Plotting and Graphics

Visit these sites for some ideas.

- http://www.sr.bham.ac.uk/~ajrs/R/r-gallery.html
- http://gallery.r-enthusiasts.com/
- http://cran.r-project.org/web/views/Graphics.html

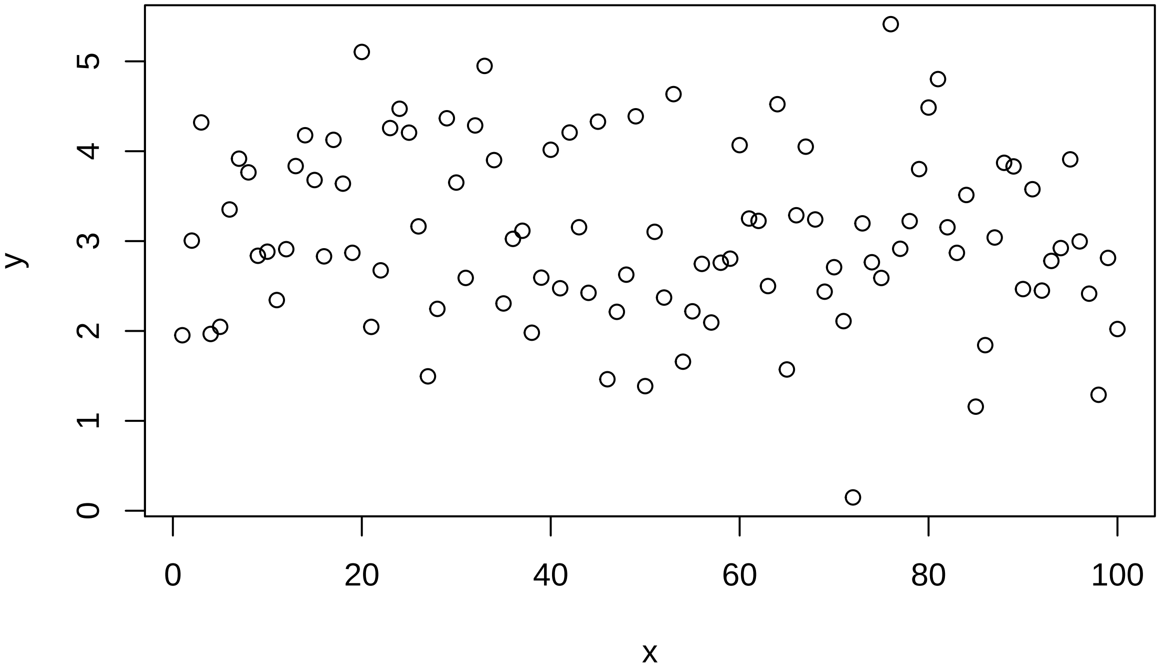
Base R graphics

The command `plot(x,y)` will plot vector x as the independent variable and vector y as the dependent variable. Within the command line, you can specify the title of the graph, the name of the x-axis, and the name of the y-axis. - main='title' - xlab='name of x axis' - ylab='name of y axis'

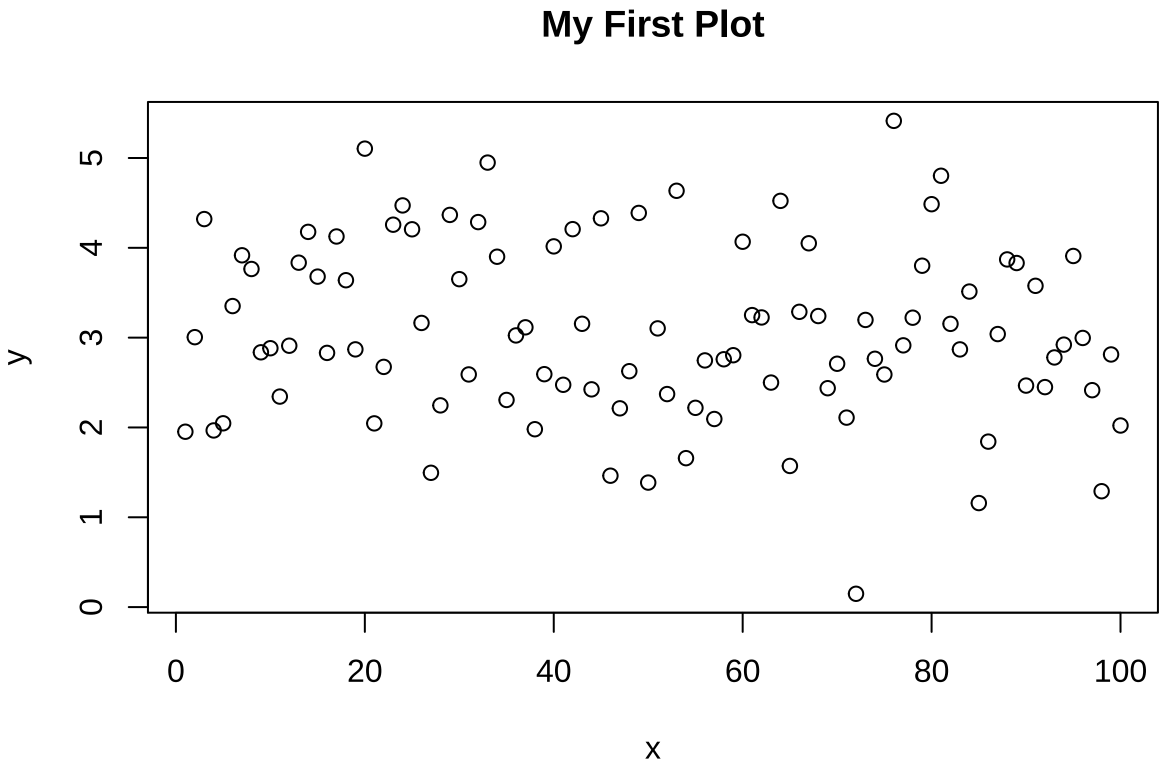
The command `lines(x,y)` adds a line segment to an existing plot. The command `points(x,y)` adds points to the plot. A legend can be created using `legend`, though getting the legend right for base graphics can be a bit challenging. To get a basic idea of what R offers, it has a build-in demo that can be run with `demo(graphics)`.

