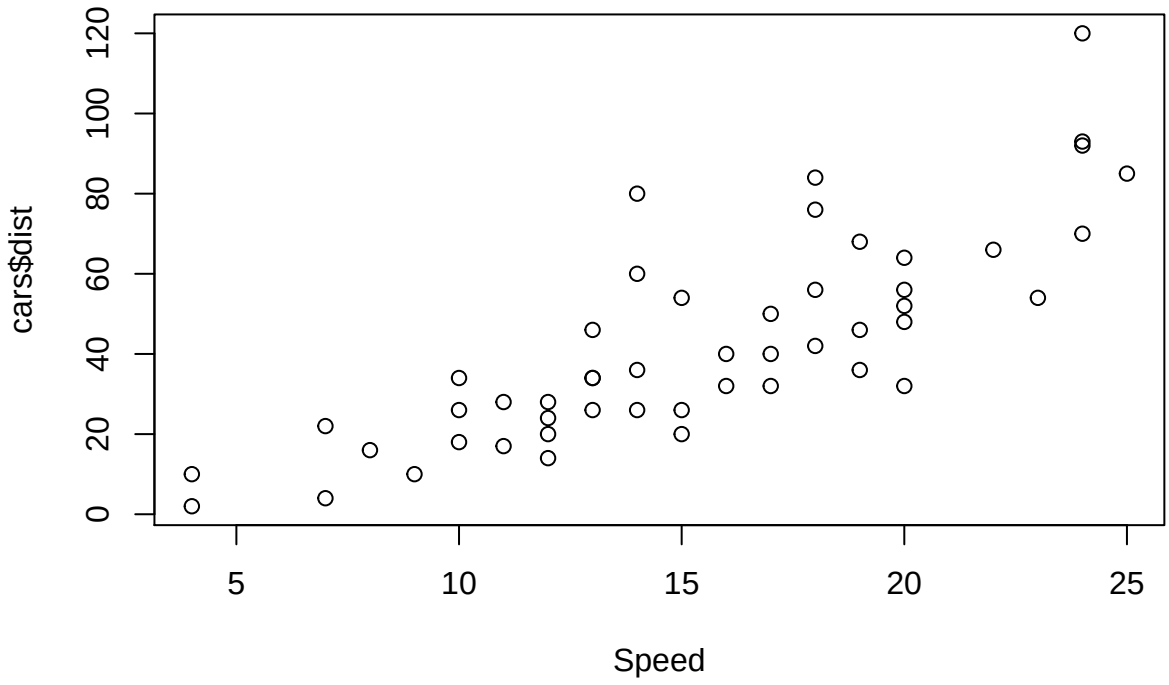


It probably makes more sense for speed to go on the x-axis since stopping distance is a function of speed more than the other way around. So, for the rest of the questions in this portion of the lession, always assign the arguments accordingly.

In fact, you can assume that the answers to the next few questions are all of the form $\mathbf{plot(x = cars}speed, y = cars\mathbf{dist, \ldots)}$, but with various arguments used in place of the ...

