Some Examples of Graphics in the Statistical Language R

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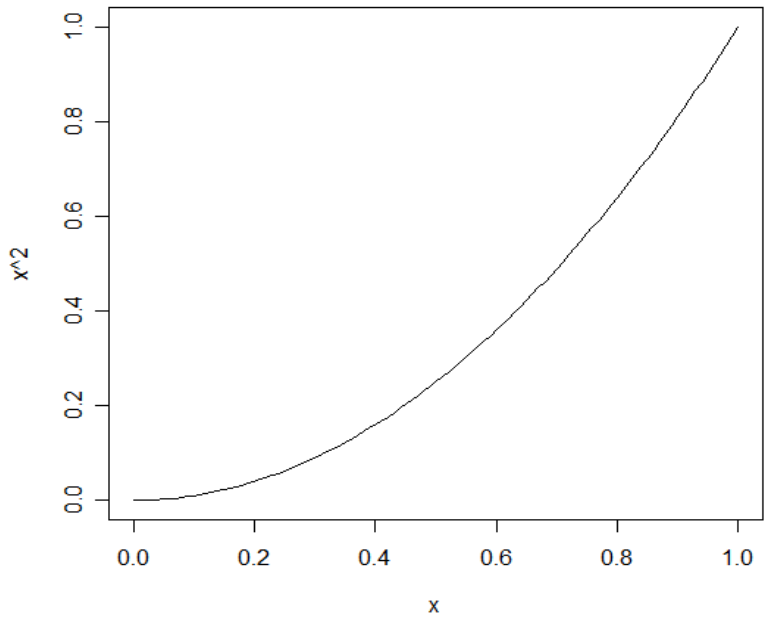
1. Introduction.

The statistical language R has some excellent graphics capabilities.
Unfortunately, there are many parameters and options and documentation is not always the best. One way to help with this situation is to have an example bank. If one can find an example close to what is needed, then the example can be modified. Everyone has specific needs. The examples presented here illustrate my needs and the needs of those who have asked me how to perform certain tasks. My examples can be combined with those of others to get a larger picture. The examples can be copied into R directly to see the commands in action. Changes are encouraged.

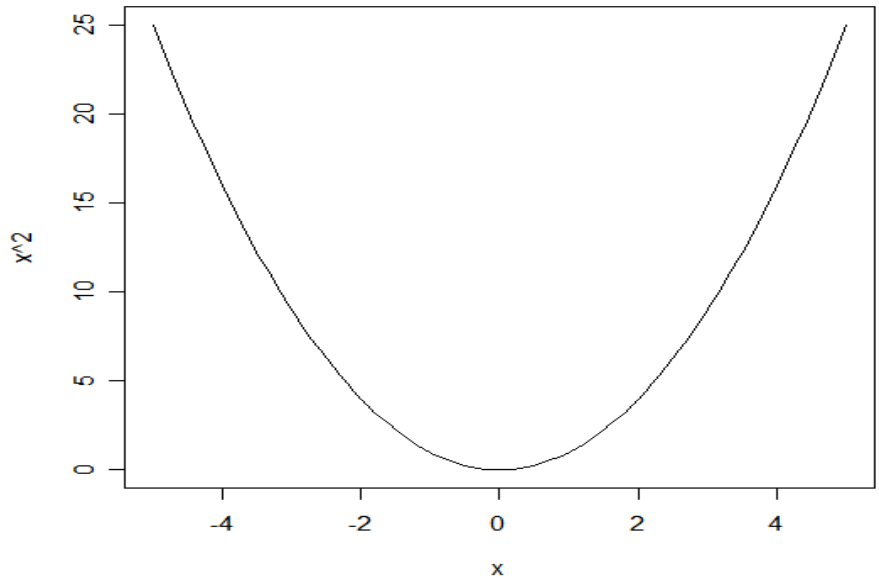
The graphs can be saved in several formats. If one right clicks on the graph, the options for saving include bitmap (for placing diagrams into MS Word documents) and postscript (for placing diagrams into LaTeX documents, which I label as eps files when I name them).

EXAMPLE 1: We begin with a graph of $y=x^2$.

```
curve(x^2)
#The graphics system in R chooses its own scaling. I would  choose other limits.
```



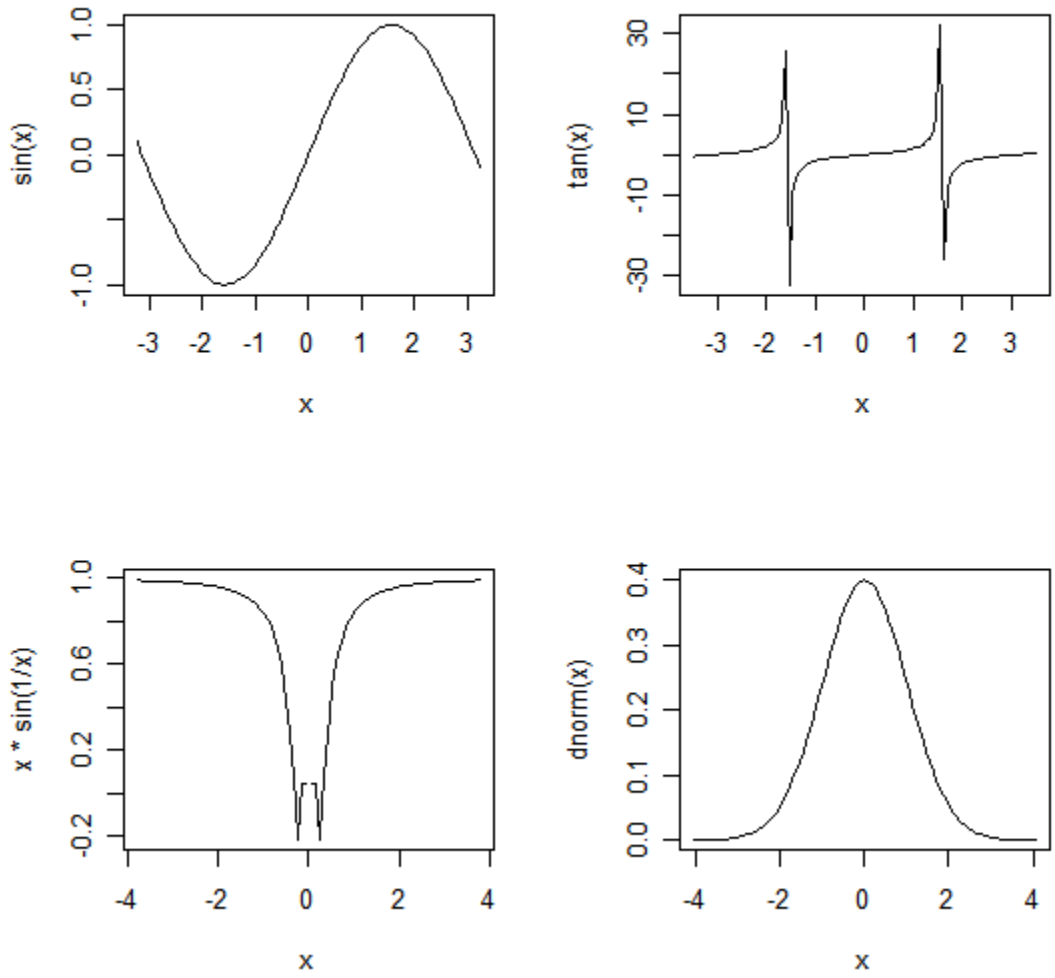

```
curve(x^2,-5,5)
#We control the horizontal axis from x=-5 to x=5.  That's better.
```



EXAMPLE 2

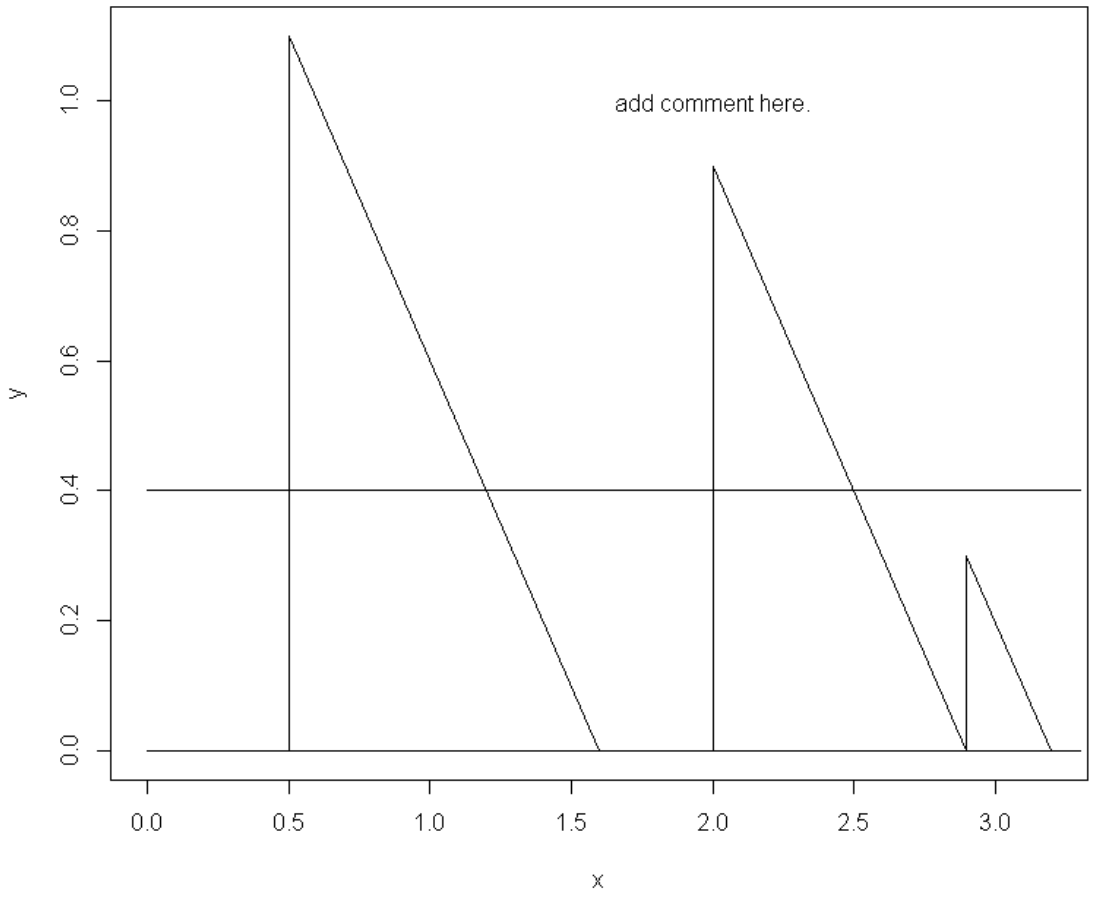
```
op= par(mfrow=c(2,2))    #op means options; par means parameters
curve(sin(x))
curve(tan(x))
curve(x*sin(1/x))
curve(dnorm(x))
```

This will give four (2 x 2) small plots



EXAMPLE 3: My colleague needs diagrams like this one.

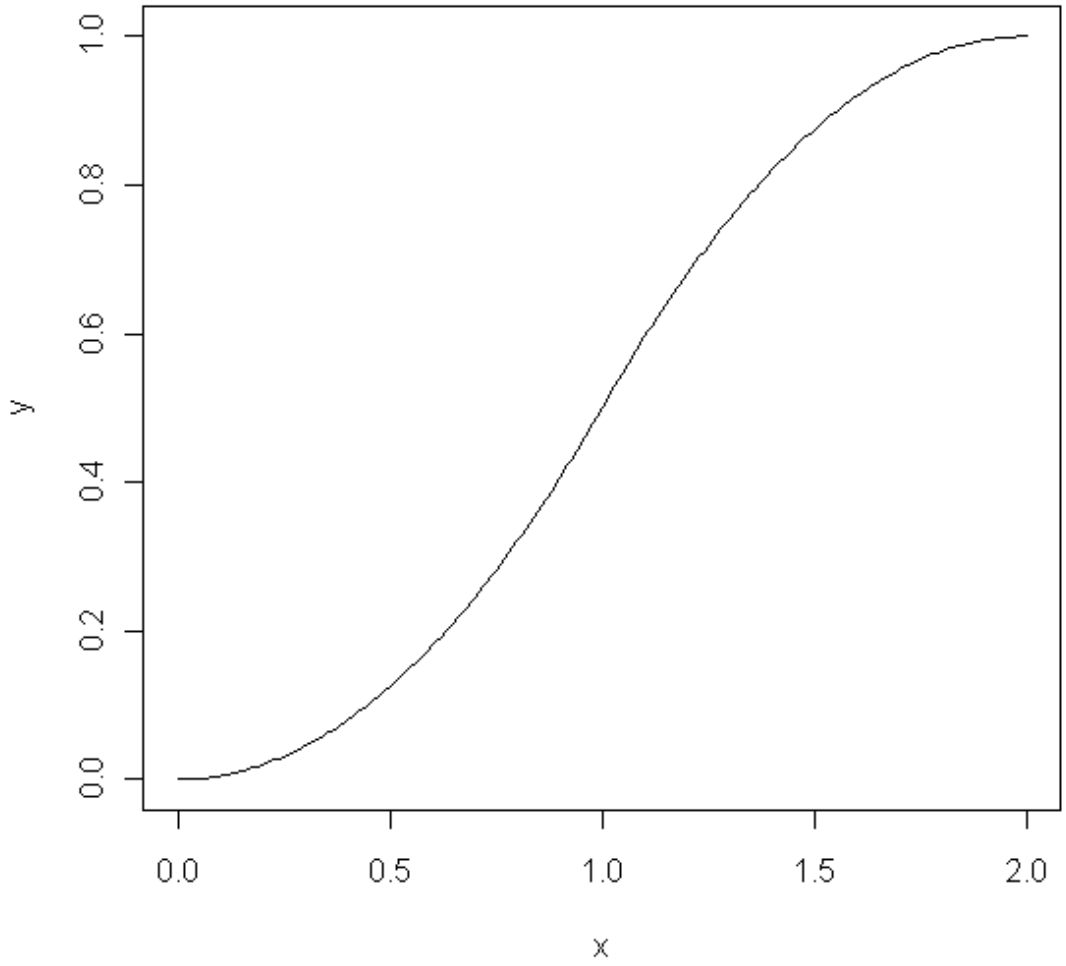
```
x=c(0.0, 0.5, 0.5, 1.6, 2.0, 2.0, 2.9, 2.9, 3.2)
y=c( 0.0, 0.0, 1.1, 0.0, 0.0, 0.9, 0.0, 0.3, 0.0)
# The x,y values were actually entered in spreadsheet fashion using the command
# data.entry(x,y), not as shown above.
x1=c(0.0, 3.3)    #Add level x line
y1=c(0.4, 0.4)
x2=c(0.0, 3.3)    #Add line for x axis
y2=c(0, 0)
plot(x,y,t="l")   #The “l” refers to “line”
lines(x1,y1,t="l")    #the plot command has to come first.
lines(x2,y2,t="l")
text(2,1,"add comment here.")   # It is centered at point (2,1).
```