Try this yourself:

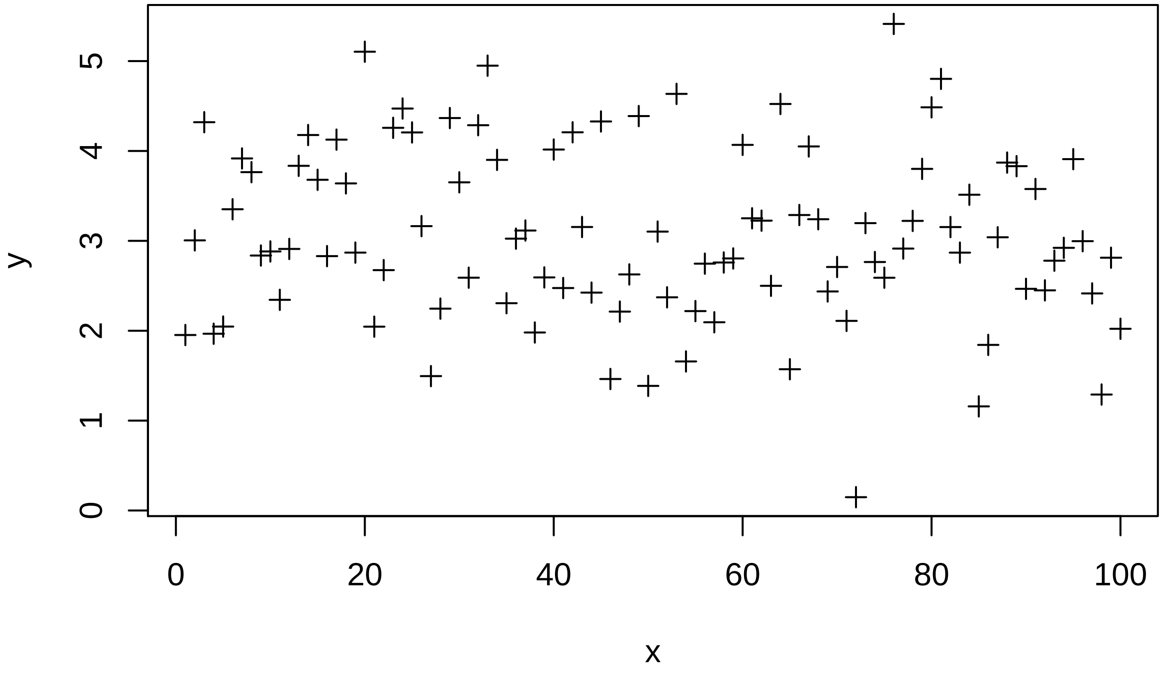
```
x = 1:100
y = rnorm(100,3,1) # 100 random normal deviates with mean=3, sd=1
plot(x,y)
```



