

Lecture 6: Graphics with R

- Graphical functions & parameters
- Multiple plots on one page
- Save a plot

There are different packages in R that suit all kinds of plotting needs people may have.

- **graphics**
 - In base R and loads automatically every time you open R
- **grid**
 - In base R but does not load automatically
- **ggplot2**
 - Not in base R
 - Create Elegant Data Visualisations Using the Grammar of Graphics
 - Depends on **grid**
- ...

Today we use the **graphics** package to draw various 2D plots.

<https://stat.ethz.ch/R-manual/R-devel/library/graphics/html/00Index.html>
(<https://stat.ethz.ch/R-manual/R-devel/library/graphics/html/00Index.html>).

You will have to google a lot.

You cannot imagine how much I googled to make these lecture notes.

In [1]:

```
head(iris)
```

A data.frame: 6 × 5

Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
<dbl>	<dbl>	<dbl>	<dbl>	<fct>
5.1	3.5	1.4	0.2	setosa
4.9	3.0	1.4	0.2	setosa
4.7	3.2	1.3	0.2	setosa
4.6	3.1	1.5	0.2	setosa
5.0	3.6	1.4	0.2	setosa
5.4	3.9	1.7	0.4	setosa

In [2]:

```
summary(iris)
```

Sepal.Length	Sepal.Width	Petal.Length	Petal.Width
Min. :4.300	Min. :2.000	Min. :1.000	Min. :0.100
1st Qu.:5.100	1st Qu.:2.800	1st Qu.:1.600	1st Qu.:0.300
Median :5.800	Median :3.000	Median :4.350	Median :1.300
Mean :5.843	Mean :3.057	Mean :3.758	Mean :1.199
3rd Qu.:6.400	3rd Qu.:3.300	3rd Qu.:5.100	3rd Qu.:1.800
Max. :7.900	Max. :4.400	Max. :6.900	Max. :2.500

Species

setosa :50

versicolor:50

virginica :50

6.1 Graphical functions & parameters

Functions:

New plot

- plot()
- pie()
- boxplot()
- hist()
- curve()
- ...

Add to existing plot

- lines()
- points()

- `abline()`
- `legend()`
- `axis()`
- ...

Parameters

Parameters are used to customize your plots. I will show the use of some parameters here and there in the lecture.

There are many so you will not see all the parameters here. Check out the link below or google when you need to plot something fancy.

<https://stat.ethz.ch/R-manual/R-devel/library/graphics/html/par.html>
(<https://stat.ethz.ch/R-manual/R-devel/library/graphics/html/par.html>).

Different parameters are allowed in different functions. Parameters can also be specified before plotting using **`par()`**.