Example f(x)=.5 x^2 for 0<x<1 and f(x)=1-.5(2-x)^2 for 1<x<2.

```
x1=seq(0,1,.01)
 x2=seq(1,2,.01)
 y1=x1^2/2
 y2=1-(2-x2)^2/2
 y=c(y1,y2)
 x=c(x1,x2)
 plot(x,y,t="l")
```

Output is

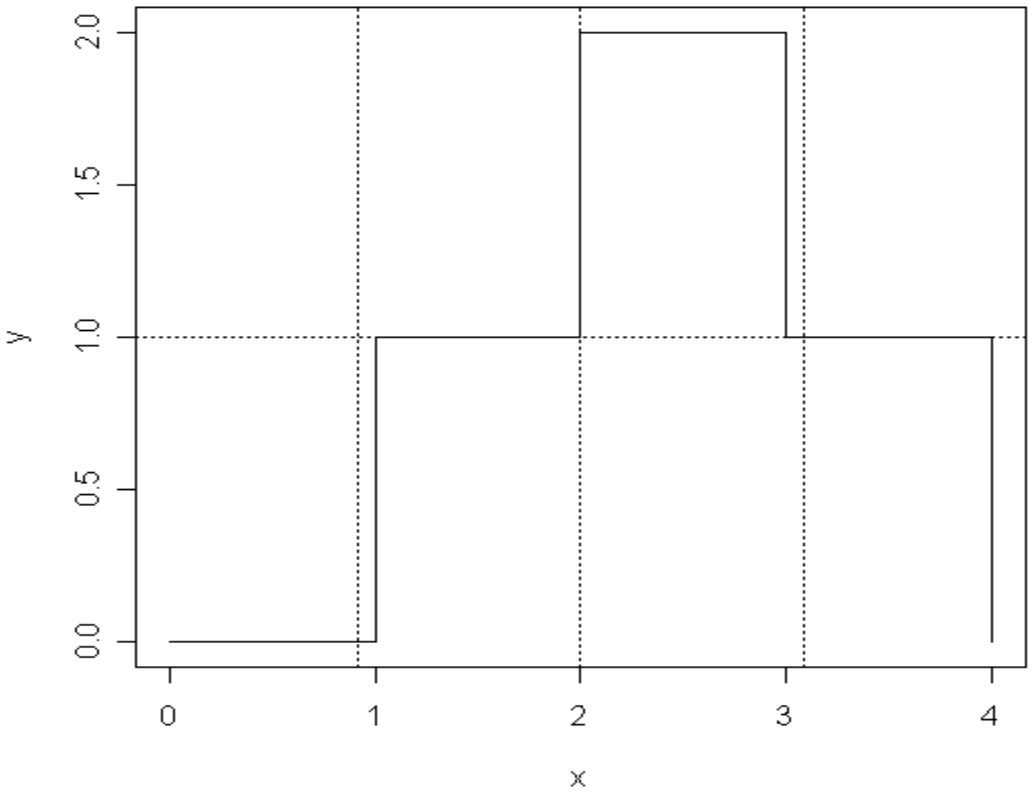


EXAMPLE 4: I need this to draw random walks.

#Again use data.entry(x,y)
#This sets up a spread sheet to aid for data entry. The values chosen for x and y are

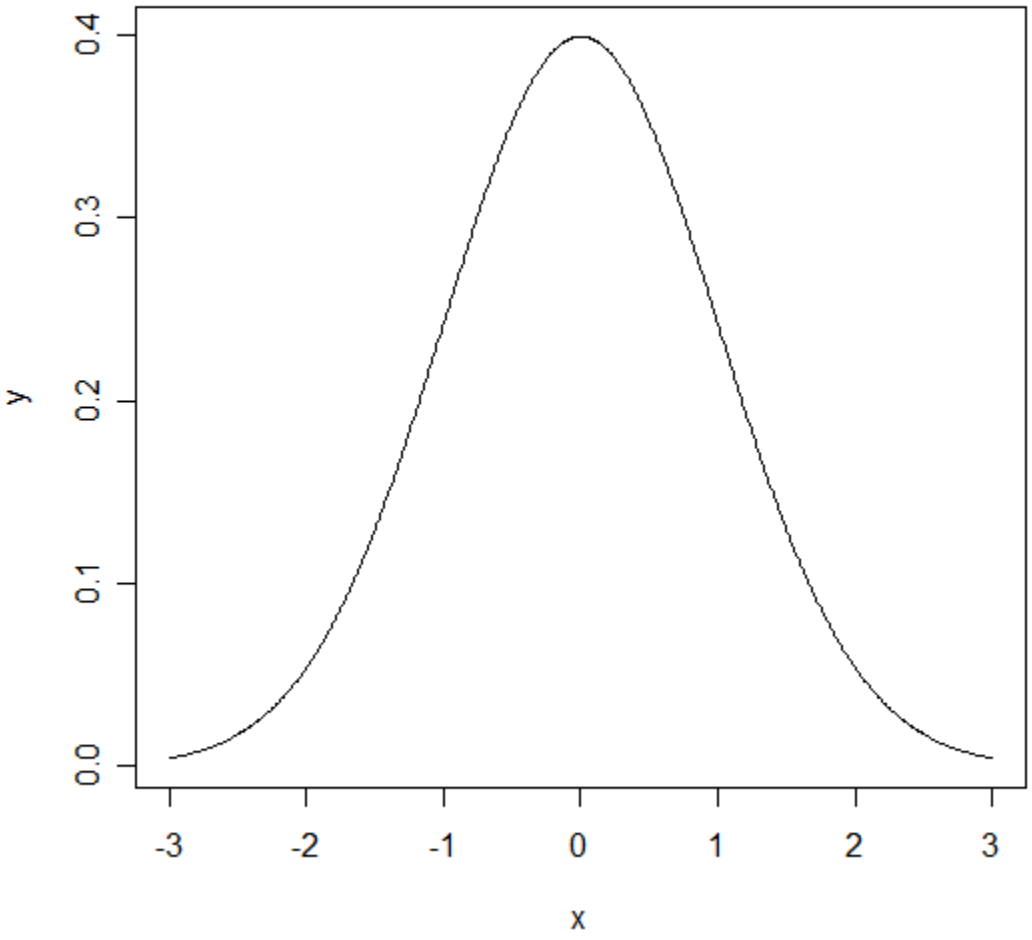
x=c(0, 1, 1, 2, 2, 3, 3, 4, 4)
y= c(0, 0, 1, 1, 2, 2, 1, 1, 0)
plot(x,y,"l") # The (x,y) points are plotted with the joining lines (“l”)
grid(4,2, col="black")   # This gives 4 vertical and 2 horizontal sections.

This will plot a random walk in the plane. Then add grid lines. The default color is light grey which is hard to see. So I made the color “black.”



EXAMPLE 5:
I was asked how statisticians get diagrams of pdf's. This plots a normal pdf. We can do the same for t, F, chi-square, etc.

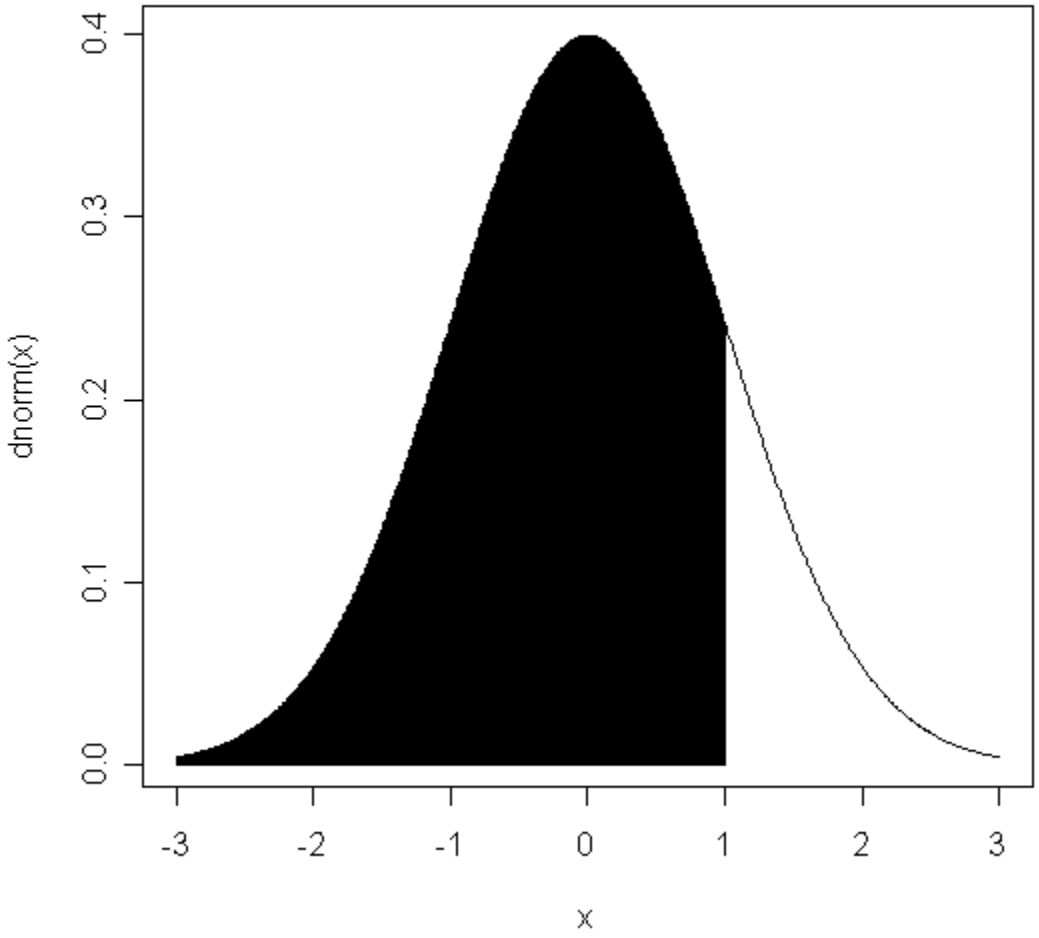
```
x=seq(-3,3,.01)  # This gives lots of values on the x axis
y=dnorm(x)   #dnorm is the pdf of a normal(0,1)
plot(x,y,"l")
```



EXAMPLE 6. The following code shows an overlay of graphs. A statistics book author wanted a small diagram to put over the normal table values that were computed.

```
>x=seq(-3,3,.01)
> plot(x,dnorm(x),"l")
> x=seq(-3,1,.01)
> lines(x,dnorm(x),"h")
```

The “h” part is the blackened region.