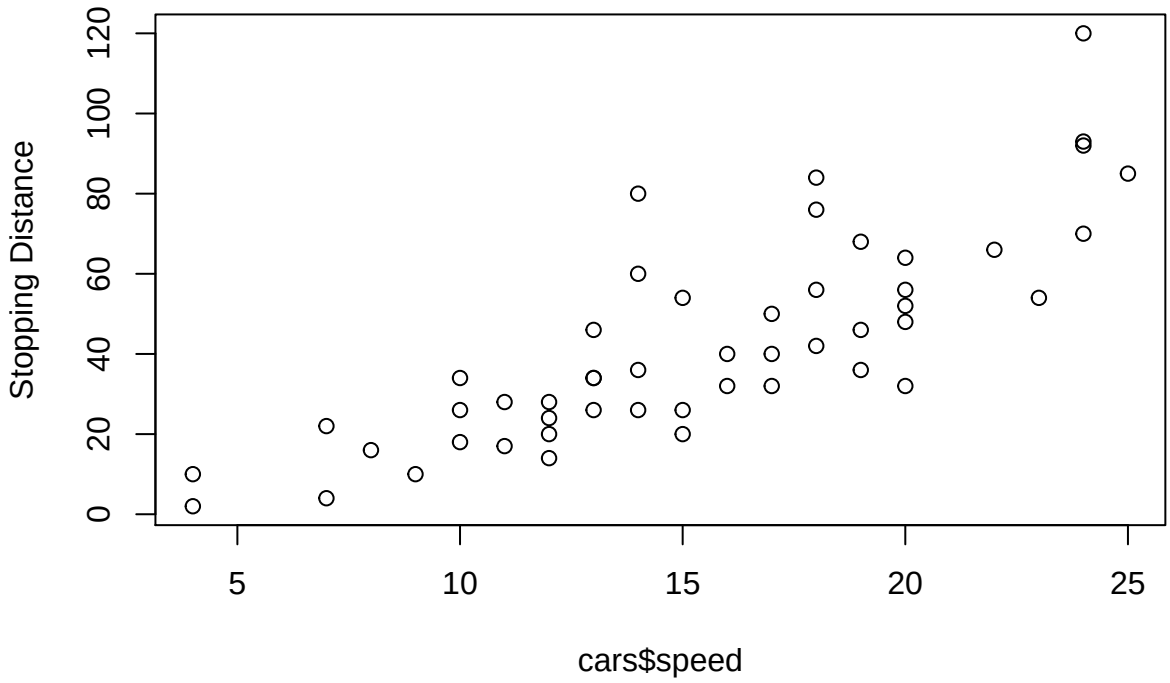
Recreate the plot with the label of the x-axis set to "Speed".

```
plot(x = cars$speed, y = cars$dist, xlab = "Speed")
```



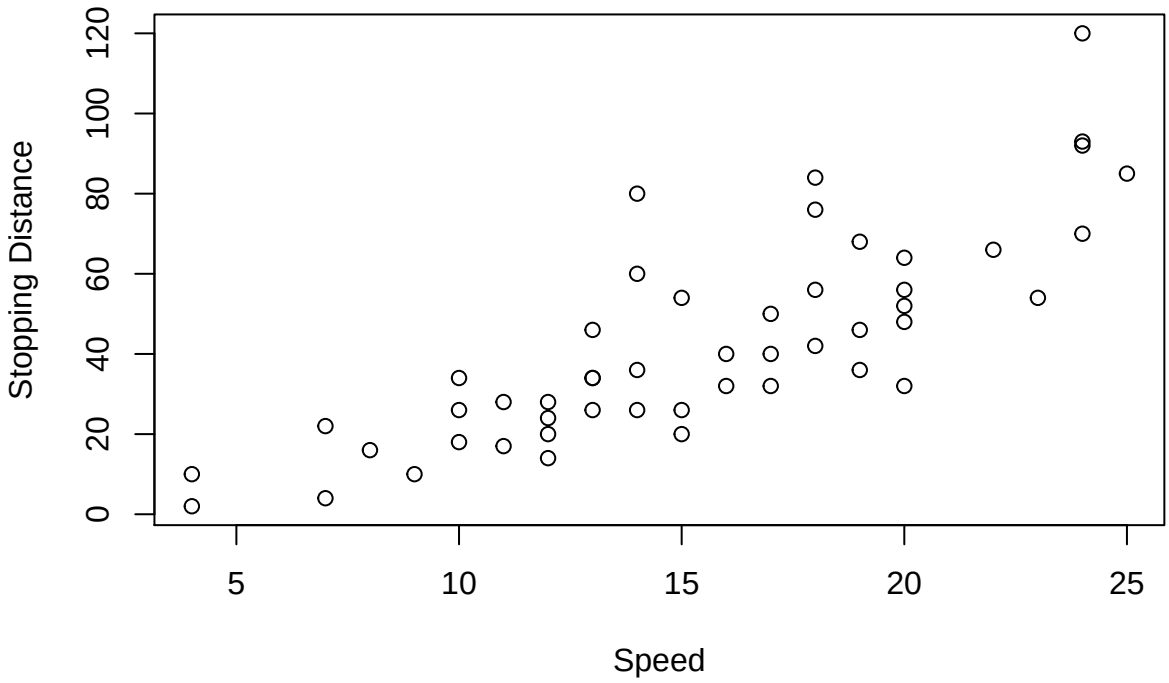
Recreate the plot with the label of the y-axis set to “Stopping Distance”

```
plot(x = cars$speed, y = cars$dist, ylab = "Stopping Distance")
```