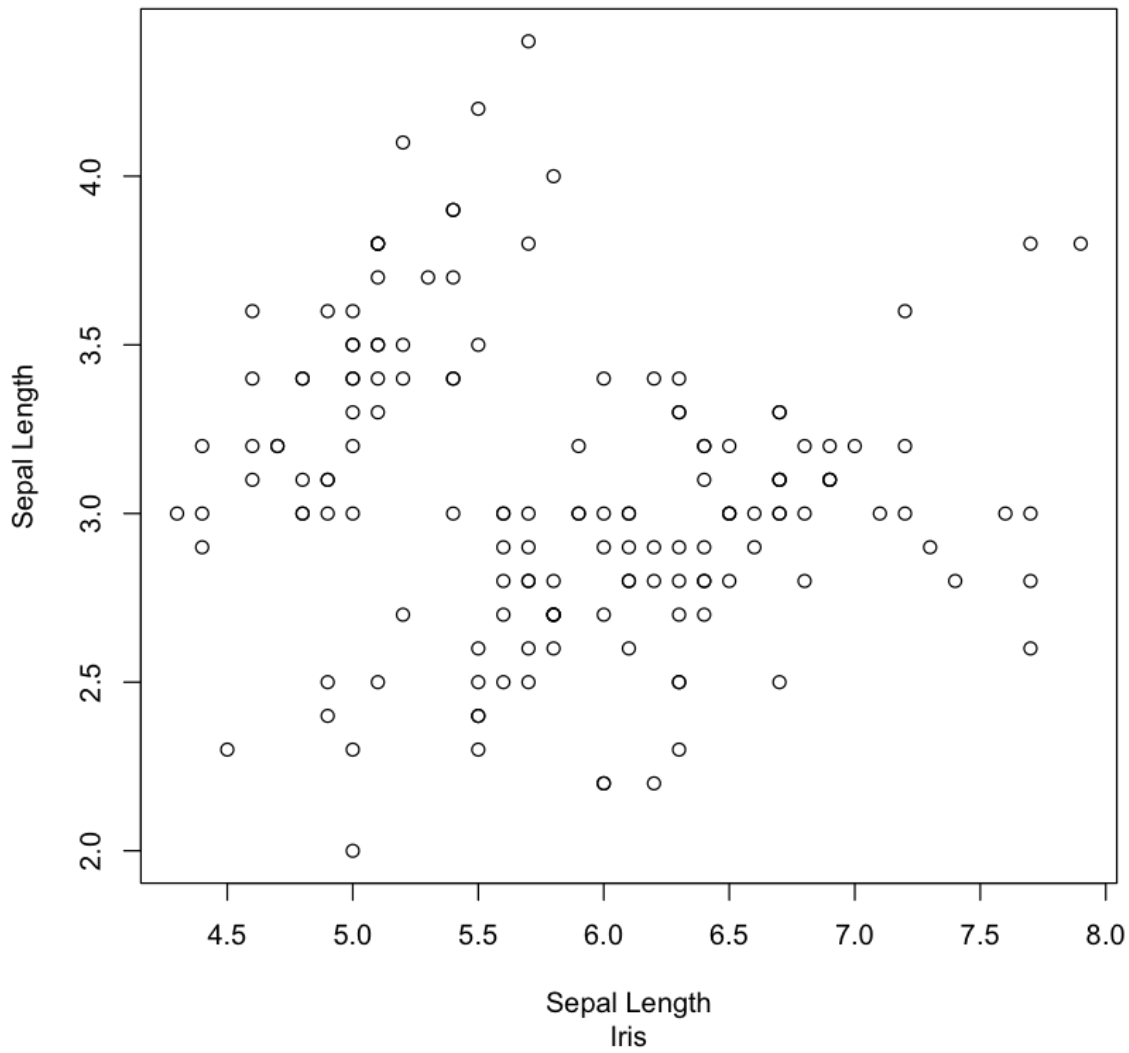
6.1.1 Scatter plot

Coffee consumption vs. screen time

In [3]:

```
# Some parameters related to titles, labels, limits...
plot(x = iris$Sepal.Length, y = iris$Sepal.Width,
     main = "Sepal Width vs. Sepal Length",      # Title
     sub = "Iris",                             # Sub title
     xlim = range(iris$Sepal.Length),           # limits of x-axi
s
     #      ylim =,                             # Limits of y-a
xis
     xlab = "Sepal Length",                     # Label of x-axis
     ylab = "Sepal Length",                     # Label of y-axis
     #      log = "x"                           # Axis to be se
t on log scale
)
# x and y are arguments - these two are sufficient for a plot
# In this plot, I specified some most basic graphical parameters
.
```

Sepal Width vs. Sepal Length

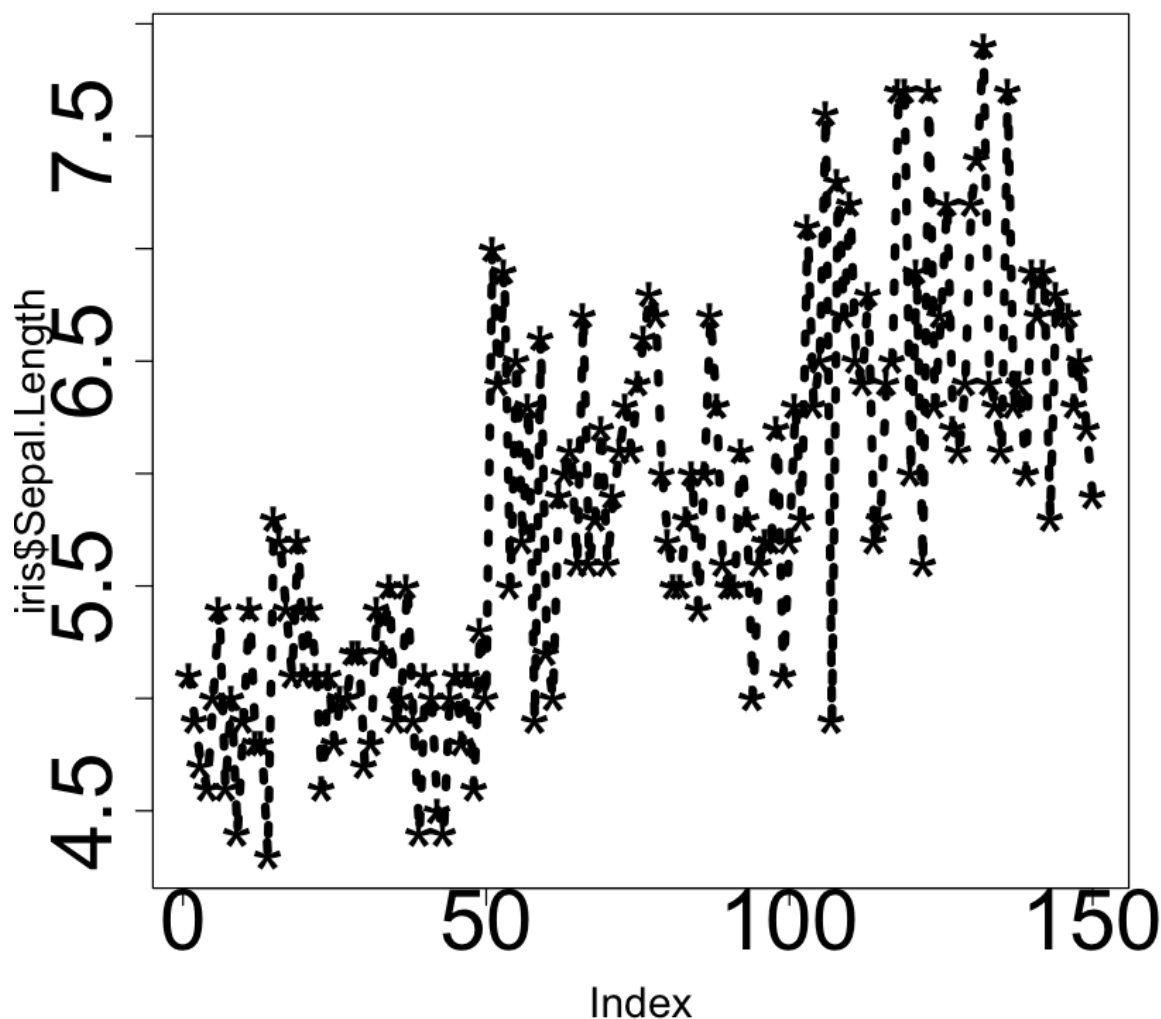


See the changes in all sepal lengths

In [4]:

```
# Some parameters related to text and plot size.
plot(iris$Sepal.Length,
     type = "o",      # Type of plot, default is points.
     pch = "*",       # plotting symbols, 1~25 plus anything you want.
     cex = 3,         # Plotting text and symbol size
     cex.axis = 3,    # Axis annotation size
     main = "Sepal Length",
     cex.main = 3,    # Title text size
     cex.lab = 1.5,   # Axis label size
     lwd = 5,         # Line width
     lty = 3
)
```