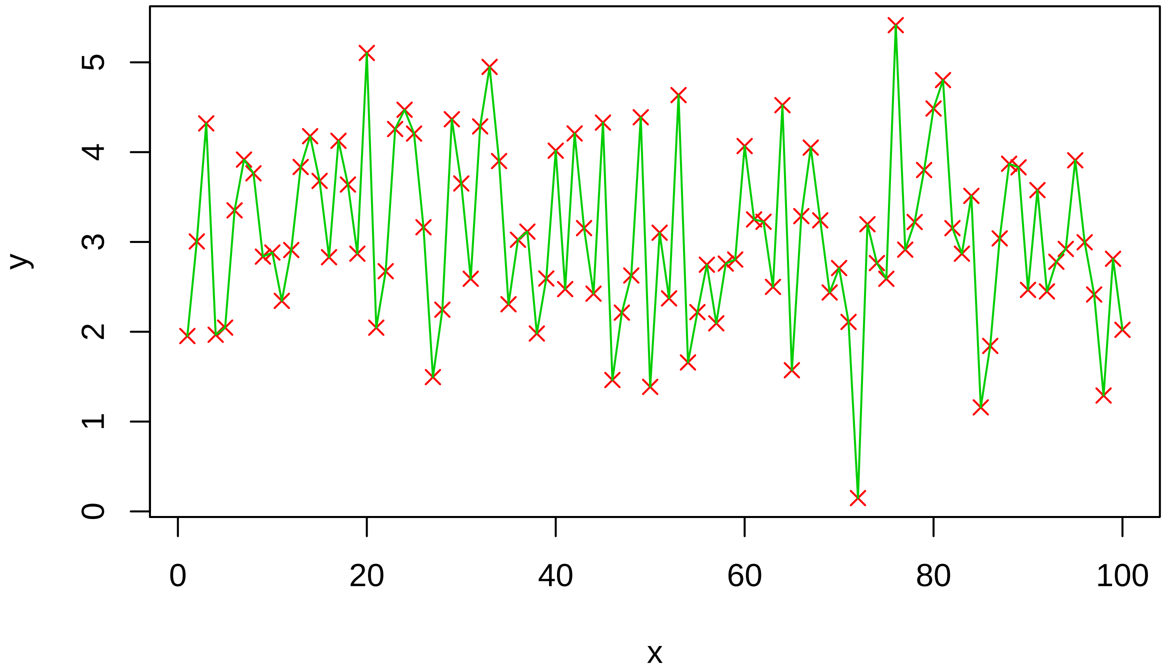
```
plot(x,y,main='My First Plot')
```



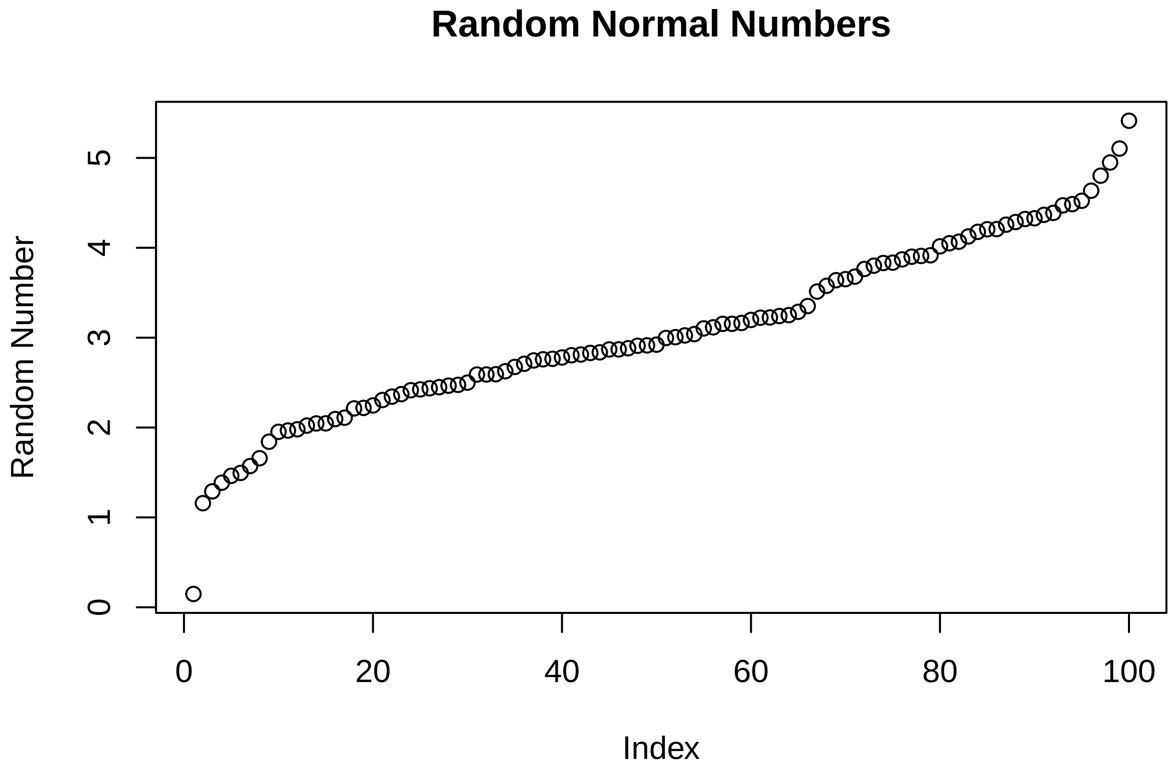
```
# change point type
plot(x,y,pch=3)
```



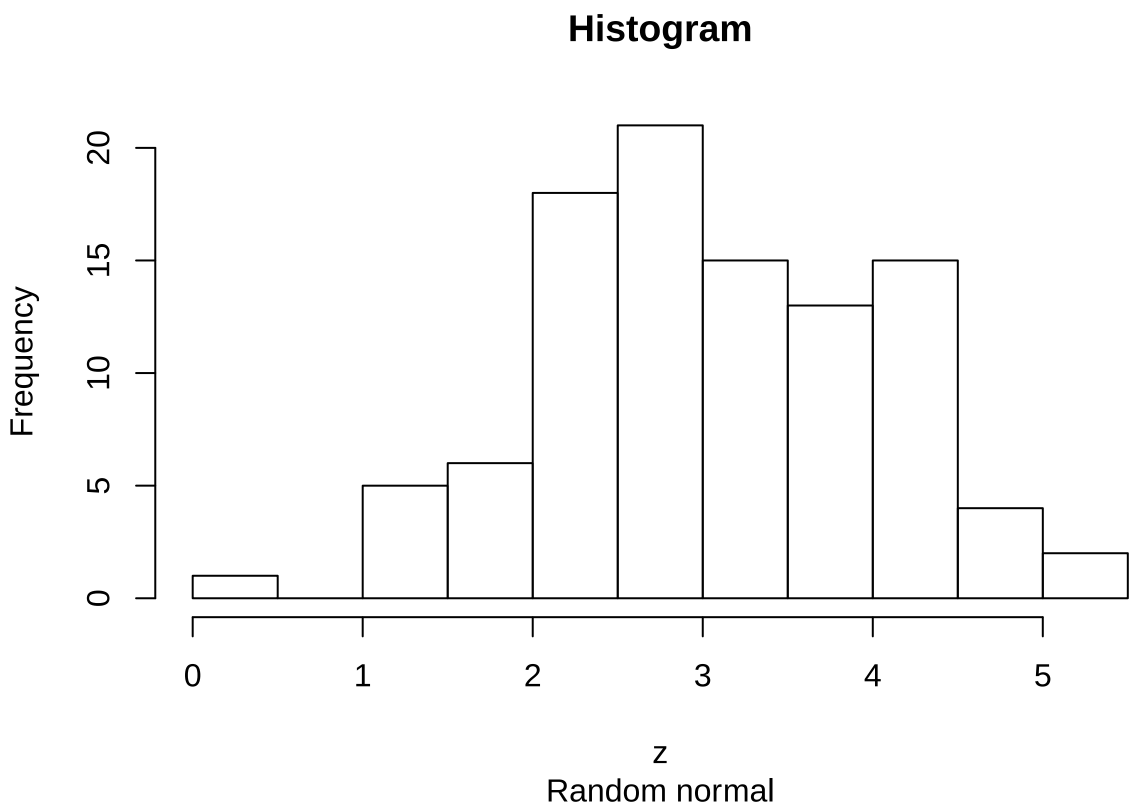
```
# change color
plot(x,y,pch=4,col=2)
# draw lines between points
lines(x,y,col=3)
```