Recreate the plot with "Speed" and "Stopping Distance" as axis labels.

```
plot(x = cars$speed, y = cars$dist, xlab = "Speed", ylab = "Stopping Distance")
```



The reason that plot(cars) worked at the beginning of the lesson was that R was smart enough to know that the first element (i.e., the first column) in cars should be assigned to the x argument and the second element to the y argument. To save on typing, the next set of ansers will all be of the form, plot(cars, ...) with various arguments added.

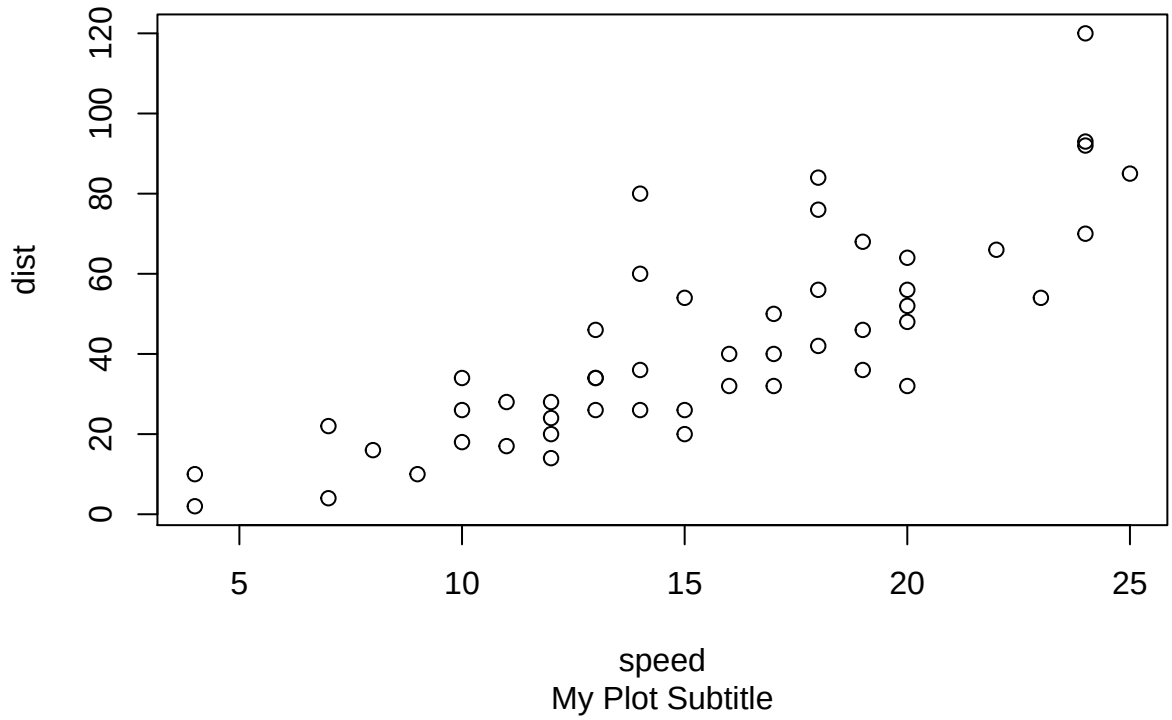
For each question, we will only want one additional argument at a time. Of course, you can pass in more than one argument when doing a real project.

Plot cars with a main title of "My Plot". Note that the argument for the main title is **main** and not **title**.

```
plot(cars, main = "My Plot")
```

Plot cars with a sub title of "My Plot Subtitle".