EXAMPLE 7: This command gives information about some plotting commands/

library(help="graphics")

The output is:

Information on package 'graphics'

Description:

Package:	graphics
Version:	2.4.1
Priority:	base
Title:	The R Graphics Package
Author:	R Development Core Team and contributors worldwide
Maintainer:	R Core Team <R-core@r-project.org>
Description:	R functions for base graphics
Depends:	grDevices
License:	GPL Version 2 or later.
Built:	R 2.4.1; ; 2006-12-18 09:43:18; windows

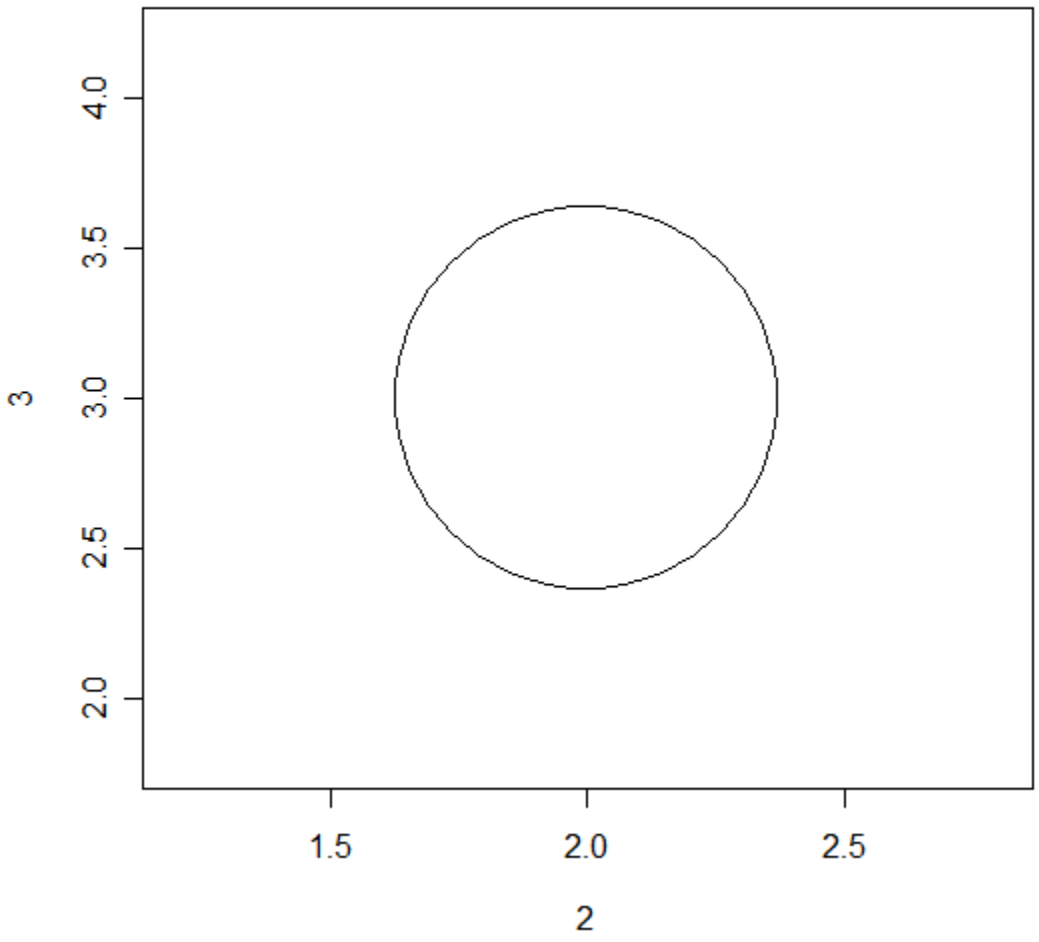
Index:

Axis	Generic function to add an Axis to a Plot
abline	Add a Straight Line to a Plot
arrows	Add Arrows to a Plot
assocplot	Association Plots
axTicks	Compute Axis Tickmark Locations
axis	Add an Axis to a Plot
axis.POSIXct	Date and Date-time Plotting Functions
barplot	Bar Plots
box	Draw a Box around a Plot
boxplot	Box Plots
bxp	Draw Box Plots from Summaries
cdplot	Conditional Density Plots
contour	Display Contours
coplot	Conditioning Plots
curve	Draw Function Plots
dotchart	Cleveland Dot Plots
filled.contour	Level (Contour) Plots
fourfoldplot	Fourfold Plots
frame	Create / Start a New Plot Frame
graphics-package	The R Graphics Package
grid	Add Grid to a Plot
hist	Histograms
hist.POSIXt	Histogram of a Date or Date-Time Object

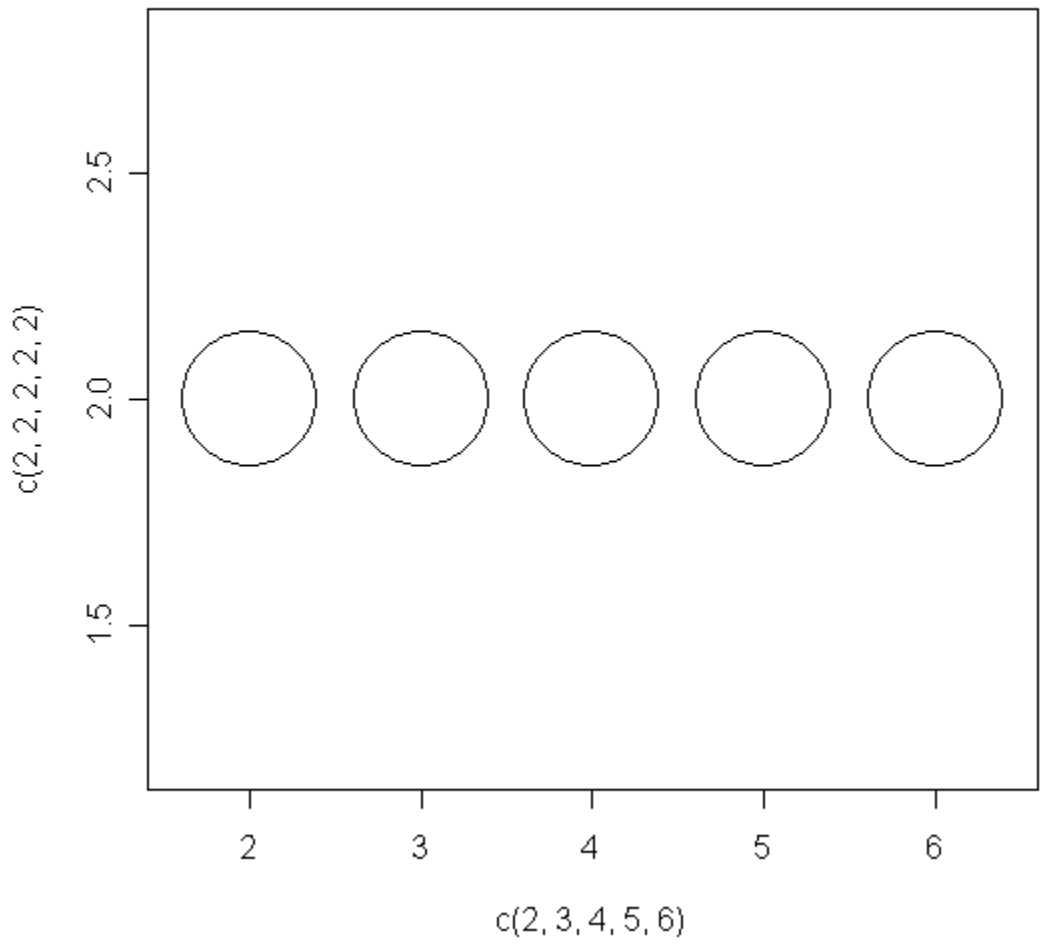
identify Identify Points in a Scatter Plot
image Display a Color Image
layout Specifying Complex Plot Arrangements
legend Add Legends to Plots
lines Add Connected Line Segments to a Plot
locator Graphical Input
matplot Plot Columns of Matrices
mosaicplot Mosaic Plots
mtext Write Text into the Margins of a Plot
pairs Scatterplot Matrices
panel.smooth Simple Panel Plot
par Set or Query Graphical Parameters
persp Perspective Plots
pie Pie Charts
plot Generic X-Y Plotting
plot.data.frame Plot Method for Data Frames
plot.default The Default Scatterplot Function
plot.design Plot Univariate Effects of a 'Design' or Model
plot.factor Plotting Factor Variables
plot.formula Formula Notation for Scatterplots
plot.histogram Plot Histograms
plot.table Plot Methods for 'table' Objects
plot.window Set up World Coordinates for Graphics Window
plot.xy Basic Internal Plot Function
points Add Points to a Plot
polygon Polygon Drawing
rect Draw One or More Rectangles
rug Add a Rug to a Plot
screen Creating and Controlling Multiple Screens on a Single Device
segments Add Line Segments to a Plot
spineplot Spine Plots and Spinograms
stars Star (Spider/Radar) Plots and Segment Diagrams
stem Stem-and-Leaf Plots
stripchart 1-D Scatter Plots
strwidth Plotting Dimensions of Character Strings and Math Expressions
sunflowerplot Produce a Sunflower Scatter Plot
symbols Draw Symbols (Circles, Squares, Stars, Thermometers, Boxplots) on a Plot
text Add Text to a Plot
title Plot Annotation
xinch Graphical Units

EXAMPLE 8: Draw a circle.

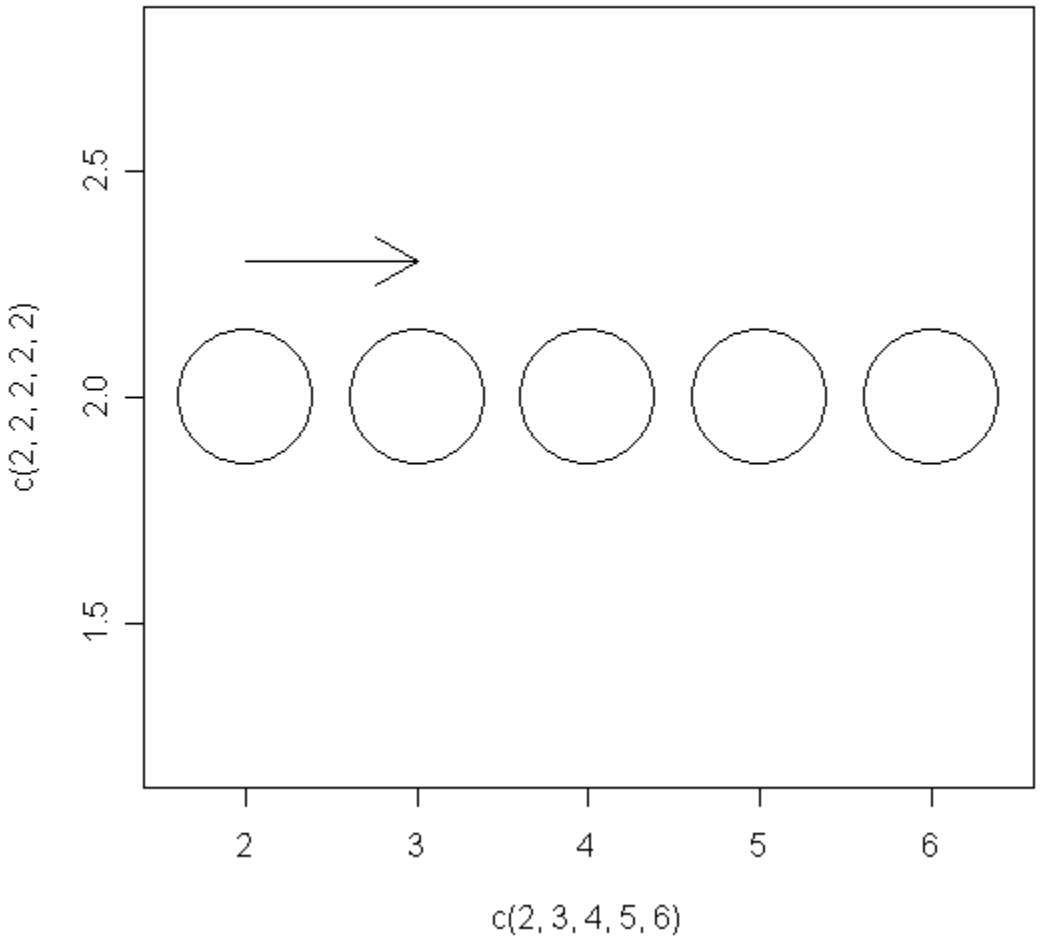
symbols(2,3,circles=c(1))
The (2,3) gives the center of the circle and the 1 is the radius.
Output is



EXAMPLE 9: Draw 5 circles.
symbols(c(2,3,4,5,6),c(2,2,2,2,2),circles=c(.4,.4,.4,.4,.4), inches=FALSE)
This gives 5 circles centered at (2,2), (3,2), (4,2) (5,2) (6,2) with radii all equal to 0.4. The inches=FALSE is important because the default will change all the .4 to 1.

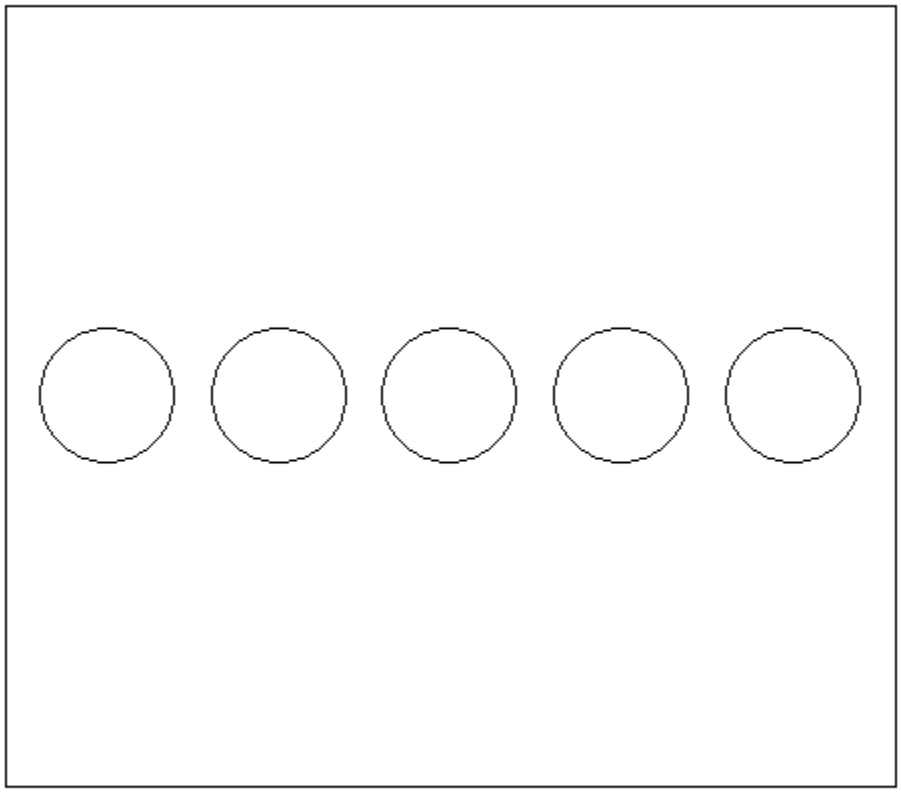


EXAMPLE 10:
symbols(c(2,3,4,5,6),c(2,2,2,2,2),circles=c(.4,.4,.4,.4,.4), inches=FALSE)
arrows(2,2.3,3,2.3)
#This adds an arrow from (2,2.3) to (3,2.3).