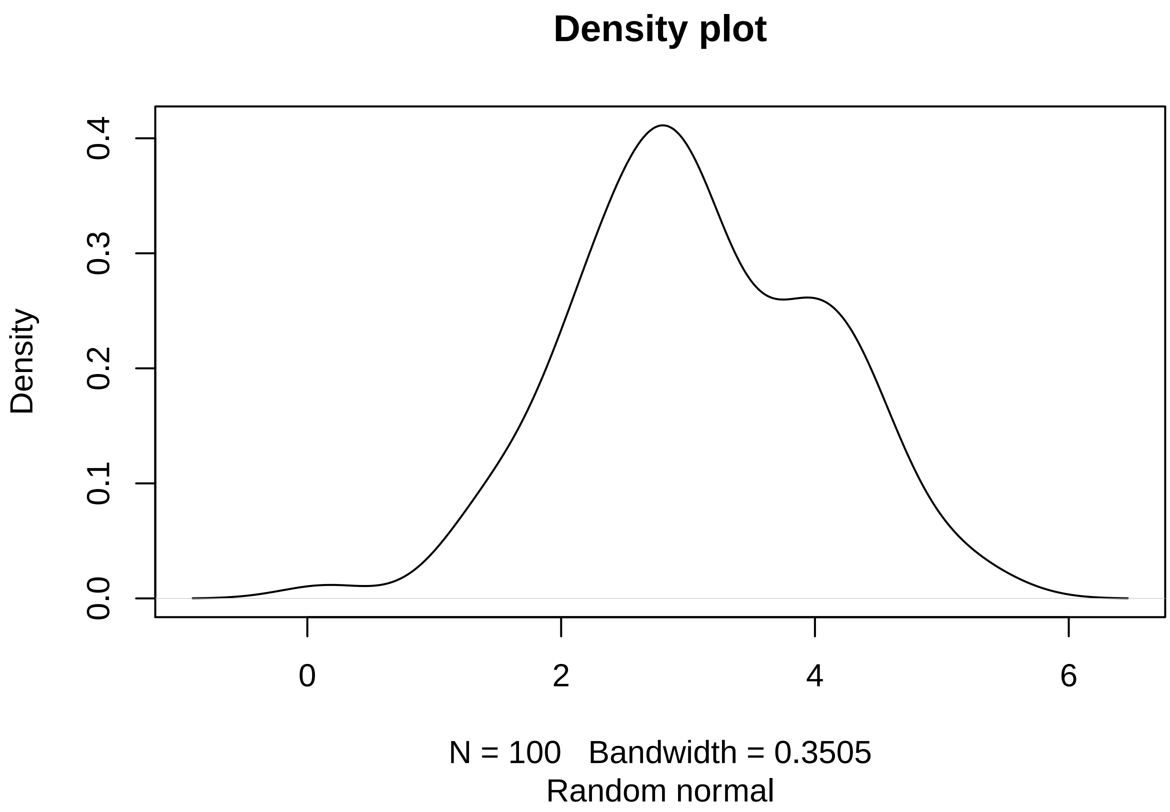
```
z=sort(y)
# plot a sorted variable vs x
plot(x,z,main='Random Normal Numbers',
     xlab='Index',ylab='Random Number')
```



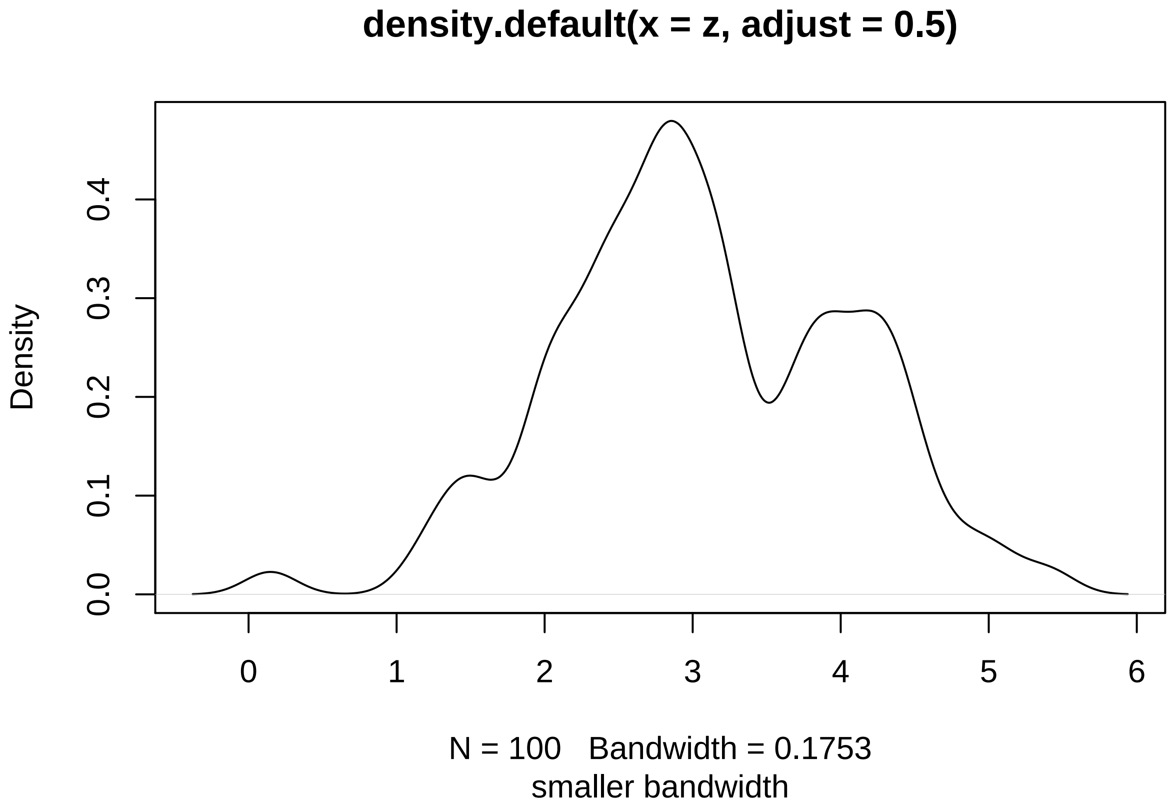
```
# A basic histogram
hist(z, main="Histogram",
     sub="Random normal")
```



```
# A "density" plot
plot(density(z), main="Density plot",
     sub="Random normal")
```



```
# A smaller "bandwidth" to capture more detail
plot(density(z, adjust=0.5),
     sub="smaller bandwidth")
```