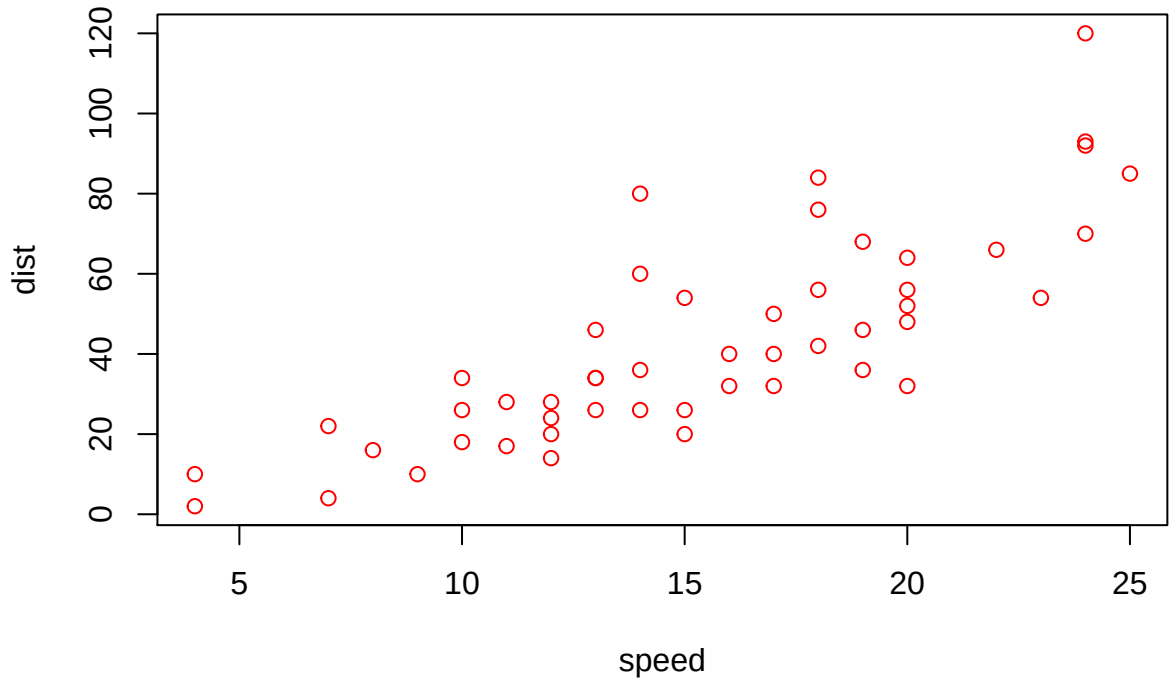
```
plot(cars, sub = "My Plot Subtitle")
```



The plot help page only covers a small number of the many arguments that can be passed into the plot() function and to other graphical functions. To begin to explore the many other options, look at ?par. Let's look at some of the more commonly used ones. Continue using plot(cars, ...) as the base answer to these questions.