Sepal Length



6.1.2 Pie plot

In [5]:

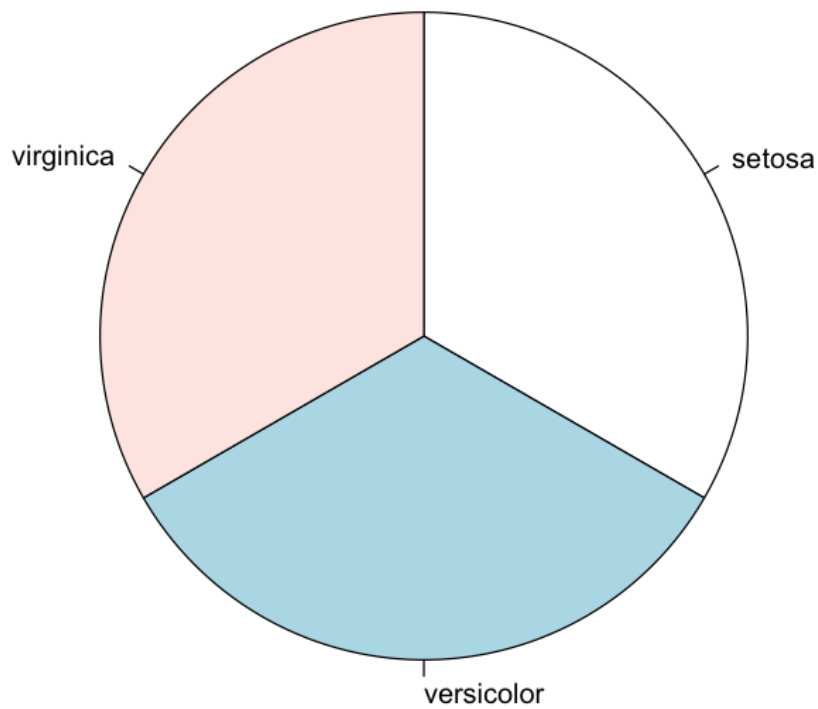
```
table(iris$Species)
```

setosa	versicolor	virginica
50	50	50

In [6]:

```
# My second pie chart.....  
pie(x = table(iris$Species),  
    col =,  
    clockwise = T,  
    main = "Species of Iris",  
)
```


Species of Iris



6.1.3 Histogram

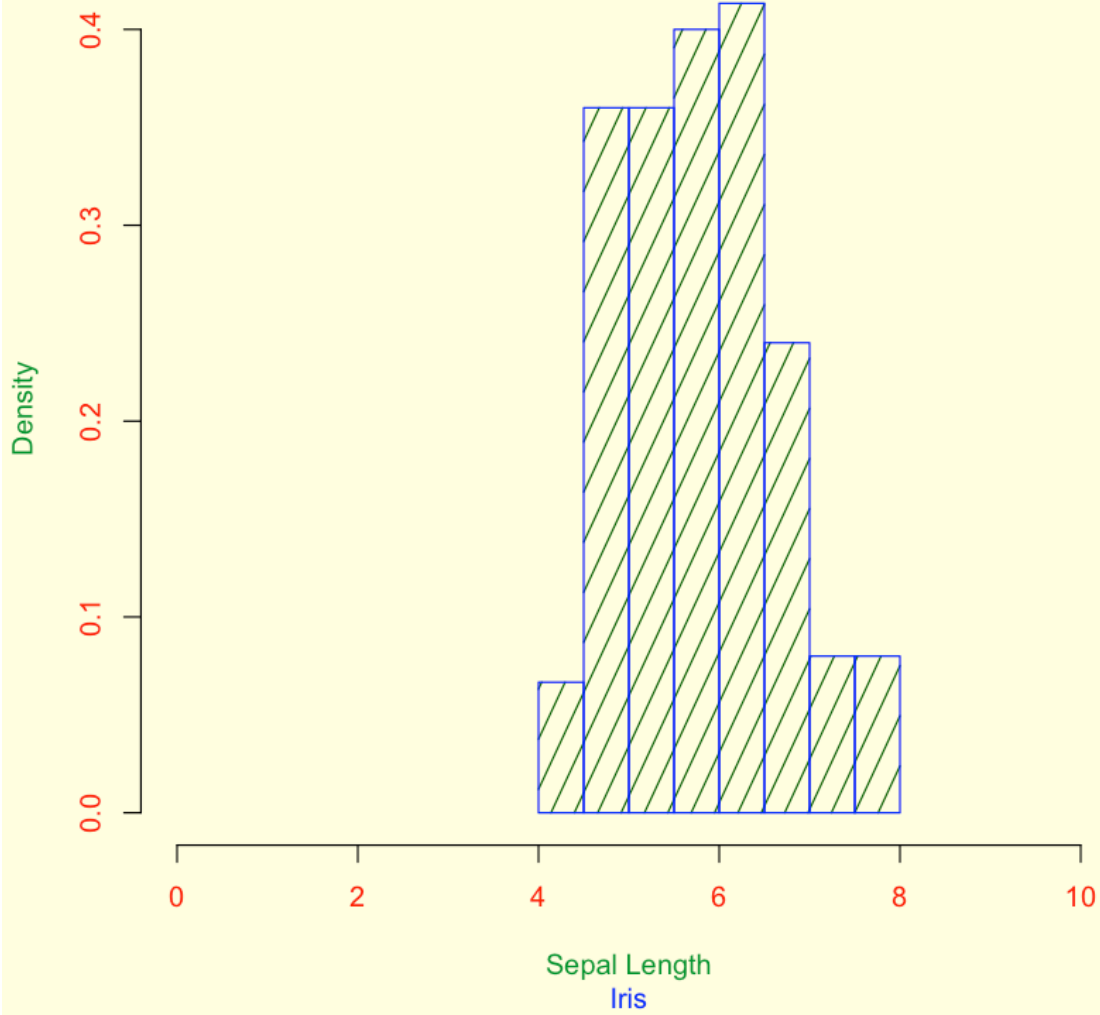
hist(x) requires that the x is numeric.