Plotting with ggplot2

The `ggplot2` package is a relatively novel approach to generating highly informative publication-quality graphics. The "gg" stands for "Grammar of Graphics". In short, instead of thinking about a single function that produces a plot, `ggplot2` uses a "grammar" approach, akin to building more and more complex sentences to layer on more information or nuance. See the ggplot2 graphics gallery for some examples *with accompanying code*.

The `ggplot2` package assumes that data are in the form of a data.frame. In some cases, the data will need to be manipulated into a form that matches assumptions that `ggplot2` uses. In particular, if one has a *matrix* of numbers associated with different subjects (samples, people, etc.), the data will usually need to be transformed into a "long" data frame.

To use the `ggplot2` package, it must be installed and loaded. Assuming that installation has been done already, we can load the package directly:

```
library(ggplot2)
```

mtcars data

We are going to use the mtcars dataset, included with R, to experiment with `ggplot2`.

```
data(mtcars)
```

- Exercise: Explore the `mtcars` dataset using `View`, `summary`, `dim`, `class`, etc.

We can also take a quick look at the relationships between the variables using the `pairs` plotting function.

```
pairs(mtcars)
```

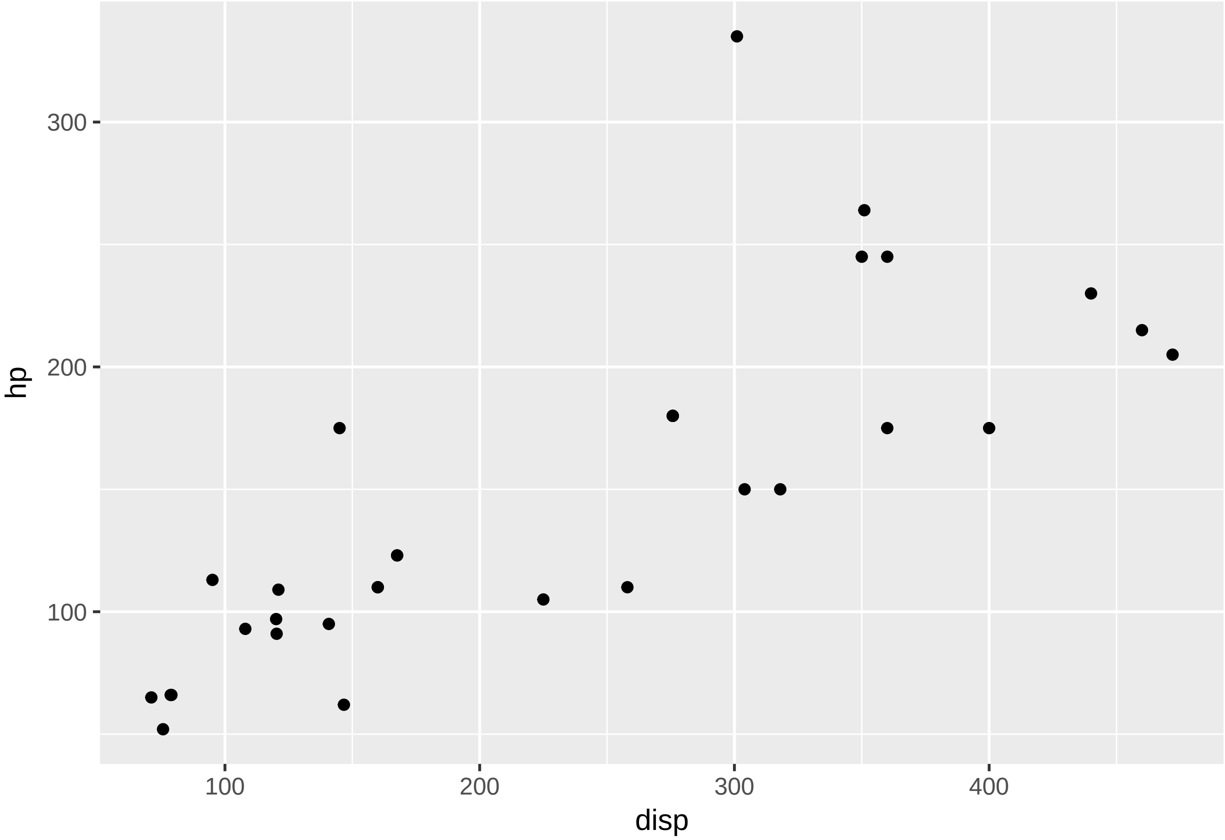
That is a useful view of the data. We want to use `ggplot2` to make an informative plot, so let's approach this in a piecewise fashion. We first need to decide what type of plot to produce and what our basic variables will be. In this case, we have a number of choices.

```
ggplot(mtcars,aes(x=disp,y=hp))
```

First, a little explanation is necessary. The `ggplot` function takes as its first argument a `data.frame`. The second argument is the "aesthetic", `aes`. The `x` and `y` take column names from the `mtcars` `data.frame` and will form the basis of our scatter plot.