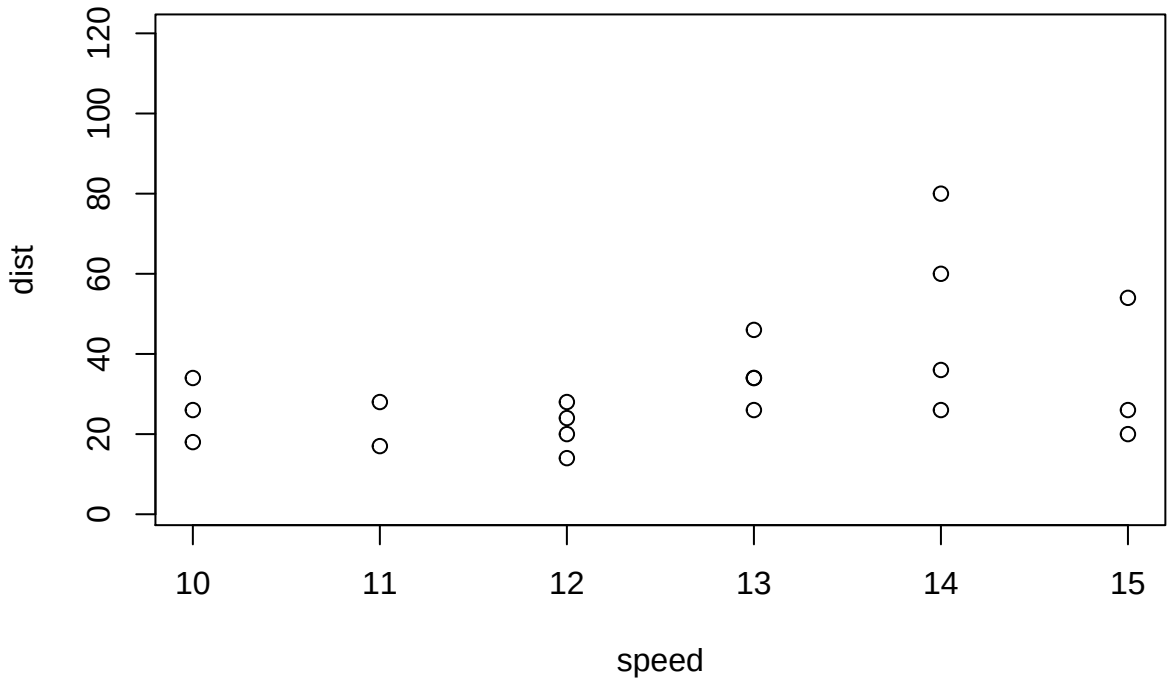
Plot cars so that the plotted points are coloured red. (Use col = 2 to achieve this effect).

```
plot(cars, col = 2)
```



Plot cars while limiting the x-axis to 10 through 15. (Use xlim = c(10, 15) to achieve this effect)