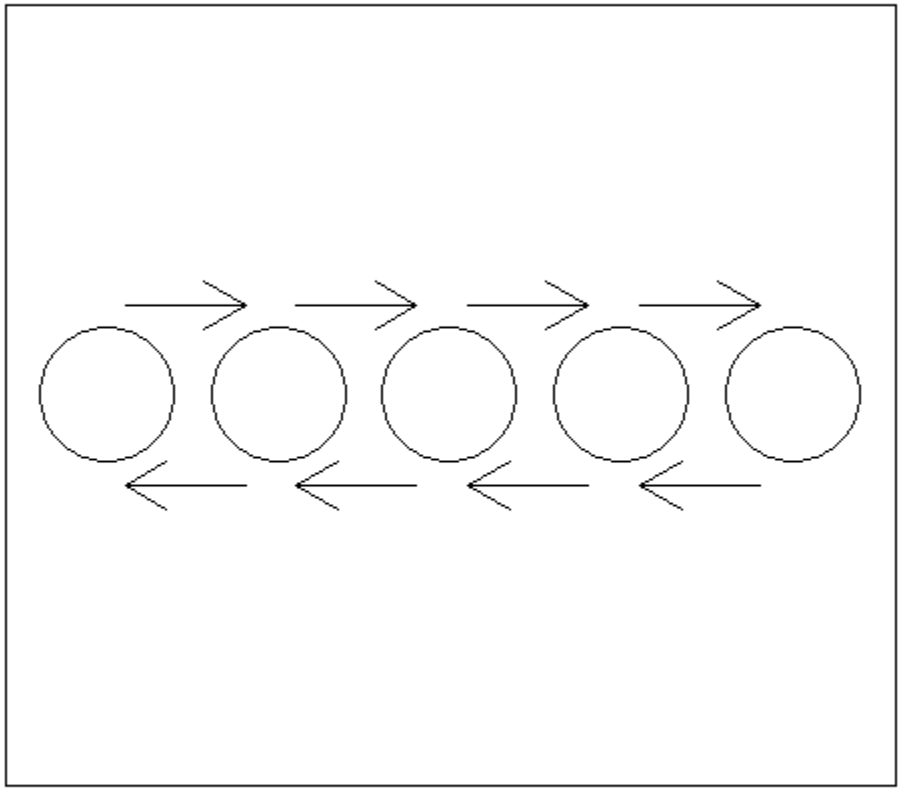
EXAMPLE 11: No axis labels this time.

```
symbols(c(2,3,4,5,6),c(2,2,2,2,2),circles=c(.4,.4,.4,.4,.4),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
#xaxt=”n” means no tick marks on the x axis
#ann=FALSE means no labels on the axes
```



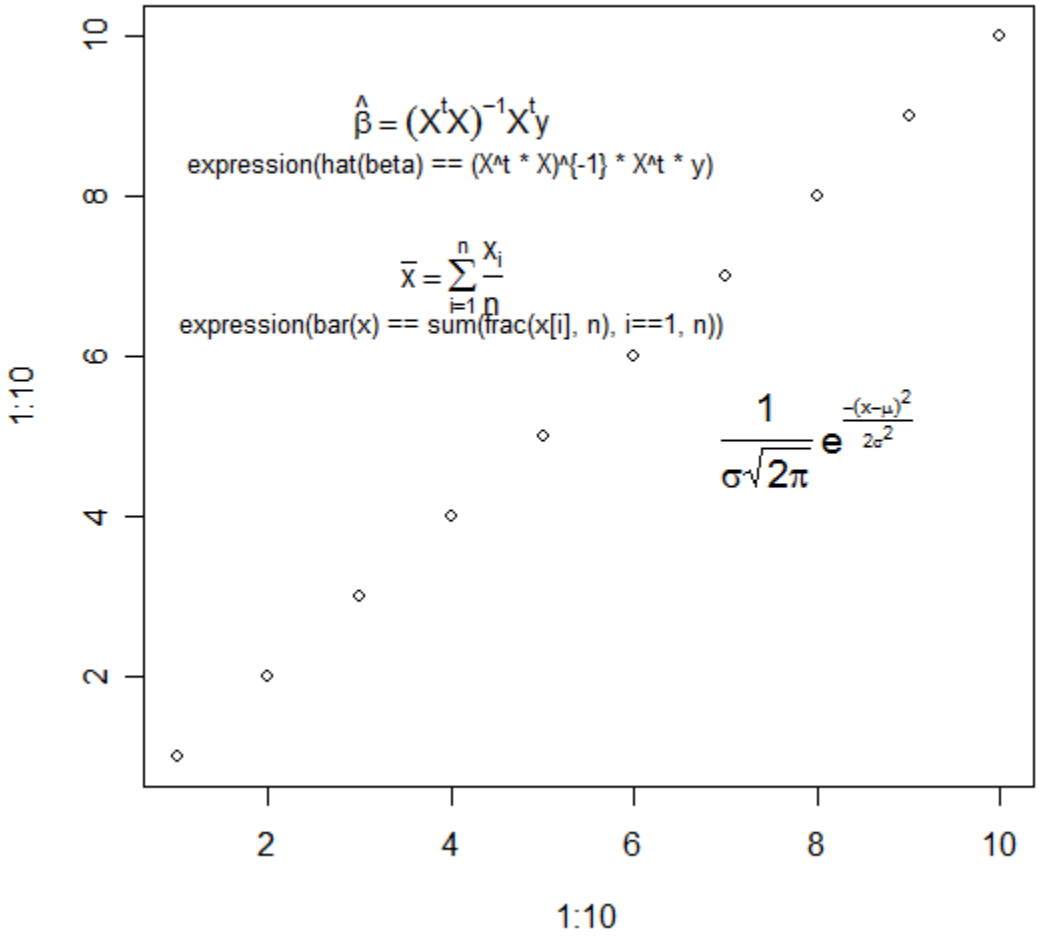
EXAMPLE 12: Include lots of arrows.

```
symbols(c(2,3,4,5,6),c(2,2,2,2,2),circles=c(.4,.4,.4,.4,.4),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
 arrows(2.1,2.2,2.8,2.2)
 arrows(3.1,2.2,3.8,2.2)
 arrows(4.1,2.2,4.8,2.2)
 arrows(5.1,2.2,5.8,2.2)
 arrows(5.8,1.8,5.1,1.8)
 arrows(4.8,1.8,4.1,1.8)
 arrows(3.8,1.8,3.1,1.8)
 arrows(2.8,1.8,2.1,1.8)
```



EXAMPLE 13: Here is an example from R's help menu about adding text to a plot.

```
plot(1:10, 1:10)
text(4, 9, expression(hat(beta) == (X^t * X)^{-1} * X^t * y))
text(4, 8.4, "expression(hat(beta) == (X^t * X)^{-1} * X^t * y)",   cex = .8)
text(4, 7, expression(bar(x) == sum(frac(x[i], n), i==1, n)))
text(4, 6.4, "expression(bar(x) == sum(frac(x[i], n), i==1, n))",  cex = .8)
 text(8, 5, expression(paste(frac(1, sigma*sqrt(2*pi)), " ",
                      plain(e)^{frac(-(x-mu)^2, 2*sigma^2)})),  cex = 1.2)
# cex stands for  numeric character expansion factor which controls character size
```

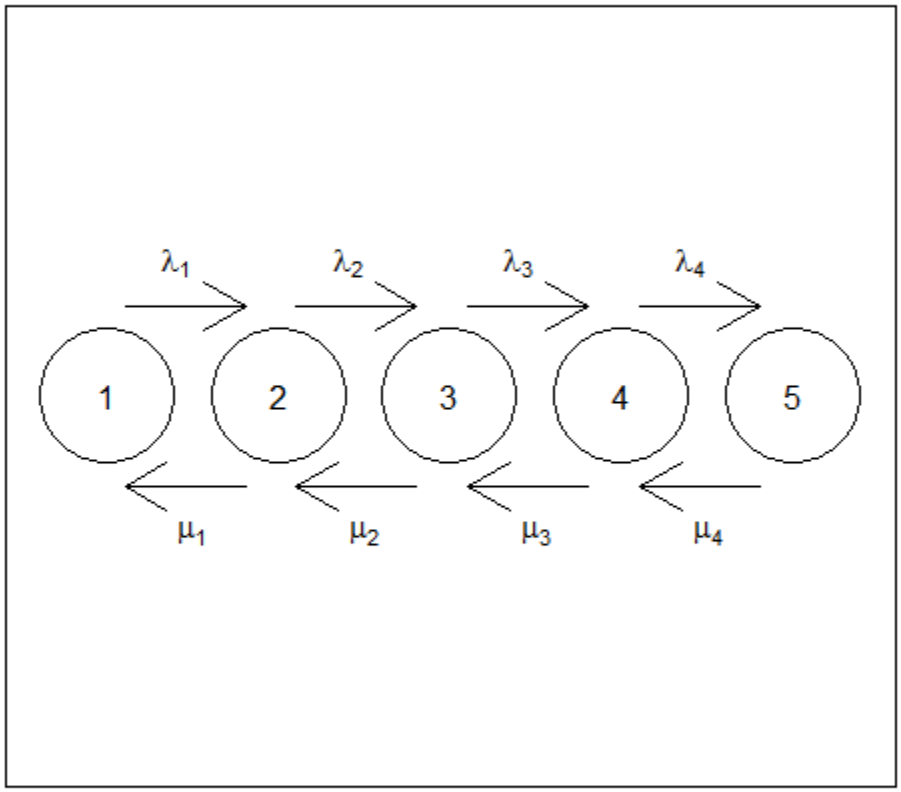


lin

es(x,y)

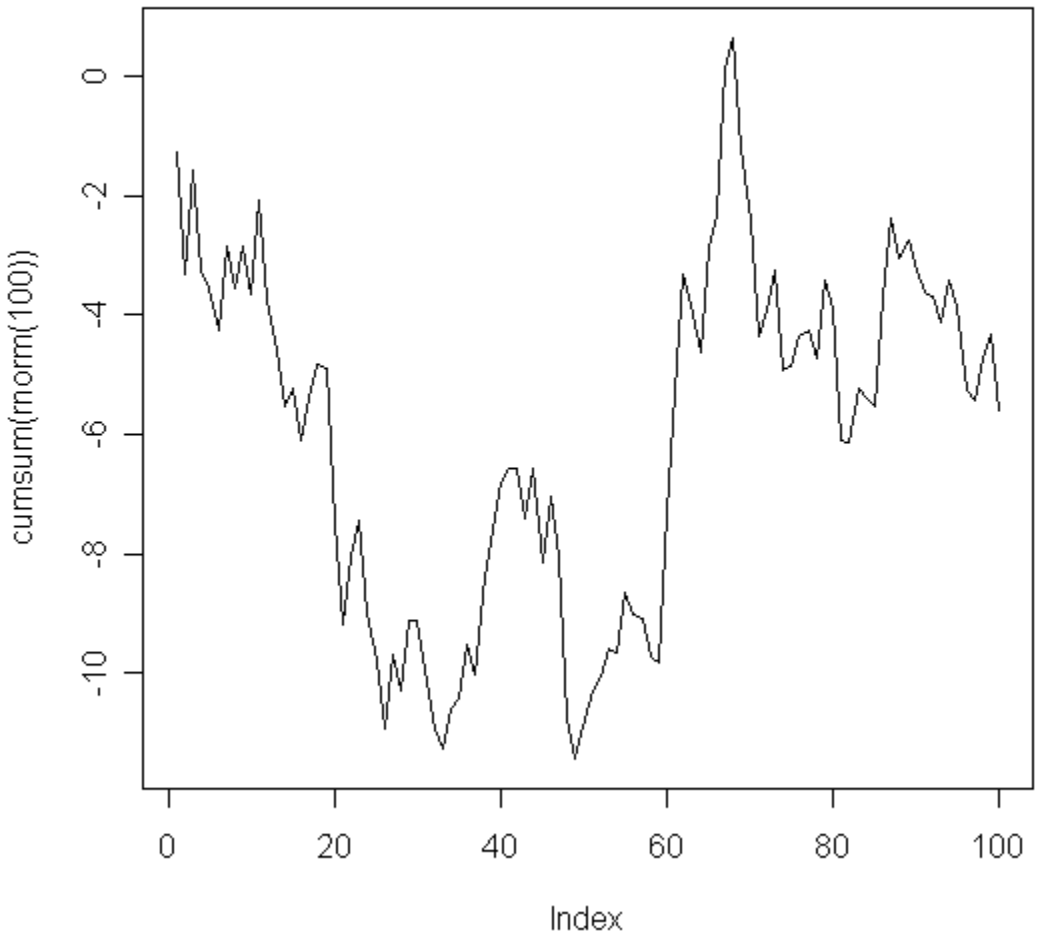
EXAMPLE 14: Back to our flow chart. Add Greek letters with

```
symbols(c(2,3,4,5,6),c(2,2,2,2,2),circles=c(.4,.4,.4,.4,.4),
     inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(2.1,2.2,2.8,2.2) ; arrows(3.1,2.2,3.8,2.2)
arrows(4.1,2.2,4.8,2.2) ; arrows(5.1,2.2,5.8,2.2)
arrows(5.8,1.8,5.1,1.8) ; arrows(4.8,1.8,4.1,1.8)
arrows(3.8,1.8,3.1,1.8) ; arrows(2.8,1.8,2.1,1.8)
text(2.4,2.3, expression(lambda[1])); text(3.4,2.3, expression(lambda[2]))
text(4.4,2.3, expression(lambda[3])); text(5.4,2.3, expression(lambda[4]))
text(2.5,1.7, expression(mu[1])); text(3.5,1.7, expression(mu[2]))
text(4.5,1.7, expression(mu[3])); text(5.5,1.7, expression(mu[4]))
text(2,2,1); text(3,2,2);  text(4,2,3);  text(5,2,4);  text(6,2,5)
```