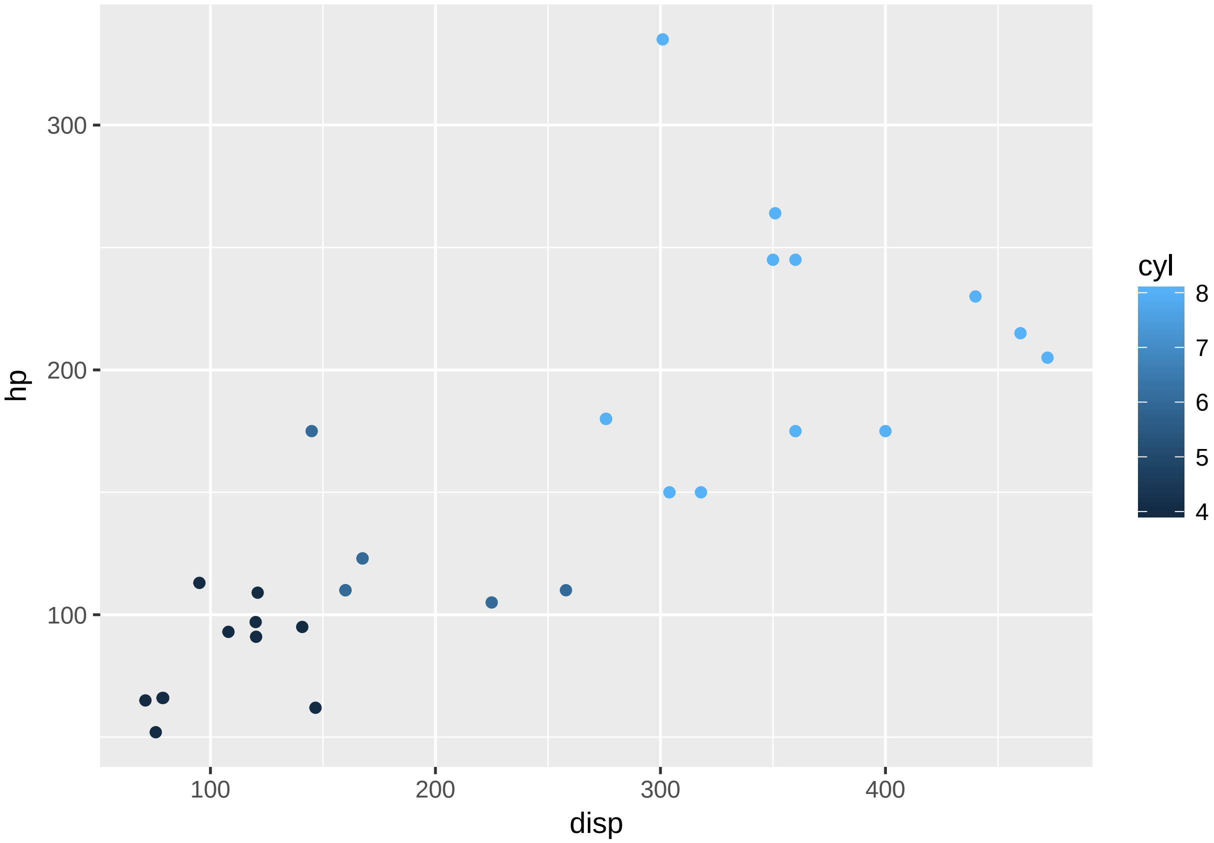
But why did we get that "Error: No layers in plot"? Remember that *ggplot2* is a "grammar of graphics". We supplied a subject, but no verb (called a *layer* by ggplot2). So, to generate a plot, we need to supply a verb. There are many possibilities. Each "verb" or *layer* typically starts with "geom" and then a descriptor. An example is necessary.

```
ggplot(mtcars,aes(x=disp,y=hp)) + geom_point()
```



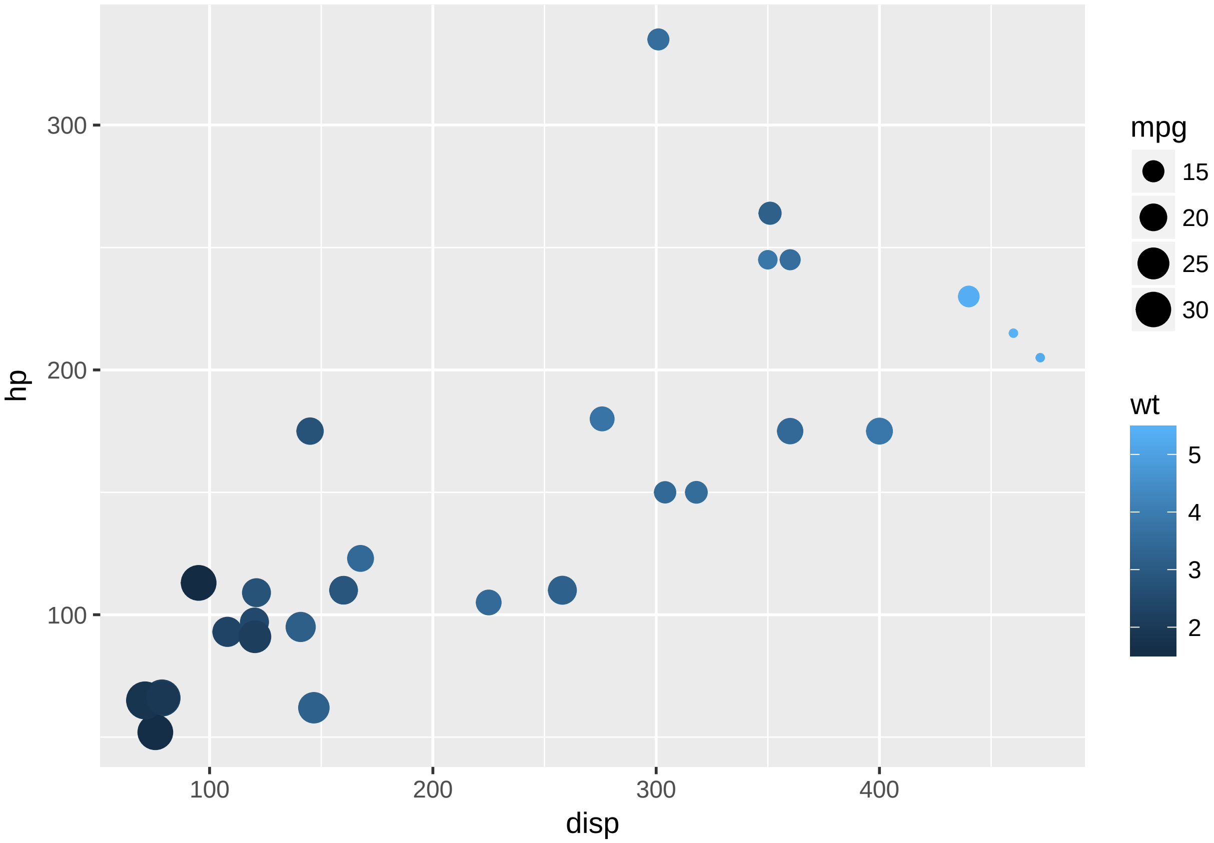
We finally produced a plot. The power of *ggplot2*, though, is the ability to make very rich plots by adding "grammar" to the "plot sentence". We have a number of other variables in our `mtcars` `data.frame`. How can we add another value to a two-dimensional plot?

```
ggplot(mtcars,aes(x=disp,y=hp,color=cyl)) + geom_point()
```