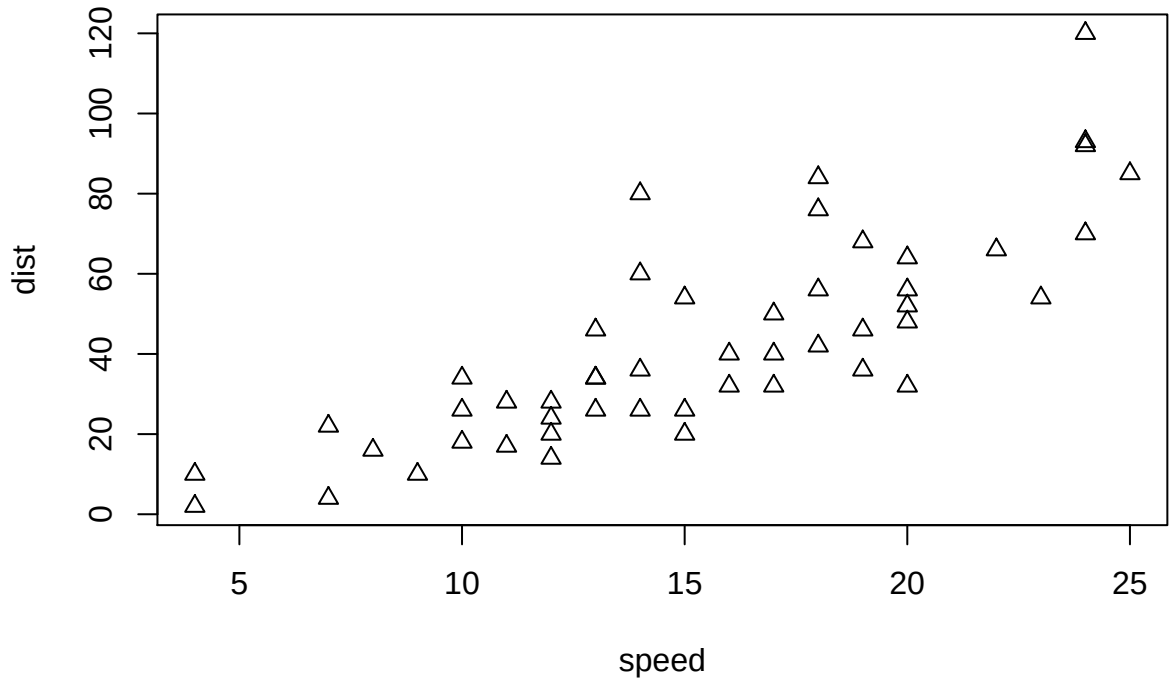
```
plot(cars, xlim = c(10, 15))
```



You can also change the shape of the symbols in the plot. The help page for points (?points) provides the details.

Plot cars using triangles. (Use pch = 2 to achieve this effect)

```
plot(cars, pch = 2)
```



Arguments like **col** and **pch** may not seam very intuitive. And that is because they are not. So many/most peole use more modern packages, like ggplot2 for creating their graphics in R.

It is, however, useful to have an introduction to the base graphics because many of the idioms in lattice and ggplot2 are modelled on them.

Lets now look at some other functions in the base graphics that may be useful, starting with boxplots.

Loat the mtcars data frame.

```
data(mtcars)
```

Anytime that you load up a new data frame, you should explore it before using it.

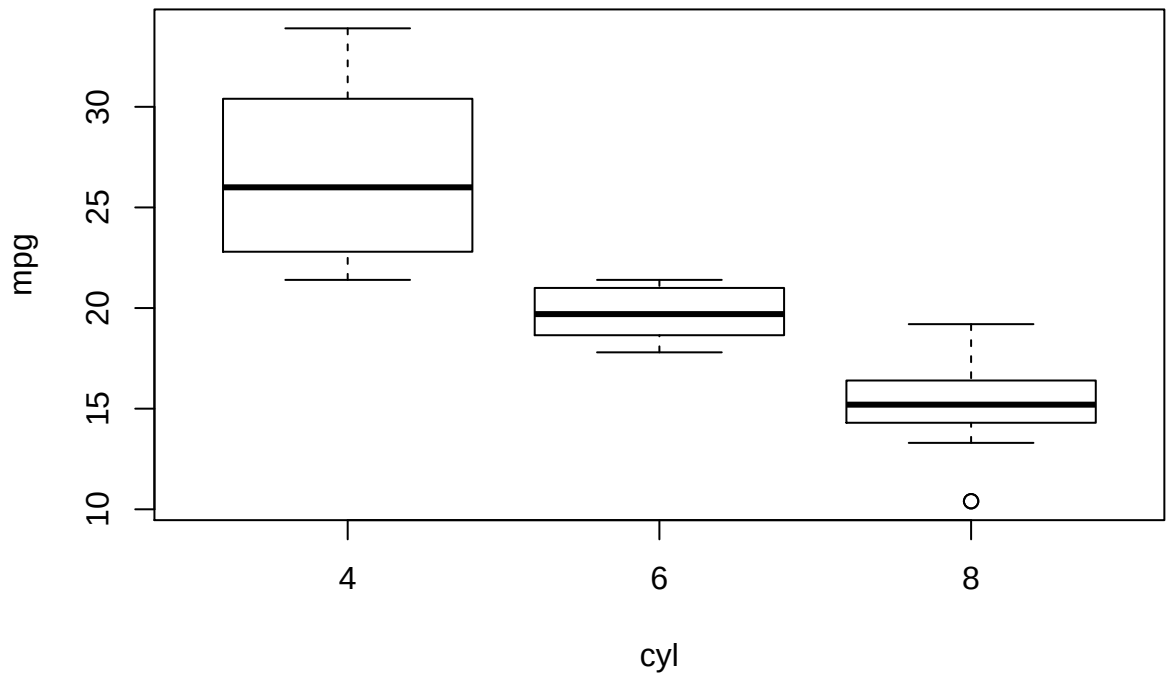
You can look at the boxplot help file by typing ?boxplot.