EXAMPLE 15:

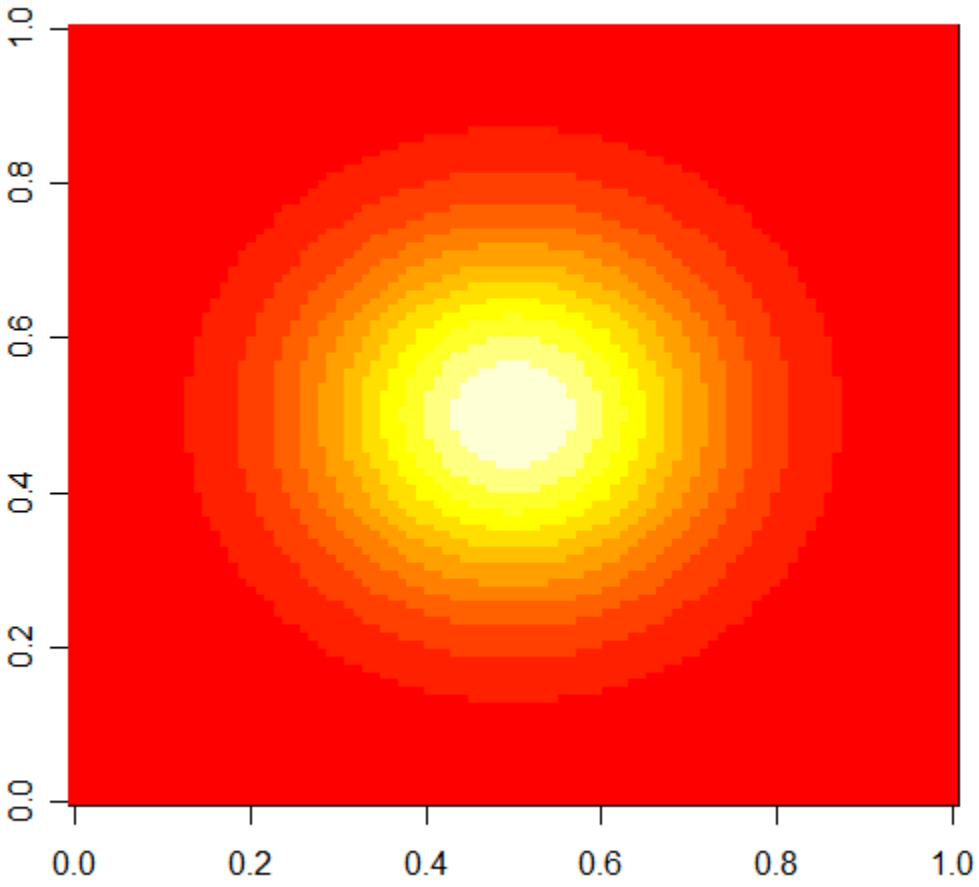
plot(cumsum(rnorm(100)),type="l")
# This will plot a Brownian motion based on 100 normal values and their cumulative sums.



If you want the diagram to start from 0, use
plot(c(0,cumsum(rnorm(100))),type="l")

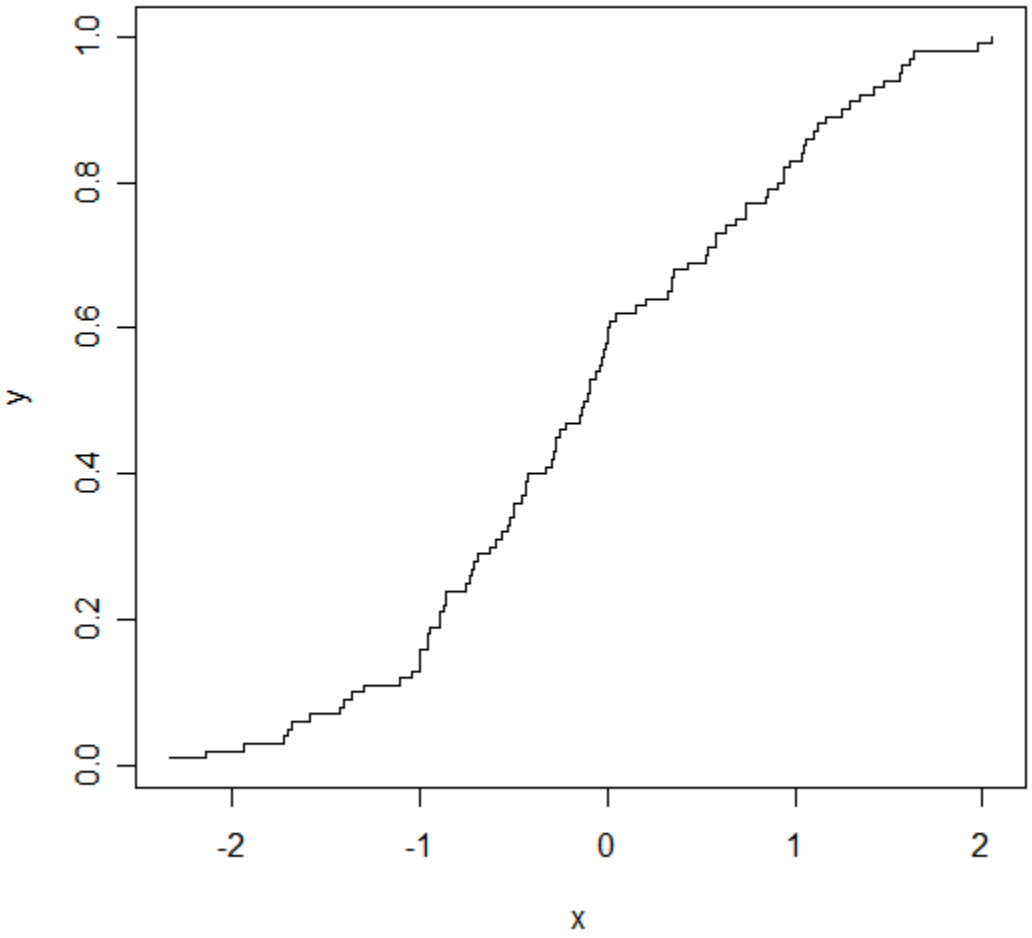
EXAMPLE 16: This is our attempt to plot a bivariate normal in colour, viewed from above.

```
a=seq(-3,3,l=100)
A=matrix(c(0),100,100)    # create a 100x100 matrix full of zeros
for(i in 1:100){ for (j in 1:100){A[i,j]=dnorm(a[i])*dnorm(a[j])} }
image(t(A)[ncol(A):1,])
```



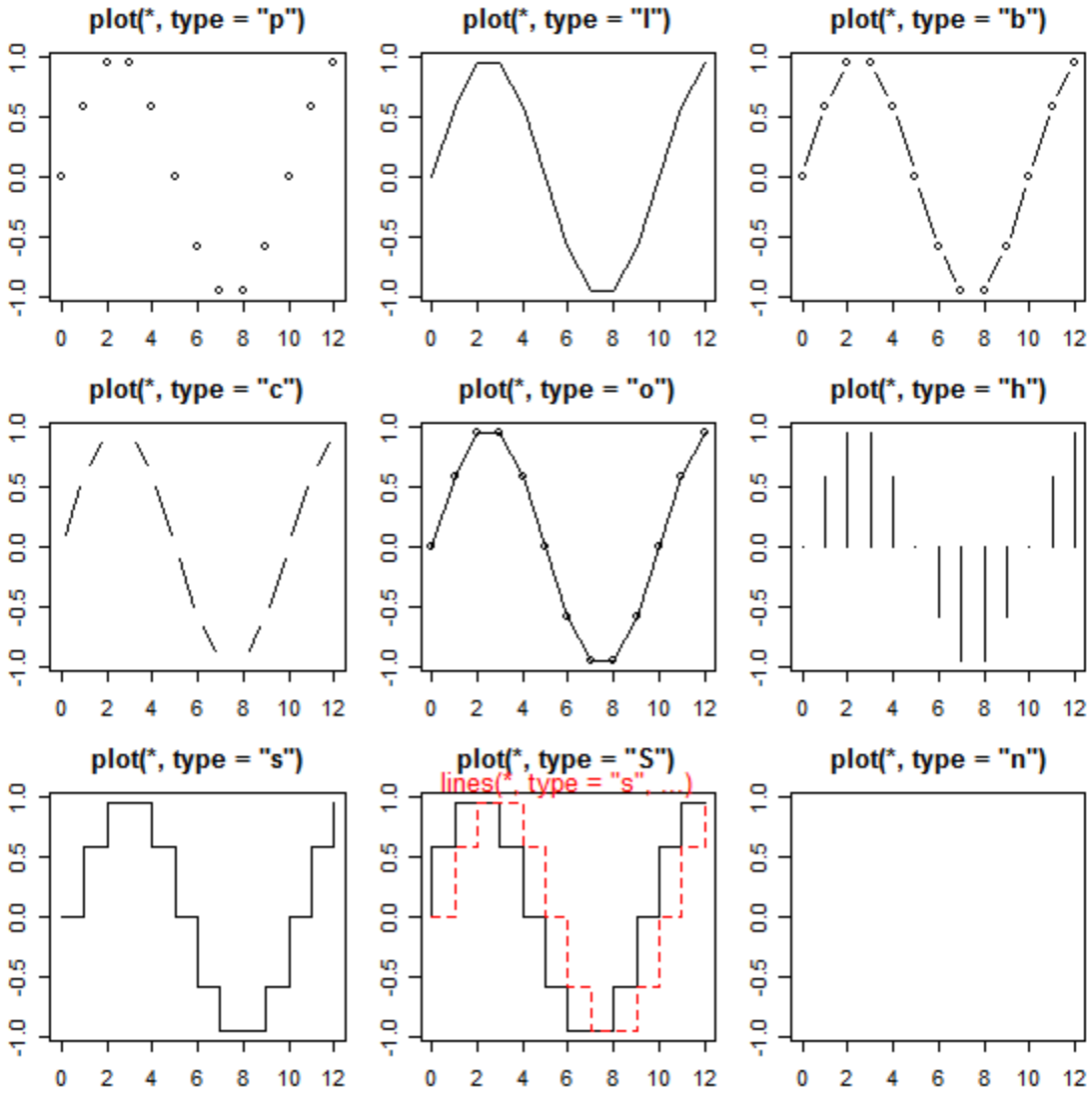
EXAMPLE 17: Empirical Distribution Function.

```
x=sort(rnorm(100))
y=seq(1:100)/100
plot(x,y,"s")
```