The color of the points is a based on the numeric variable `wt`, the weight of the car. Can we do more? We can change the size of the points, also.

```
ggplot(mtcars,aes(x=disp,y=hp,color=wt,size=mpg)) + geom_point()
```



So, on our 2D plot, we are now plotting four variables. Can we do more? We can manipulate the shape of the points in addition to the color and the size.

```
ggplot(mtcars,aes(x=disp,y=hp)) + geom_point(aes(size=mpg,color=wt,shape=cyl))
```

Why did we get that error? Ggplot2 is trying to be helpful by telling us that a "continuous varialbe cannot be mapped to 'shape' ". Well, in our `mtcars data.frame`, we can look at `cyl` in detail.

```
class(mtcars$cyl)
```

```
## [1] "numeric"
```

```
summary(mtcars$cyl)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##   4.000   4.000   6.000   6.188   8.000   8.000
```

```
table(mtcars$cyl)
```

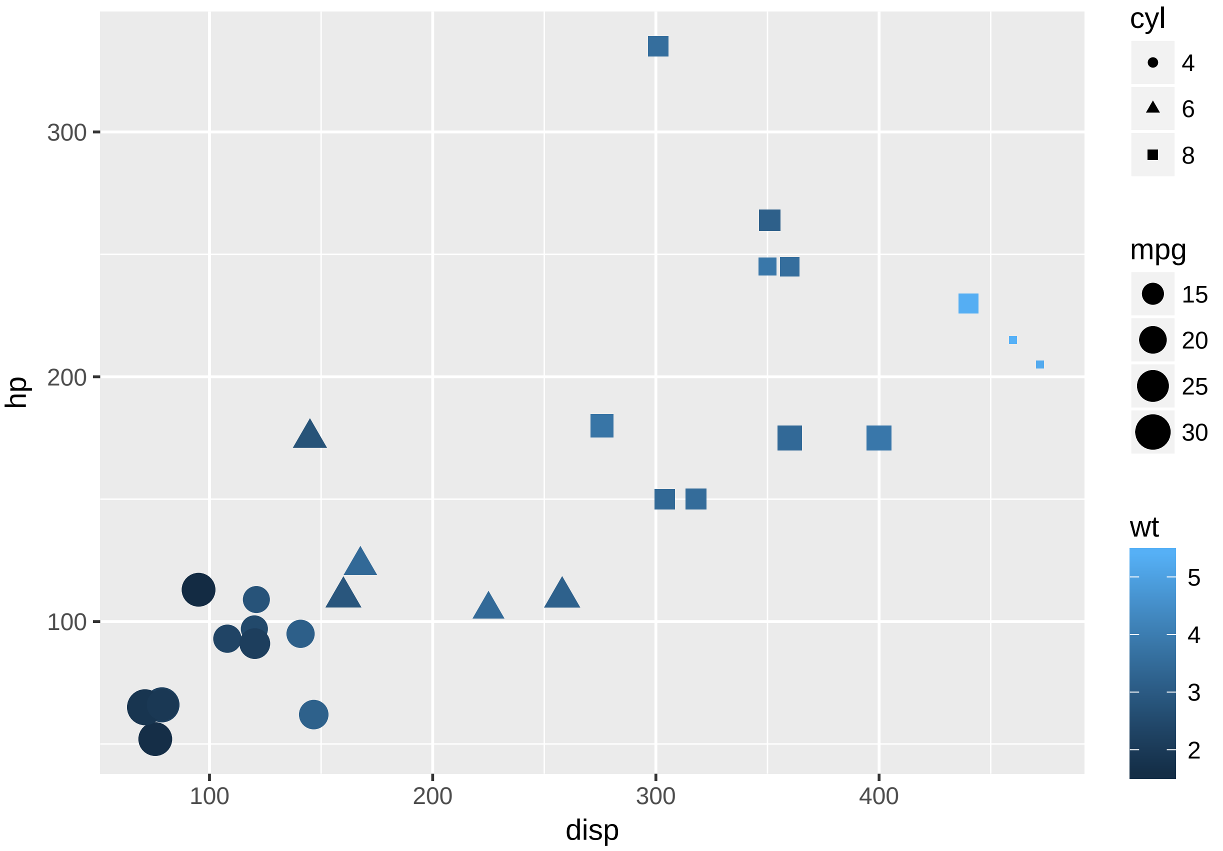
```
## 
##  4  6  8 
## 11  7 14
```

The `cyl` variable is "kinda" continuous in that it is numeric, but it could also be thought of as a "category" of engines. R has a specific data type for "category" data, called a *factor*. We can easily convert the `cyl` column to a factor like so:

```
mtcars$cyl = as.factor(mtcars$cyl)
```