Instead of adding data columns directly as input arguments, as we did with plot(), it is often handy to pass in the entire data frame. This is what the **data** argument in boxplot() allows.

boxplot(), like many R functions, also takes a **formula** argument, generally an expression with a tilde (~) which indicates the releationship between the input variables. This allows you to ener something like mpg ~ cyl to plot the relationship between cyl (number of cylnders) on the x-axis and mpg (miles per gallon) on the y-axis.

Use boxplot() with formula = mpg ~ cyl and data = mtcars to create a box plot.

```
boxplot(formula = mpg ~ cyl, data = mtcars)
```

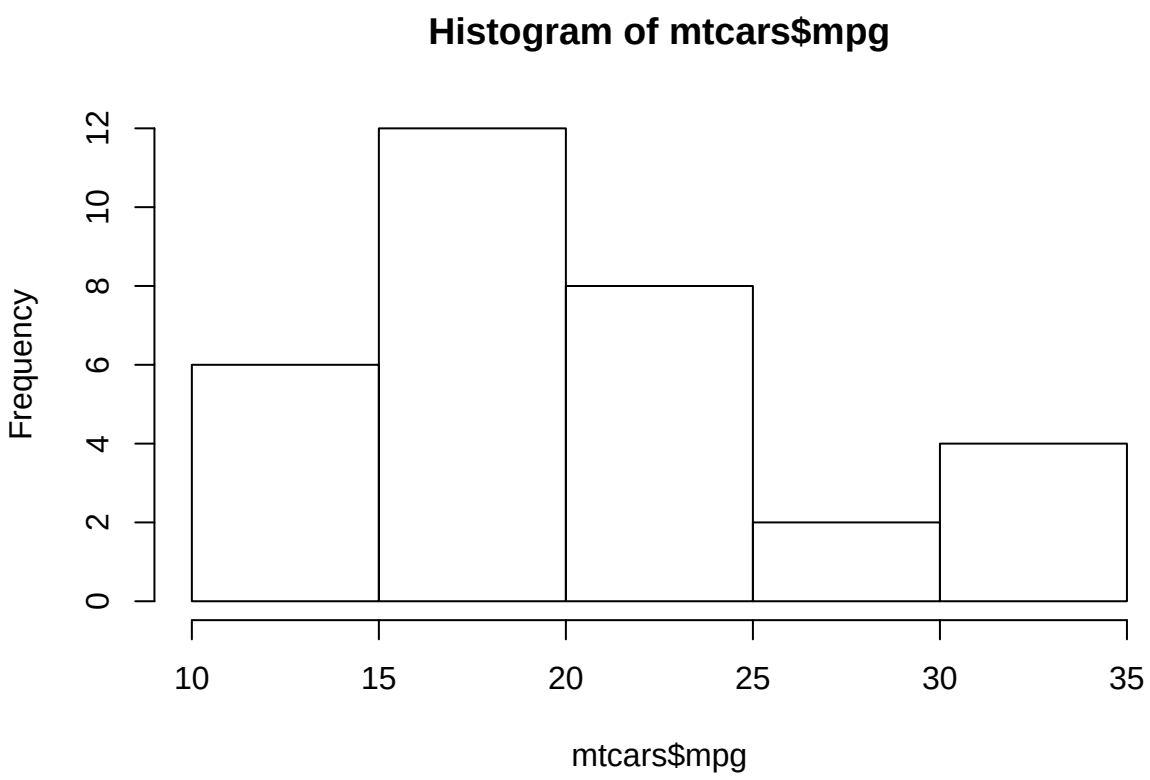


The plot shows that mpg is much lower for cars with more cylinders. Note that we can use the same set of arguments that we explored with plot() above to add axis labels, titles and so on.

WHen looking at a single variable, histograms are a useful tool. hist() is the associated R function. Like plot(), hist() is best used by passing in a single vector.

Use hist() with the vector mtcars$mpg to create a histogram.

```
hist(mtcars$mpg)
```


Histogram of mtcars$mpg
Frequency
0
2
4
6
8
10
12
10
15
20
25
30
35
mtcars$mpg