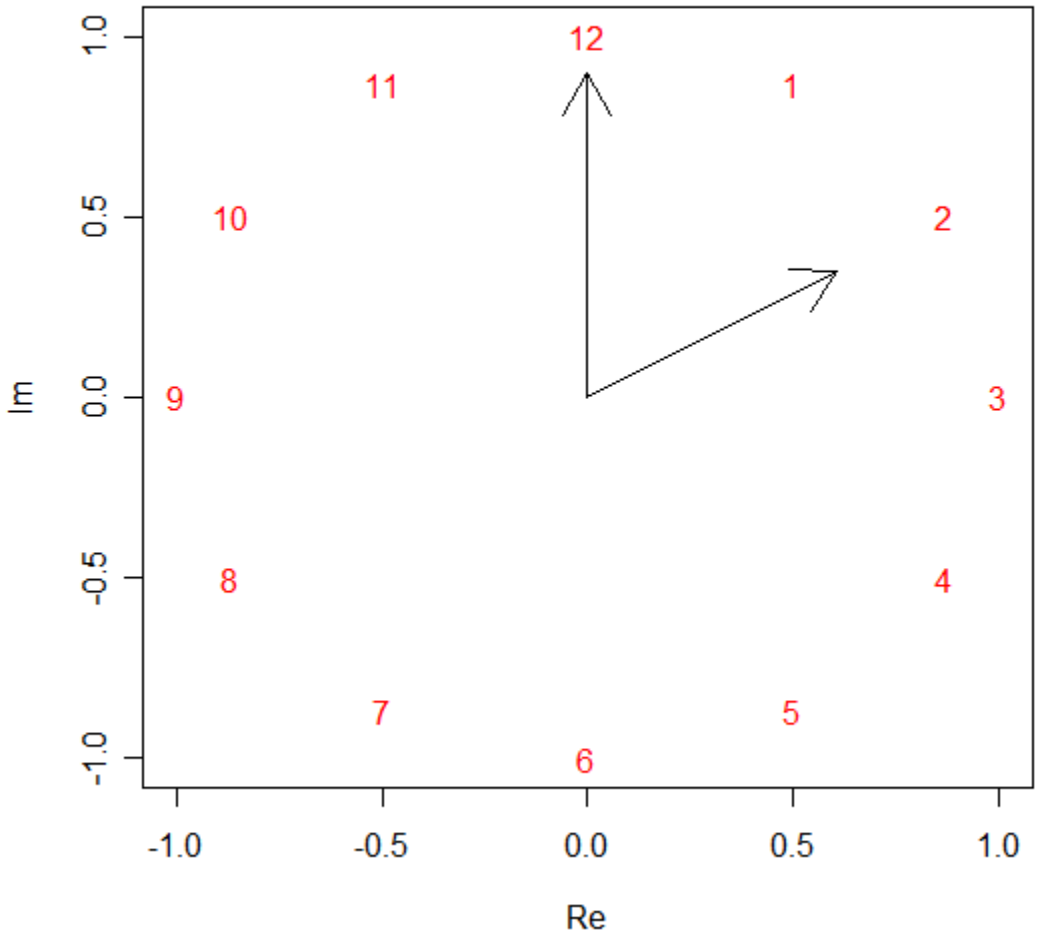
EXAMPLE 18.
Examine different plot types.

```
## Show the different plot types
x <- 0:12
y <- sin(pi/5 * x)
op <- par(mfrow = c(3,3), mar = .1+ c(2,2,3,1))
for (tp in c("p","l","b",  "c","o","h",  "s","S","n")) {
   plot(y ~ x, type = tp,
        main = paste("plot(*, type = \"",tp,"\")",sep=""))
   if(tp == "S") {
      lines(x,y, type = "s", col = "red", lty = 2)
      mtext("lines(*, type = \"s\", ...)", col = "red", cex=.8)
   }
}
par(op)    #This just resets the output size.
```



EXAMPLE 19 : This is my attempt at a clock. We are counting counterclockwise from the x axis so that is why the vector of numbers counts 2,1,12,11,10,9,…,3. I can omit the labels if I wish.

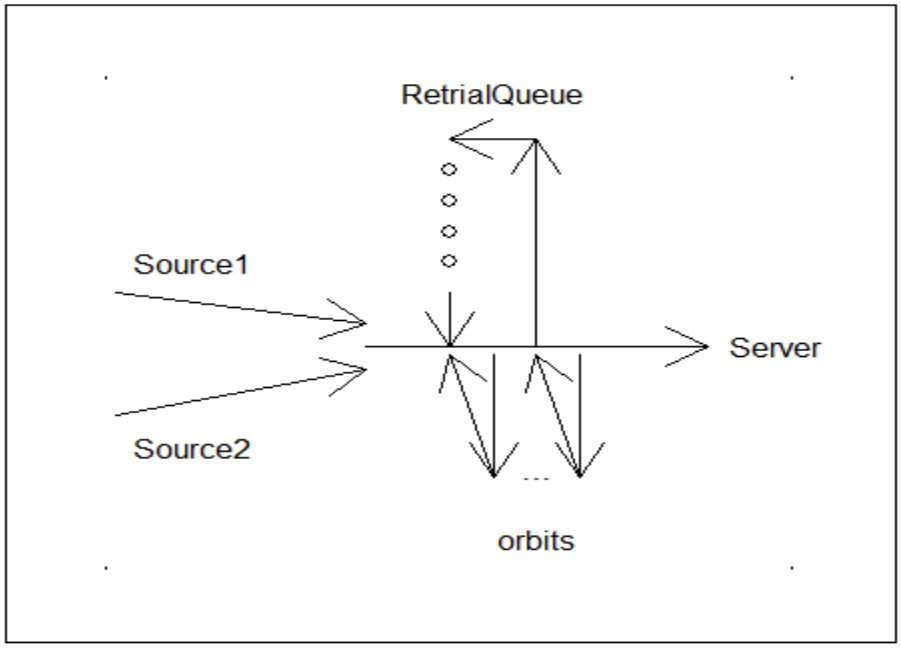
```
plot(-1:1,-1:1, type = "n", xlab = "Re", ylab = "Im")
K = 12; text(exp(1i * 2 * pi * c(2:1,12:3) / K), col = 2)
arrows(0,0,0,.9)
arrows(0,0,.7*cos(pi/6),.7*sin(pi/6))
```



EXAMPLE 20: Here I make a flow chart that I needed for a paper. Not too bad. The first four pairs of points (circles with radius zero) really just set up the size of the frame. There is likely a better way to do that but this worked.

```
symbols(c(0,0,8,8,4,4,4,4),c(-8,8,-
8,8,2,3,4,5),circles=c(0,0,0,0,.1,.1,.1,.1),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
 arrows(.1,1,3,0)
 arrows(.1,-3,3,-1.5)
 arrows(3,-.75,7,-.75)
 arrows(4,1,4,-.75)
 arrows(5,6,4,6)
 arrows(5,-.7,5,6)
 arrows(4.5,-5,4,-1)
 arrows(4.5,-1,4.5,-5)
 arrows(5.5,-5,5,-1)
 arrows(5.5,-1,5.5,-5)
 text(5,-7, expression(orbits))
 text(4.5,7.5,expression(RetrialQueue))
 text(7.8,-.7,expression(Server))
 text(1,2,expression(Source1))
 text(1,-4,expression(Source2))
 text(5,-5,expression(...))
```

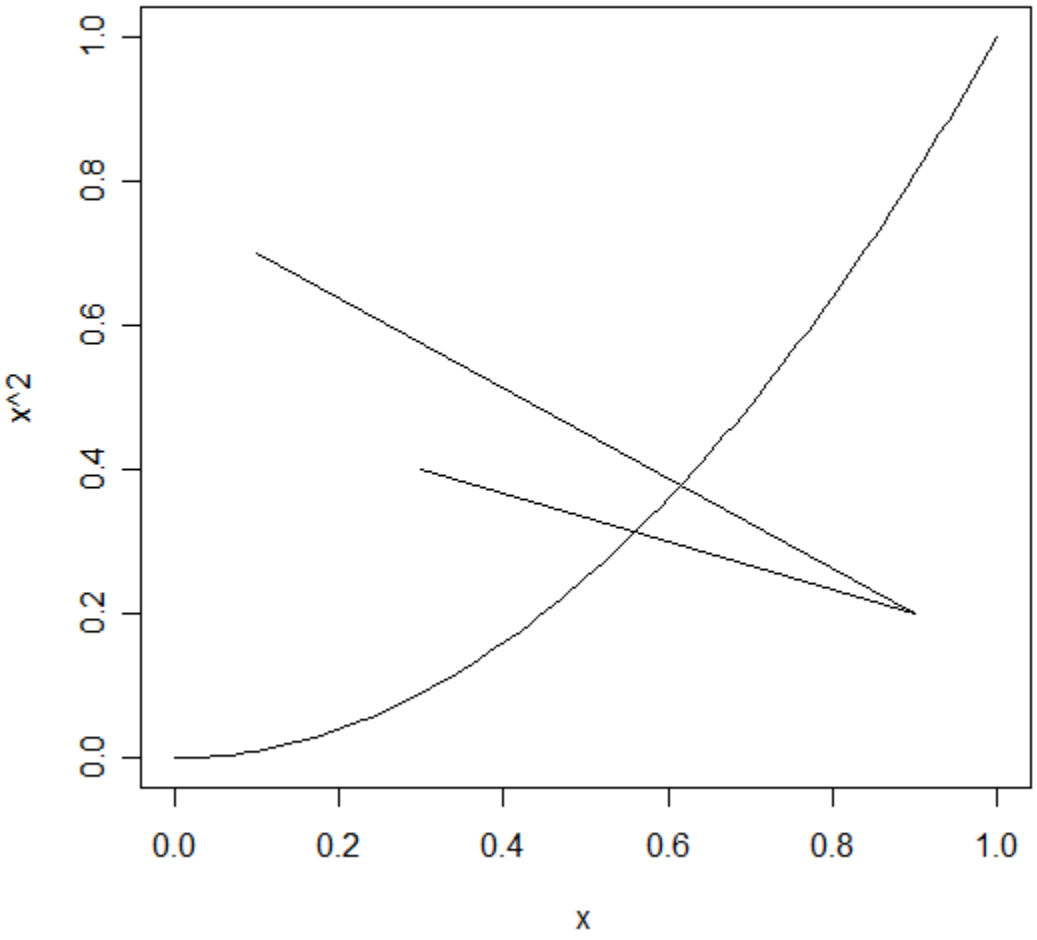
Output is



EXAMPLE 21. Here we add a line segments to an existing graph.

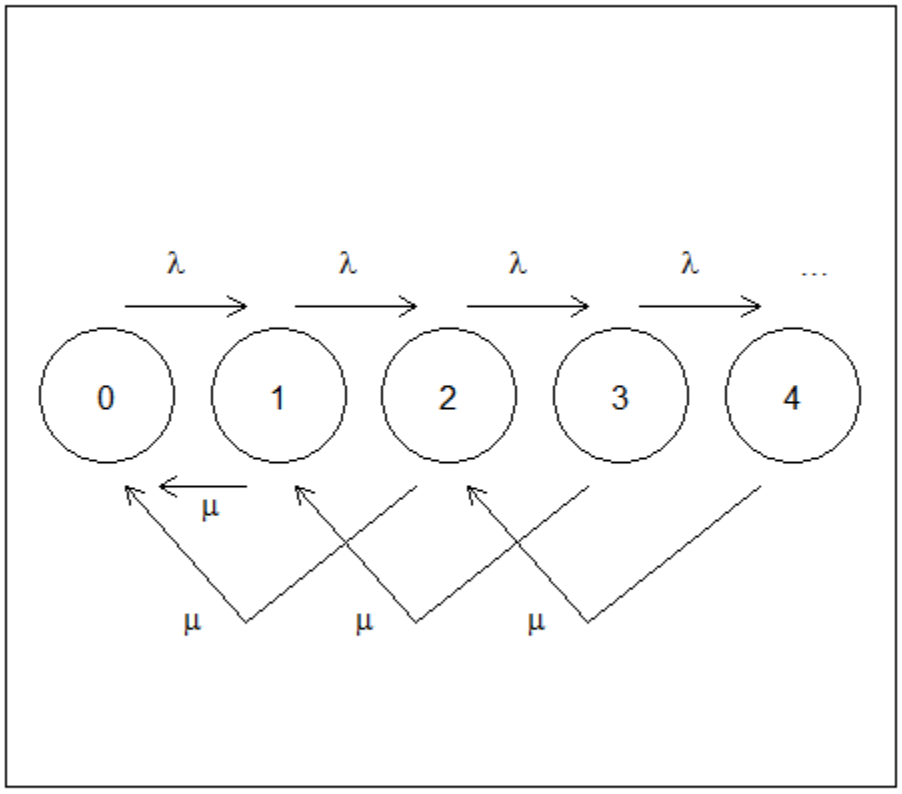
```
curve(x^2)
lines(c(.1,.9,.3),c(.7,.2,.4))
```

The line segments are from (.1, .7) to (.9, .2) to (.3, .4).