Consider barplot(x) and plot(x, type = "h") if x is not numeric.

In [7]:

```
# Some parameters related to colors
par(bg = "lightyellow") # par() sets graphical parameters before
plots.
hist(iris$Sepal.Length,
     freq = F,           # count or proportion
     # breaks = 15,
     breaks = seq(4,8,0.5),
     xlim = c(0, 10),
     main = "Histogram of Sepal Length",
     sub = "Iris",
     xlab = "Sepal Length",
     col.main = "blue",
     col.axis = 2,
     col.lab = "#009933",
     col.sub = 4,        # multiple ways to specify color.
     col = "darkgreen",
     border = "blue",    # Color of border of the bars
     density = 8,        # density of shading lines
     angle = 65          # angle of shading lines, in degrees
     .
 )
# border, density and angle are parameters specific to hist().
# Mostly showed parameters related to colors.
# Sorry I am really really really bad with colors.
```

Histogram of Sepal Length



In [8]:

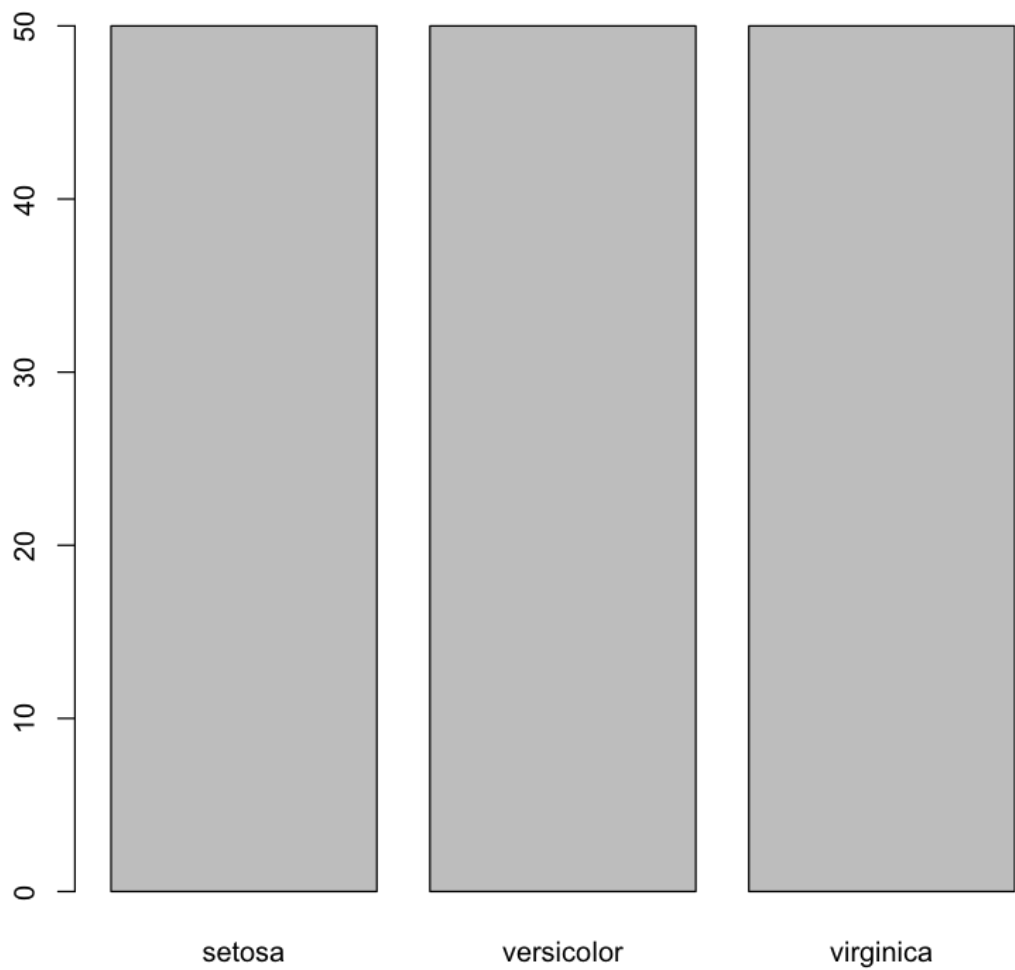
```
table(iris$Species)
barplot(table(iris$Species))
```