Now, we can go ahead with our previous approach to make a 2-dimensional plot that displays the relationships between *five* variables.

```
ggplot(mtcars,aes(x=disp,y=hp)) + geom_point(aes(size=mpg,color=wt,shape=cyl))
```



- *Additional exercises*
  - Use `geom_text` to add labels to your plot.
  - Convert all your work to plotly for interactive versions of the plots.

NYC Flight data

I leave this section open-ended for you to explore further options with the *ggplot2* package. The data represent the on-time data for all flights that departed New York City in 2013.

```
# install.packages('nycflights13')
library(nycflights13)
data(flights)
head(flights)
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>
## 1  2013     1     1      517            515         2      830
## 2  2013     1     1      533            529         4      850
## 3  2013     1     1      542            540         2      923
## 4  2013     1     1      544            545        -1     1004
## 5  2013     1     1      554            600        -6      812
## 6  2013     1     1      554            558        -4      740
## # ... with 12 more variables: sched_arr_time <int>, arr_delay <dbl>,
## #   carrier <chr>, flight <int>, tailnum <chr>, origin <chr>, dest <chr>,
## #   air_time <dbl>, distance <dbl>, hour <dbl>, minute <dbl>,
## #   time_hour <dttm>
```

Use ggplot and other plotting tools to explore the data and look for features that might contribute to airport delays. Consider using other “geoms” during your exploration.

Graphics Devices and Saving Plots

To make a plot directly to a file use: `png()`, `postscript()`, etc.

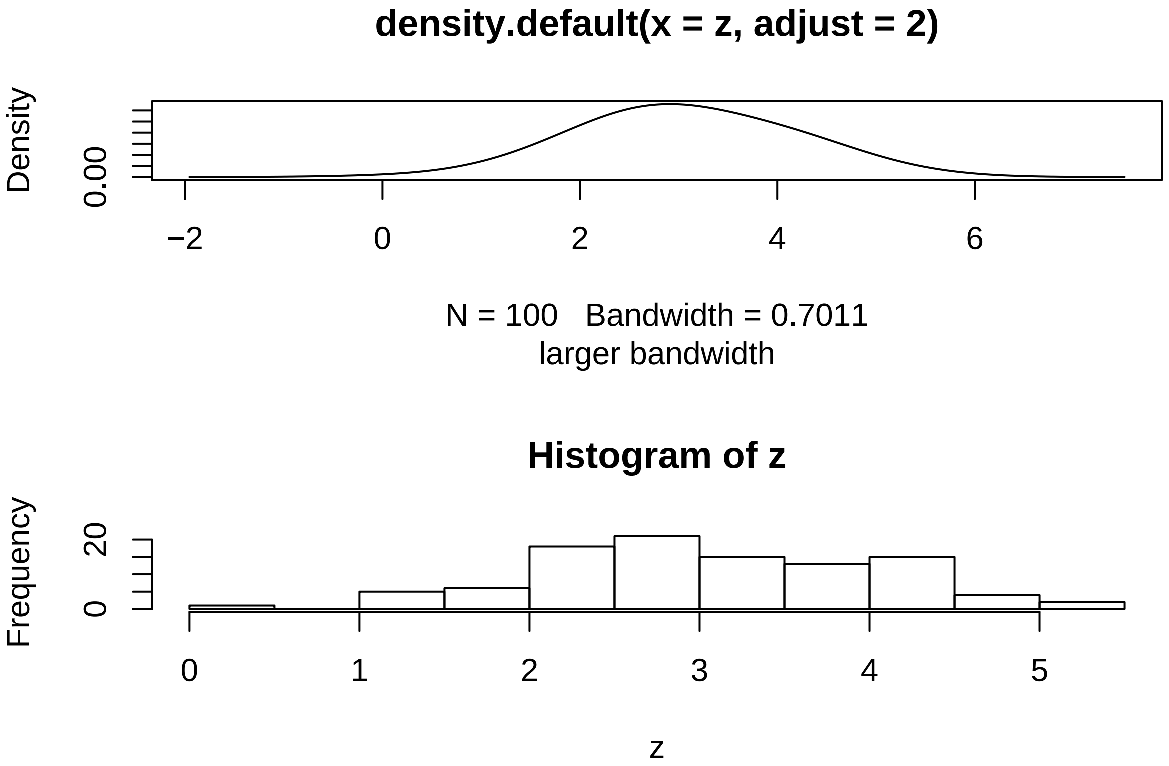
```
png(file="myplot.png",width=480,height=480)
plot(density(z,adjust=2.0),sub="larger bandwidth")
dev.off()
```

```
## pdf
##   2
```

On your own, save a pdf to a file. NOTE: The dimensions in `pdf()` are in *inches*.

To put multiple plots on a page, we can set the `mfrow` graphics parameter.

```
par(mfrow=c(2,1))
plot(density(z,adjust=2.0),sub="larger bandwidth")
hist(z)
```



```
    # use dev.off() to turn off the two-row plotting
```

R can have multiple graphics “devices” open.

- To see a list of active devices: `dev.list()`
- To close the most recent device: `dev.off()`
- To close device 5: `dev.off(5)`
- To use device 5: `dev.set(5)`