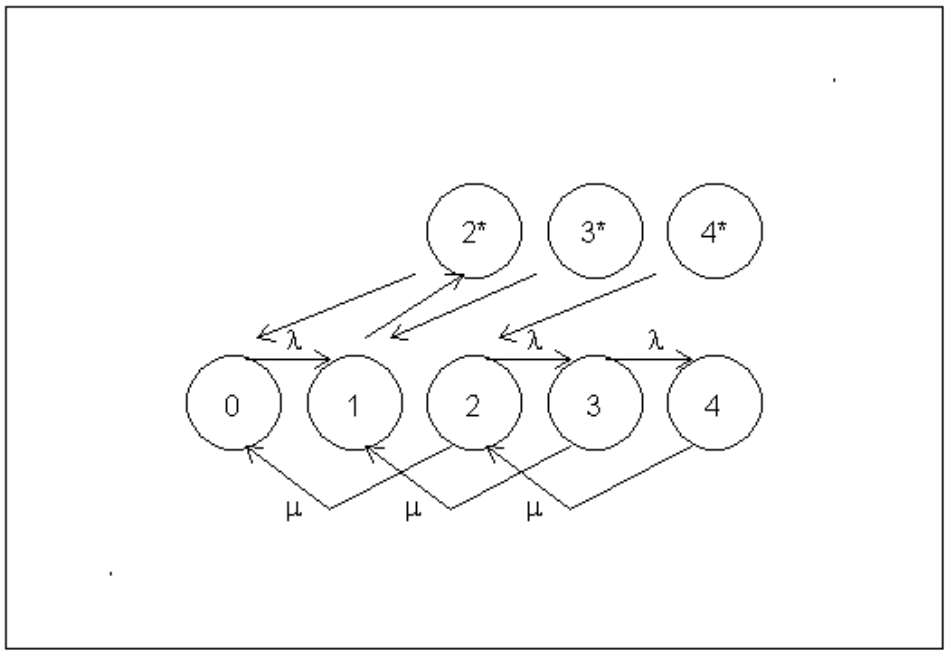
EXAMPLE 22: More queueing diagrams (smaller arrowheads).

```
symbols(c(2,3,4,5,6),c(2,2,2,2,2),circles=c(.4,.4,.4,.4,.4), inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(2.1,2.2,2.8,2.2,length=.1) ; arrows(3.1,2.2,3.8,2.2, length=.1)
arrows(4.1,2.2,4.8,2.2,length=.1) ; arrows(5.1,2.2,5.8,2.2,length=.1)
lines(c(5.8,4.8),c(1.8,1.5));arrows(4.8,1.5,4.1,1.8,length=.1)
lines(c(4.8,3.8),c(1.8,1.5));arrows(3.8,1.5,3.1,1.8,length=.1)
lines(c(3.8,2.8),c(1.8,1.5));arrows(2.8,1.5,2.1,1.8,length=.1)
arrows(2.8,1.8,2.3,1.8,length=.1)
text(2.4,2.3, expression(lambda)); text(3.4,2.3, expression(lambda))
text(4.4,2.3, expression(lambda)); text(5.4,2.3, expression(lambda));
text(6.1,2.3,expression("…"))
text(2.5,1.5, expression(mu)); text(3.5,1.5, expression(mu))
text(4.5,1.5, expression(mu));  text(2.6,1.75, expression(mu))
text(2,2,0); text(3,2,1);  text(4,2,2);  text(5,2,3);  text(6,2,4)
```



EXAMPLE 23: Writing graph commands as a function to allow easier editing.

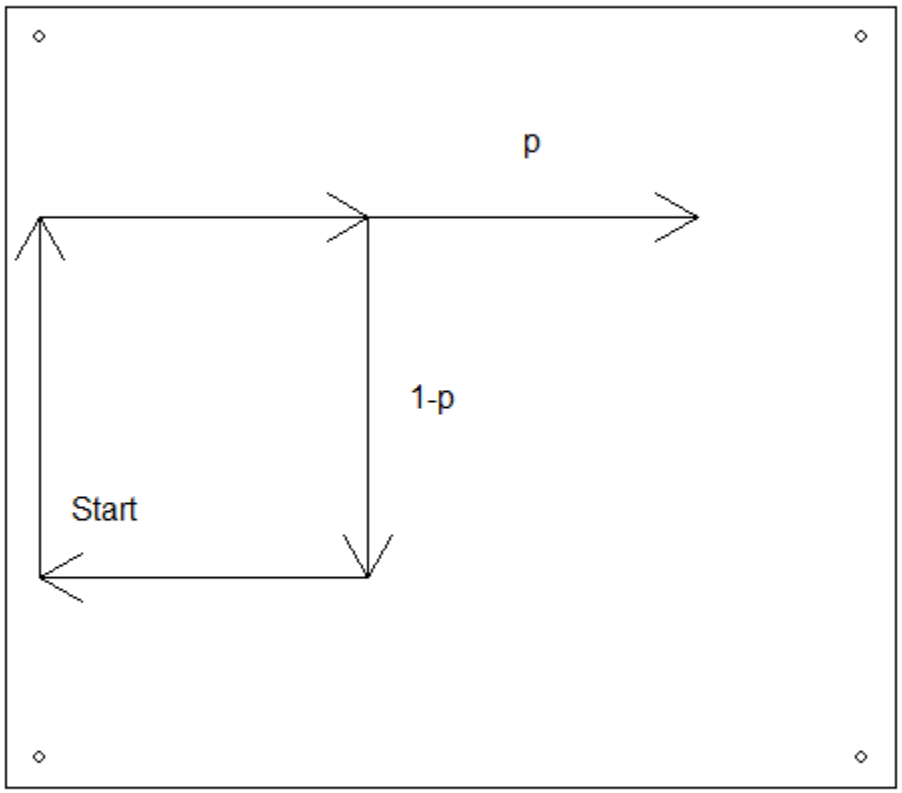
```
graph1=function(n){
symbols(c(1,7,2,3,4,5,6,4,5,6),c(1.2,3.5,2,2,2,2,2,2.8,2.8,2.8),
circles=c(.01,.01,.4,.4,.4,.4,.4,.4,.4,.4),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE);
arrows(2.1,2.2,2.8,2.2,length=.1) ;
arrows(4.1,2.2,4.8,2.2,length=.1) ;
arrows(5.1,2.2,5.8,2.2,length=.1)

arrows(3.5,2.6,2.2,2.3,length=.1);
arrows(4.5,2.6,3.3,2.3,length=.1) ;
arrows(5.5,2.6,4.2,2.3,length=.1);

arrows(3.1,2.3,3.9,2.6,length=.1);

lines(c(5.8,4.8),c(1.8,1.5));arrows(4.8,1.5,4.1,1.8,length=.1)
lines(c(4.8,3.8),c(1.8,1.5));arrows(3.8,1.5,3.1,1.8,length=.1)
lines(c(3.8,2.8),c(1.8,1.5));arrows(2.8,1.5,2.1,1.8,length=.1)
text(2.5,2.3, expression(lambda));
text(4.5,2.3, expression(lambda)); text(5.5,2.3,
expression(lambda));
text(2.5,1.5, expression(mu)); text(3.5,1.5, expression(mu))
text(4.5,1.5, expression(mu));
text(2,2,0); text(3,2,1); text(4,2,2);  text(5,2,3);  text(6,2,4)
text(4,2.8,expression("2*")); text(5,2.8,expression("3*"));
text(6,2.8,expression("4*"))}

>graph1(1)
```


2*
3*
4*
λ
λ
λ
0
1
2
3
4
μ
μ
μ

EXAMPLE 24:

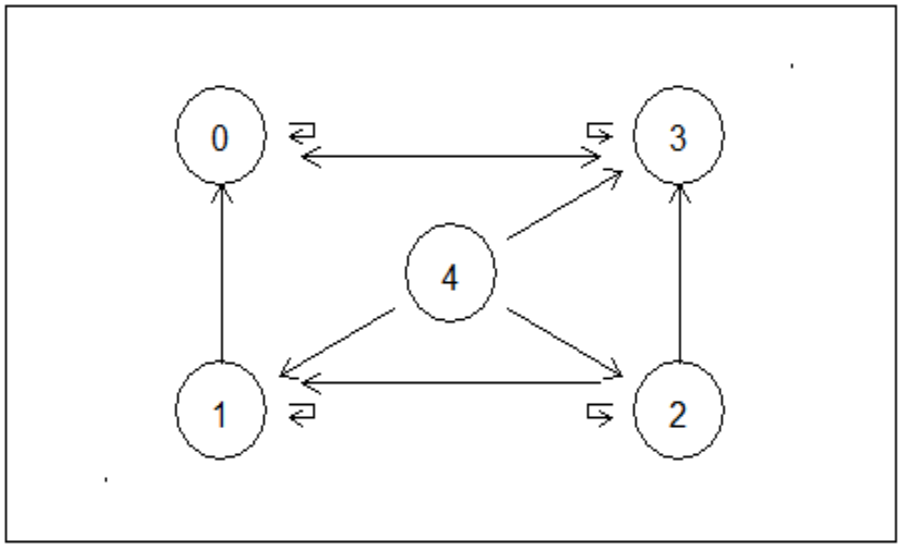
```
x1=c(0  , 0,  2.5, 2.5)
y1=c(-.5,1.5,1.5, -.5)
plot(x1,y1 ,xaxt="n",yaxt="n",ann=FALSE)
arrows(1,1,2,1)
arrows(1,1,1,0)
arrows(0,0,0,1)
arrows(0,1,1,1)
arrows(1,0,0,0)
text(1.5,1.2,"p")
text(1.2,.5,”1-p”)
text(.2,.2,”Start”)
```

Output is



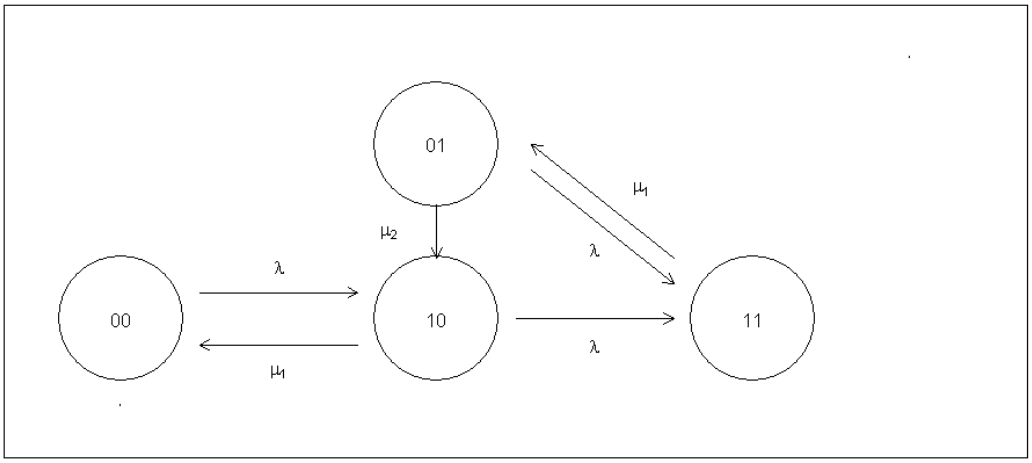
EXAMPLE 25: A Probability Transition Diagram

```
symbols(c(-1,5,0,0,2,4,4),c(-1,5,0,4,2,0,4),circles=c(.01,.01,.4,.4,.4,.4,.4),
  inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(.7,3.7,3.3,3.7, code=3, length=.1)
lines(c(.6,.8,.8),c(4.2,4.2,4.0), type="l")
arrows(.8,4.0,.6,4.0, length=.07)
lines(c(3.4,3.2,3.2),c(4.2,4.2,4.0), type="l")
arrows(3.2,4.0,3.4,4.0, length=.07)
arrows(0,.7,0,3.3, length=.1)
arrows(4,.7,4,3.3, length=.1)
arrows(3.3,.4,.7,.4, length=.1)
lines(c(.6,.8,.8),c(0.1,0.1,-.1), type="l")
arrows(.8,-.1,.6,-.1, length=.07)
lines(c(3.4,3.2,3.2),c(0.1,0.1,-.1), type="l")
arrows(3.2,-.1,3.4,-.1, length=.07)
arrows(2.5,2.5,3.5,3.5,length=.1);arrows(1.5,1.5,.5,.5,length=.1)
arrows(2.5,1.5,3.5,.5,length=.1)
text(0,0,"1");text(0,4,"0")
text(4,0,"2");text(4,4,"3")
text(2,2,"4")
```



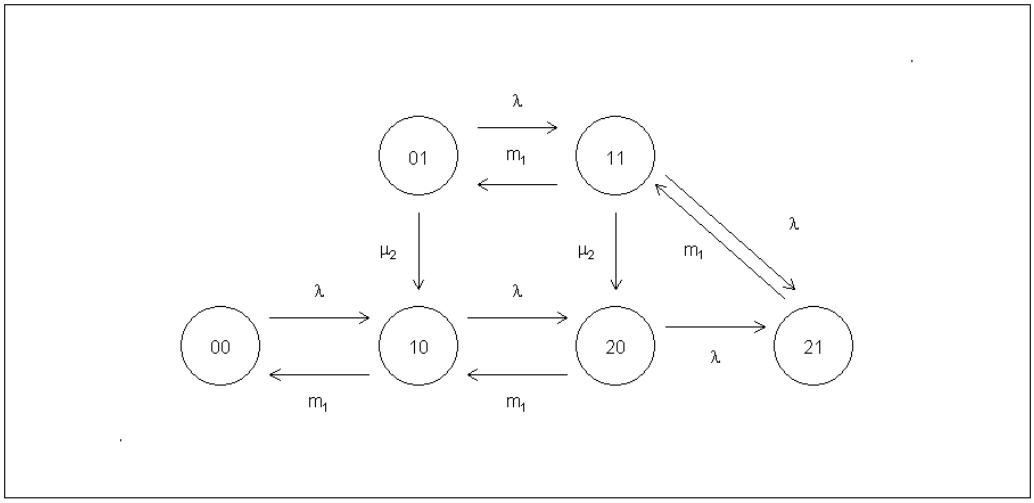
EXAMPLE (Another state transition diagram)

```
symbols(c(1,3,3,5,1,6),c(1,1,3,1,0,4),circles=c(.4,.4,.4,.4,.01,.01),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(1.5,1.3,2.5,1.3,length=.1); arrows(2.5,.7,1.5,.7,length=.1);
arrows(3.5,1,4.5,1,length=.1); arrows(3.0,2.3,3.0,1.7, length=.1);
arrows(3.6,2.7,4.5,1.4,length=.1);arrows(4.5,1.7,3.6,3.0,length=.1) ;
text(1,1,"00"); text(3,1,"10");  text(3,3,"01");  text(5,1,"11");
text(2,1.6,expression(lambda)) ; text(2,.4, expression(mu[1]))
text(2.7,2,expression(mu[2])) ; text(4,.7, expression(lambda))
text(4.3,2.5,expression(mu[1])) ; text(4,1.8, expression(lambda))
```