setosa versicolor virginica

50

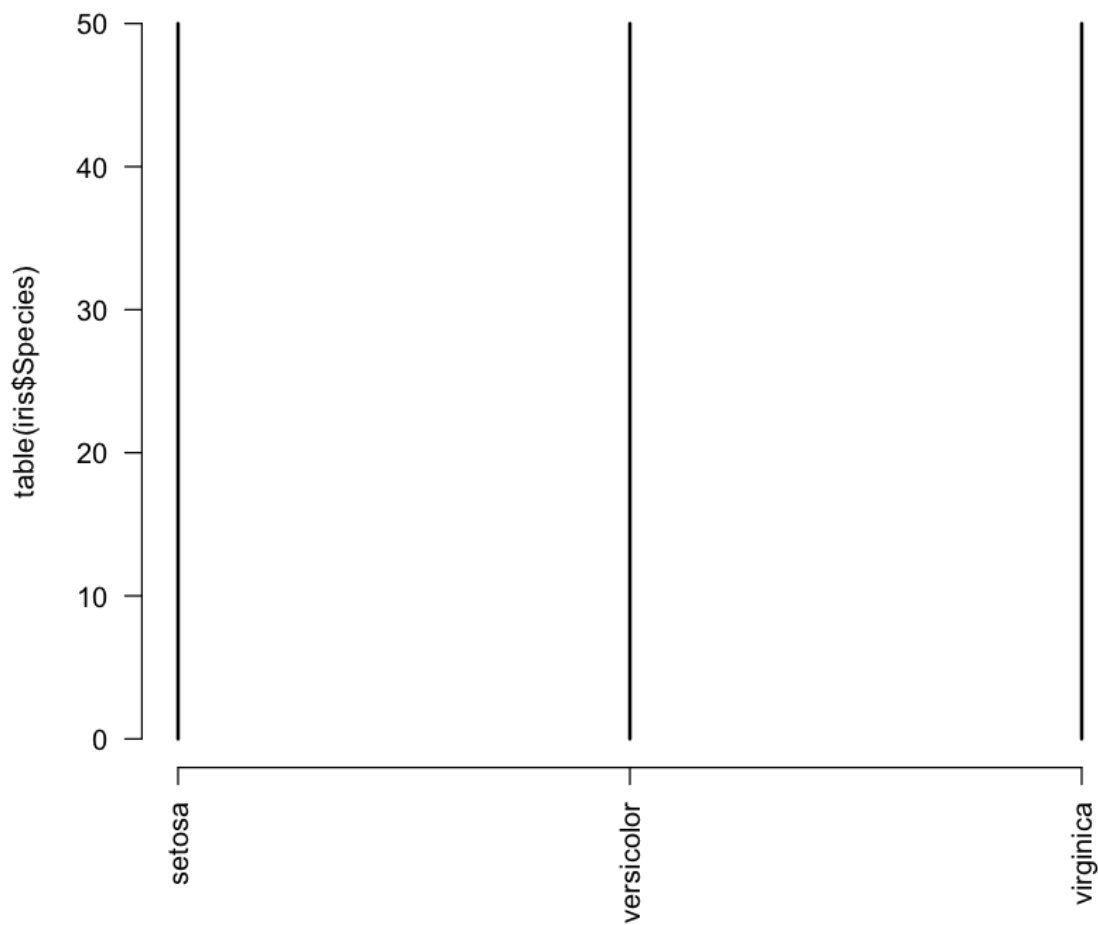
50

50



In [9]:

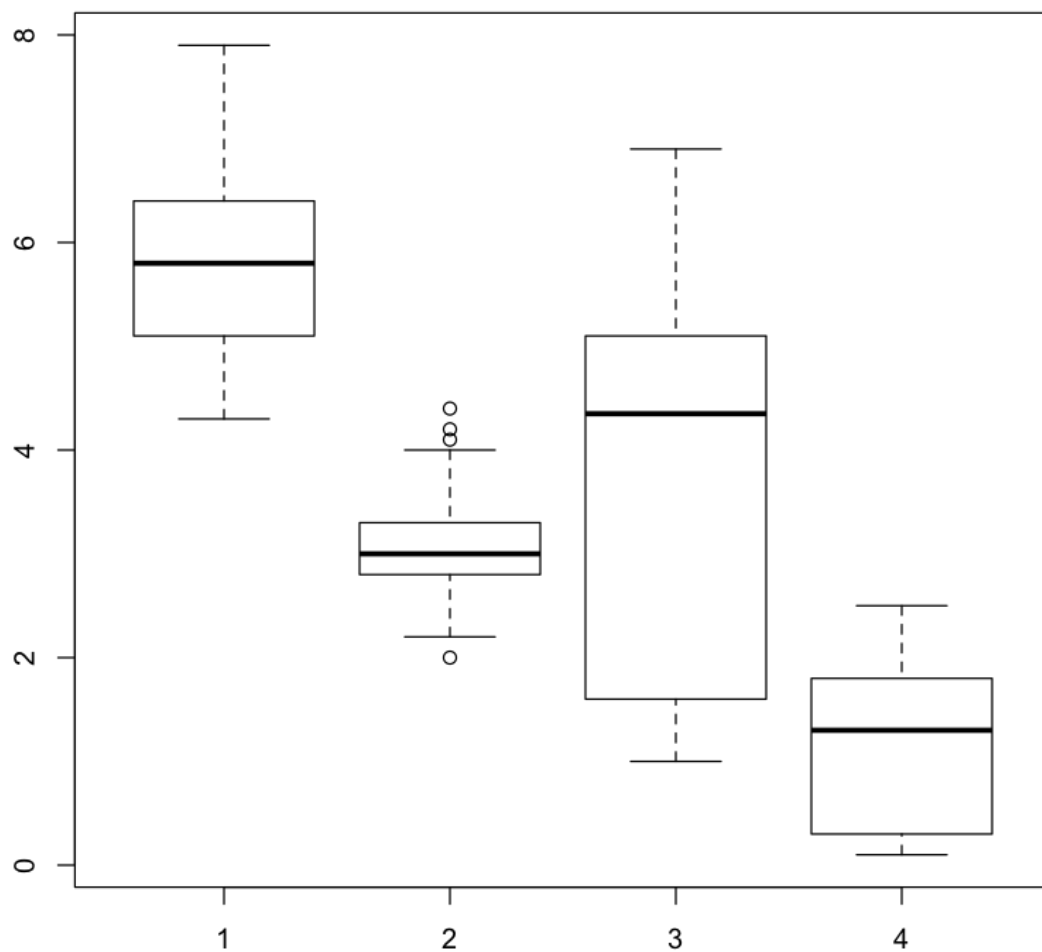
```
par(mar = c(8, 4, 4, 2) + 0.1)
# Set the margins around the plotting area
plot(table(iris$Species), type = "h", las = 2)
# las controls the orientation of axis annotations.
```



6.1.5 Boxplot

In [10]:

```
boxplot(iris$Sepal.Length, iris$Sepal.Width, iris$Petal.Length,  
iris$Petal.Width)
```



6.1.6 Draw functions

In [11]:

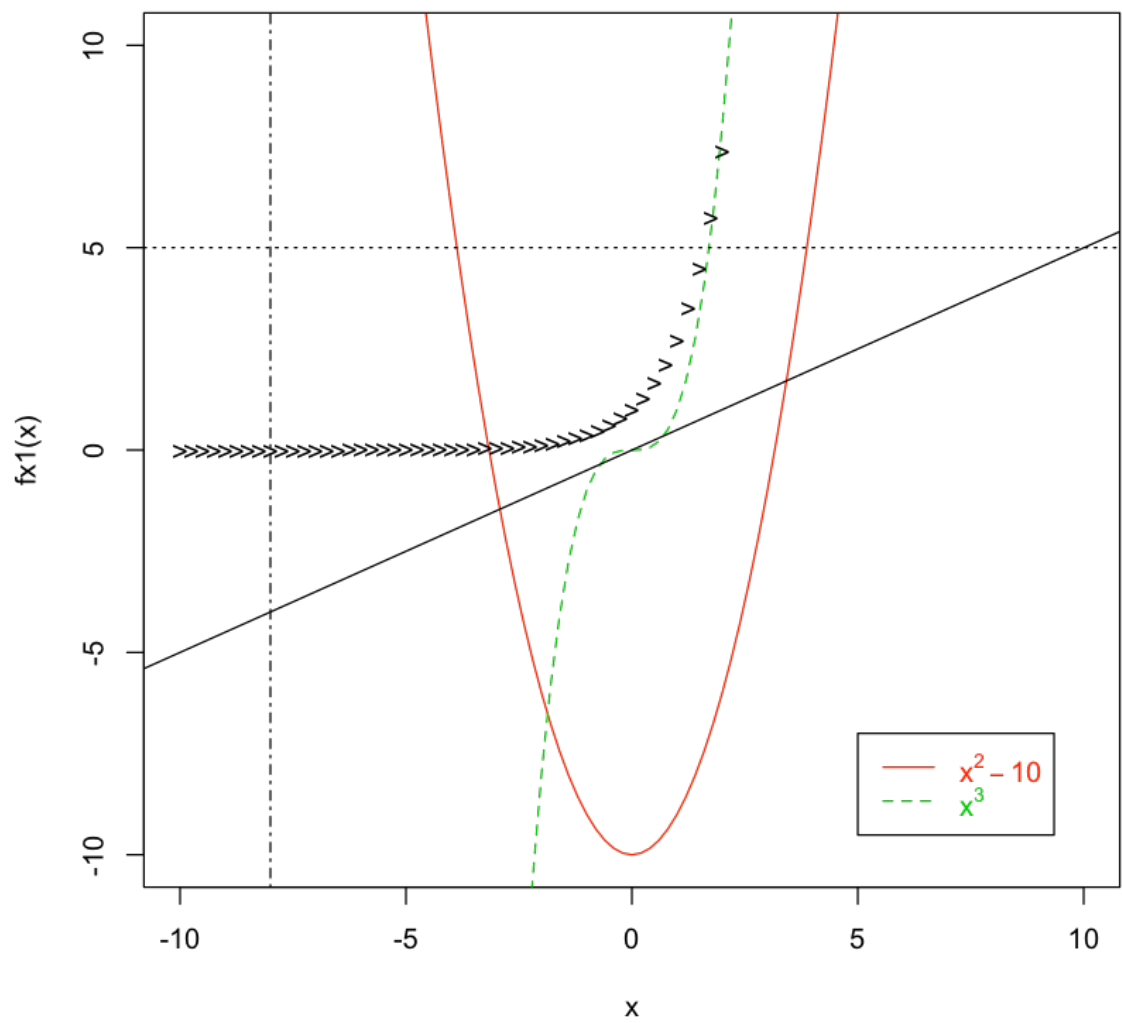
```
fx1 <- function(x){x^2-10}
fx2 <- function(x){x^3}
curve(fx1,
      xlim = c(-10, 10), ylim = c(-10, 10),
      col = 2, lty = 1)
curve(fx2, add = TRUE,      # add is an parameter in curve()
      col = 3, lty = 2)    # TRUE -> plot on the existing plot

x <- seq(from = -10, to = 2, by = 0.25)
y <- exp(x)
points(x=x, y=y, pch = ">") # Add these points to the existing
plot
# Add the smooth line containing these points to the existing pl
ot
# lines(x=x, y=y)

abline(h = 5, lty = 3)      # h -> horizontal line at y = 5
abline(v = -8, lty = "dotdash") # v => vertical line at x =
-8

abline(a = 0, b = 1/2)      # y = a + bx

# legend
legend(x = 5, y = -7,      # Can also be "top", "bottomright",
...
      c(expression(paste(x^2-10)), expression(paste(x^3))),
      col = c(2,3),        # Usually corresponds to the plot
      lty = c(1,2),
      text.col = c(2,3))
```

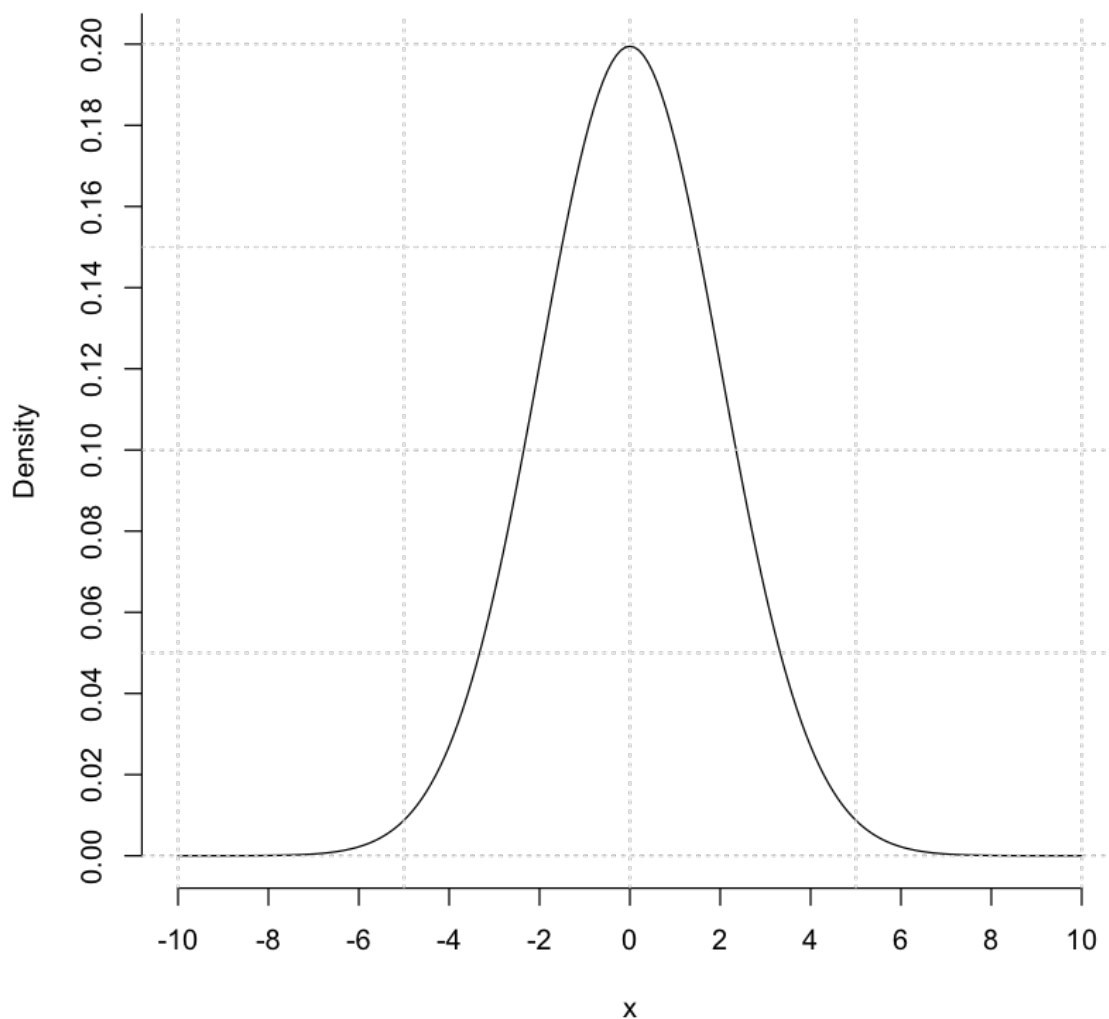


Draw density functions

In [12]:

```
xx <- seq(from = -10, to = 10, by = 0.1)
yy <- dnorm(xx, mean = 0, sd = 2)
# dnorm() gives the normal distribution density
plot(x = xx, y = yy, type = "l", main = "PDF of Normal(0, 2)",
     axes = F,          # Suppress axes
     xlab = "x", ylab = "Density"
)
# axis() allows us to customize axes.
axis(1, at = seq(from = -10, to = 10, by = 2))
axis(2, at = seq(from = 0, to = 1, by = 0.02))
grid() # add grid lines.
# Explore the parameters allowed in grid()
```

PDF of Normal(0, 2)

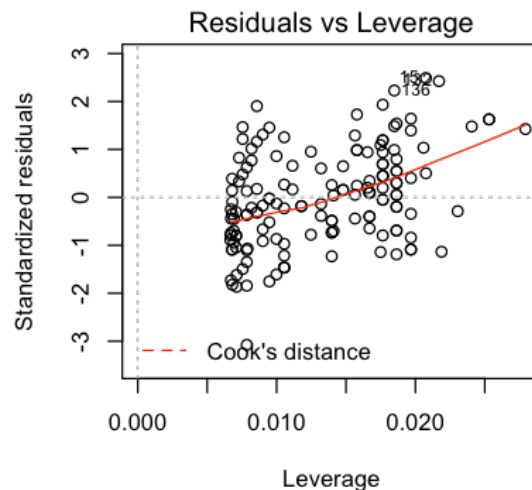
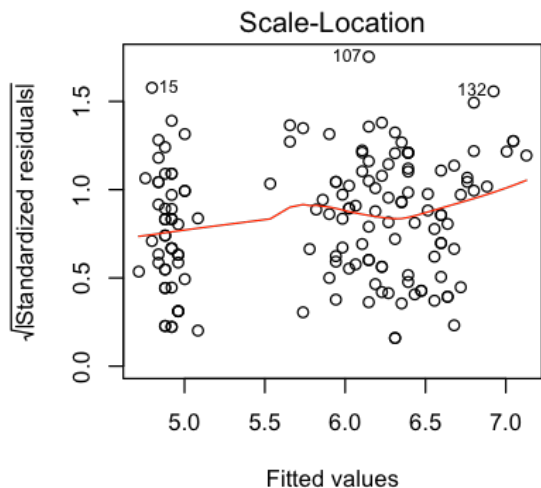
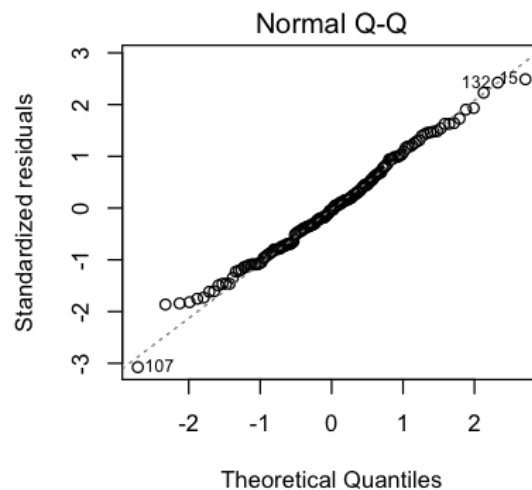
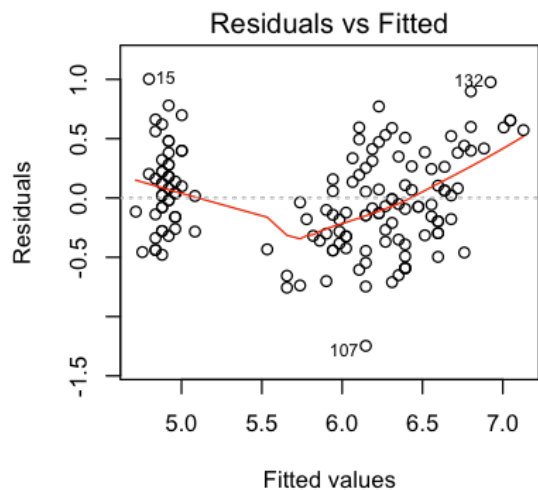


6.2 Multiple plots on one page

- `par(mfrow =)`
- `layout()`

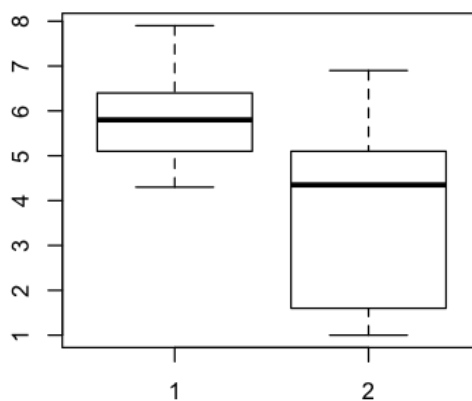
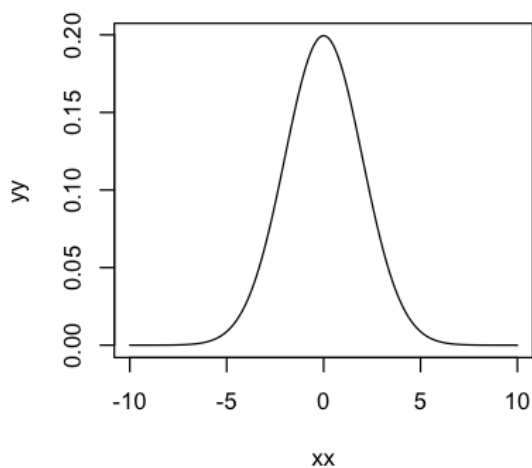
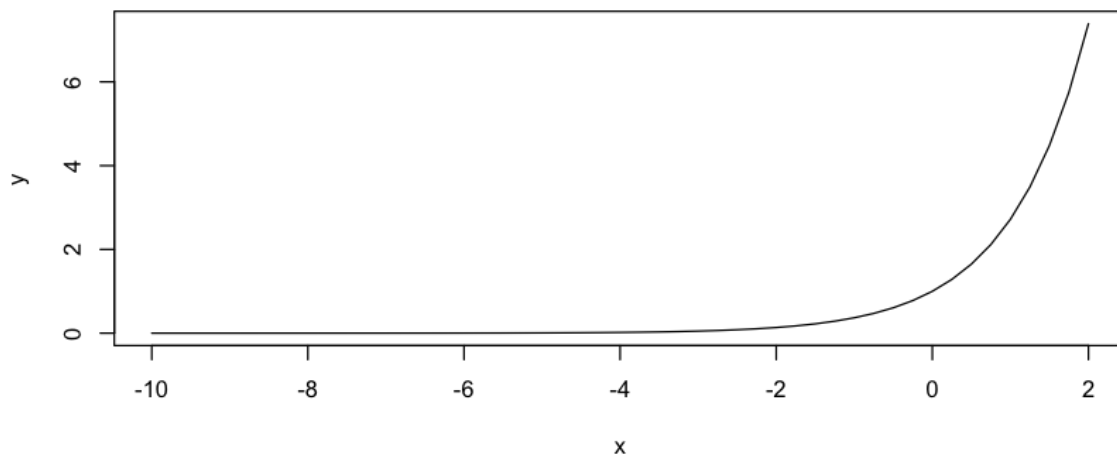
In [13]:

```
par(mfrow = c(2, 2)) # 2 x 2 = 4 plots on the same page
plot(lm(Sepal.Length~Petal.Length, data = iris))
# lm() for linear regression - EPIB 621 material
# Plot your linear regression object will give 4 diagnostic plots.
```



In [14]:

```
nf <- layout(matrix(c(1,1,2,3), 2, 2, byrow = TRUE))  
# layout.show(nf) # Shows the partition of the plotting area  
plot(x=x, y=y, type = "l")  
plot(x=xx, y=yy, type = "l")  
boxplot(iris$Sepal.Length, iris$Petal.Length)
```



6.3 Save a plot

Click!

or

In [15]:

```
pdf(file = "Normal_Density.pdf")

plot(x = xx, y = yy, type = "l", main = "PDF of Normal(0, 2)",
      axes = F, xlab = "x", ylab = "Density")
axis(1, at = seq(from = -10, to = 10, by = 2))
axis(2, at = seq(from = 0, to = 1, by = 0.02))
grid()

dev.off()
```

pdf: 2

Exercise for bonus points!

Use a for loop, draw and save density plots of Normal(0,1), Normal(1,2), Normal(2,3), Normal(3,4) and Normal(4,5) in pdf format.

Requirements:

- The plots should have the same axis limits and labels.
- The title of the plots should be Normal(0,1), Normal(1,2), Normal(2,3), Normal(3,4) and Normal(4,5).
- The plots should have different background colors.
- The density plots should have different line types - solid, dashed...
- Any customization that you think will make your plots look better.
- Add legends

In [16]:

```
mu <- 0:4
sigma <- 1:5
bg.color <- c("", "", "", "", "") # Colors of your choice
```