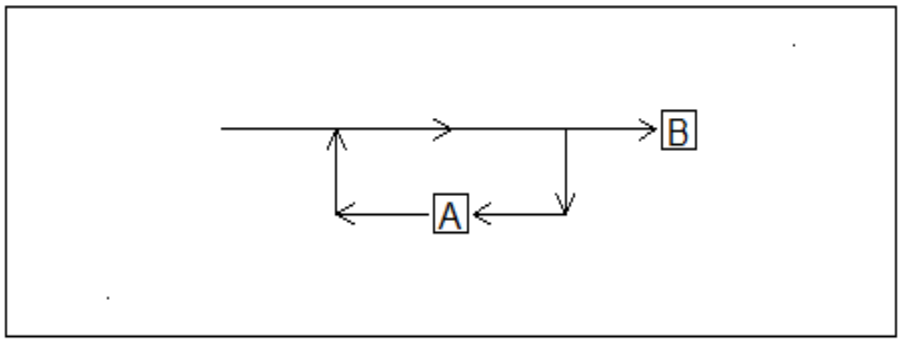
EXAMPLE (More transition diagrams)

```
symbols(c(1,3,5,7,3,5,8,0),c(1,1,1,1,3,3,4,0),circles=c(.4,.4,.4,.4,.4,.4,.01,.01),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(1.5,1.3,2.5,1.3,length=.1); arrows(3.5,1.3,4.5,1.3,length=.1);
arrows(2.5,.7,1.5,.7,length=.1); arrows(4.5,.7,3.5,.7,length=.1);
arrows(5.5,1.2,6.5,1.2,length=.1);
arrows(3.6,3.3,4.4,3.3,length=.1); arrows(4.4,2.7,3.6, 2.7,length=.1);
arrows(3,2.4, 3, 1.6,length=.1);  arrows(5, 2.4, 5,1.6,length=.1);
text(1,1,"00"); text(3,1,"10");  text(5,1,"20");  text(7,1,"21");
text(3,3,"01"); text(5,3,"11")
text(2,1.6,expression(lambda)) ; text(2,.4, expression(m[1]))
text(4,1.6,expression(lambda)) ; text(4,.4, expression(m[1]))
text(6,.9, expression(lambda))
text(4,3.6,expression(lambda)) ; text(4,3,expression(m[1])) ;
text(4,3.6,expression(lambda)) ; text(4,3,expression(m[1])) ;
text(2.7,2,expression(mu[2])) ; text(4.7,2, expression(mu[2]))
arrows(6.7,1.5,5.4,2.7,length=.1); arrows(5.5,2.8,6.8,1.6,length=.1);
text(5.8, 2.0,expression(m [1])) ; text(6.8,2.3,expression(lambda)) ;
```



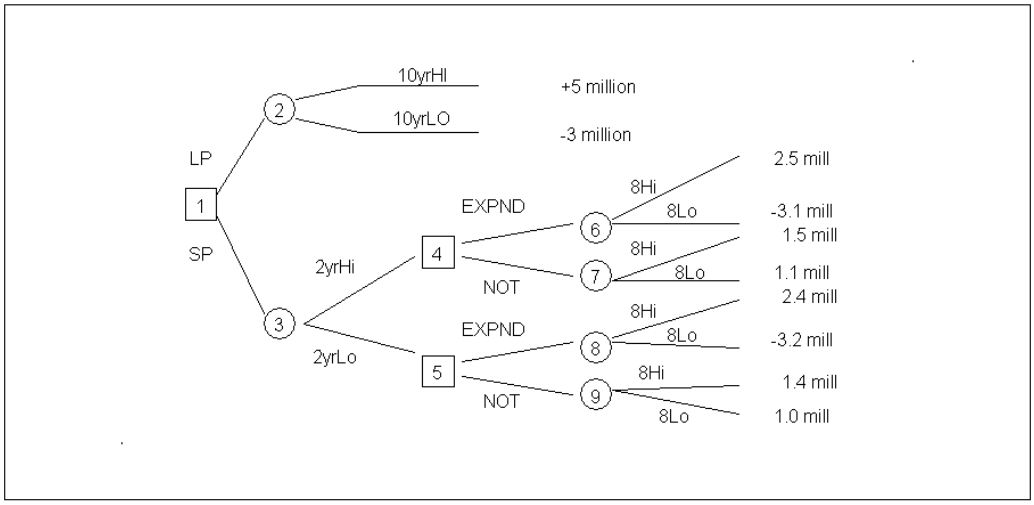
EXAMPLE: (Using squares)

```
symbols(c(0,3,5,6),c(0,1,2,3),squares=c(.001,.3,.3,.001),
     inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(1,2,3,2,length=.1) ; arrows(3,2,4.8,2,length=.1)
arrows(4,2,4,1,length=.1) ; arrows(4,1,3.2,1,length=.1)
arrows(2.8,1,2,1,length=.1) ; arrows(2,1,2,2,length=.1)
text(3,1,"A"); text(5,2,"B")
```



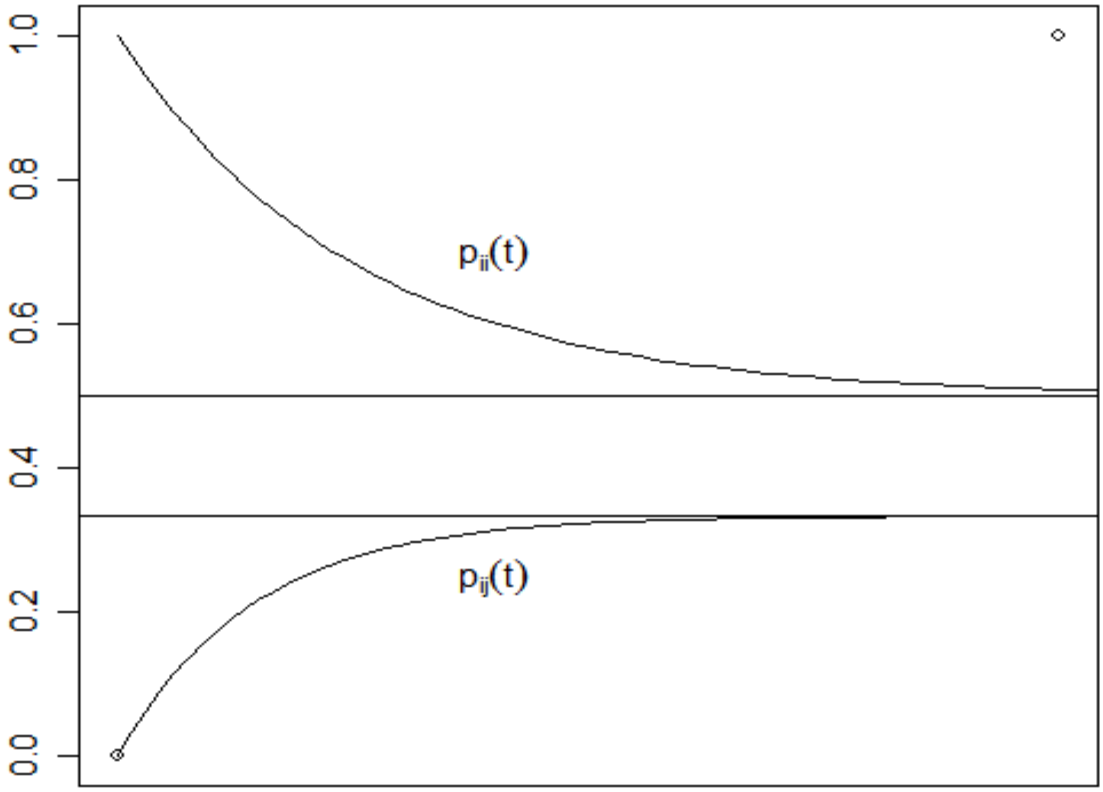
EXAMPLE (mixed symbols)

```
symbols( c(   0,   10,    1,  4,    4),
             c(    0,    8,    5,   4, 1.5    ),
 squares=c(.01, .01,  .4,  .4,   .4  ),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
symbols( c(2, 2,6,6,6,6), c( 7,  2.5, 4.5,3.5,2,1  ), circles=c(.2, .2,.2,.2,.2,.2),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE,add=T)
lines(c(1.2,1.8),c(5.2,6.8)); lines(c(1.2,1.8),c(4.8,2.7))
text(1,5,1); text(2,7,2); text(2, 2.5,3); text(4,4,4); text(4,1.5,5)
text(6,4.5,6); text(6,3.5,7); text(6,2,8); text(6,1,9)
lines(c(2.2, 3),c(7.2,7.5));lines(c(3, 4.5),c(7.5,7.5))
lines(c(2.2,3),c(6.8,6.5));lines(c(3,4.5),c(6.5,6.5))
text(1,6,"LP");  text(1,4,"SP")
text(3.8,7.7,"10yrHI"); text(3.8,6.8,”10yrLO”)
text(6,7.5," +5 million"); text(6,6.5,”-3 million”)
lines(c(2.3,3.7),c(2.5,3.9)); lines(c(2.3,3.7),c(2.5,1.9))
text(2.7,3.7,“2yrHi”); text(2.7,1.8, “2yrLo”)
lines(c(4.3,5.7), c(4.2,4.6)); lines(c(4.3,5.7), c(3.9,3.5))
lines(c(4.3,5.7), c(1.7,2.1)); lines(c(4.3,5.7), c(1.4,1.0))
text(4.7,5,”EXPND”); text(4.8, 3.3,"NOT")
text(4.7,2.4,"EXPND"); text(4.8, 0.9,"NOT")
lines(c(6.2,7.8),c(4.7,6)); lines(c(6.2,7.8),c(4.6,4.6))
lines(c(6.2,7.8),c(3.4,4.3)); lines(c(6.2,7.8),c(3.4,3.4))
lines(c(6.2,7.8),c(2.2,3.0)); lines(c(6.2,7.8),c(2.1,2.0))
lines(c(6.2,7.8),c(1.1,1.2));lines(c(6.2,7.8),c(1.1,.6))
text(6.6,5.4,"8Hi");  text(7.1,4.9,"8Lo")
text(6.6,4.1,"8Hi");  text(7.2,3.6,"8Lo")
text(6.6,2.8,"8Hi");  text(7.1,2.3,"8Lo")
text(6.7,1.5,"8Hi");  text(7.0,.6,"8Lo")
text(8.6,6, "2.5 mill"); text(8.6,4.9,"-3.1 mill")
text(8.7,4.4, "1.5 mill"); text(8.6,3.6,"1.1 mill")
text(8.7,3.1, "2.4 mill"); text(8.6,2.2,"-3.2 mill")
text(8.7,1.3, "1.4 mill"); text(8.6,0.6,"1.0 mill")
```


10yrHI
+5 million
2
10yrLO
-3 million
LP
1
SP
2yrHi
4
EXPND
6
8Hi
2.5 mill
8Lo
-3.1 mill
NOT
7
8Hi
1.5 mill
8Lo
1.1 mill
3
2yrLo
EXPND
8
8Hi
2.4 mill
8Lo
-3.2 mill
5
NOT
9
8Hi
1.4 mill
8Lo
1.0 mill

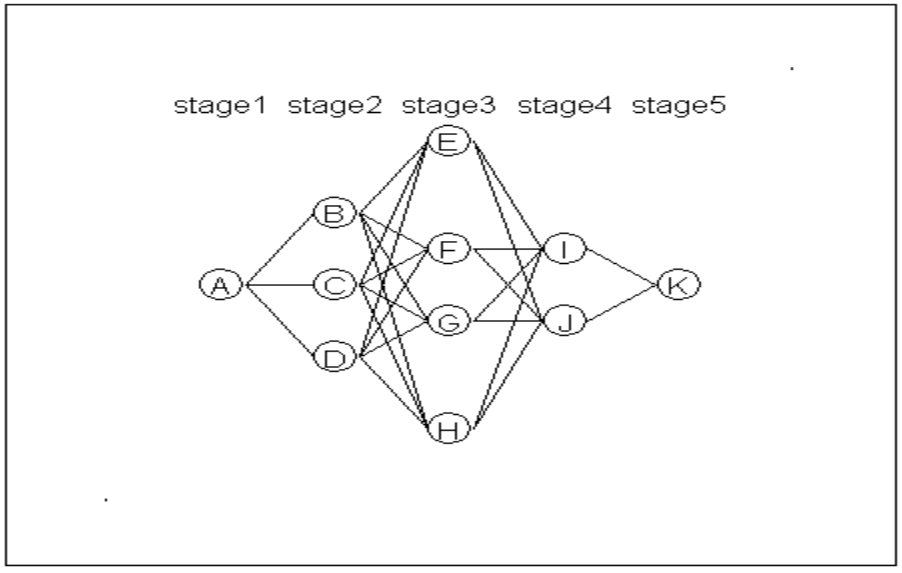
EXAMPLE:

```
plot(c(0, 10),c(0,1),ann=F,xaxt=”n”)
curve((1-exp(-.7*(x)))/3, 0, 15, add=T,xaxt=”n”)
curve(1-(1-exp(-.4*x))/2,0,15,add=T,ann=F)
abline(.5,0);abline(.333,0)
text(4,.7,expression(p[ii](t)))
text(4,.25,expression(p[ij](t)))
```



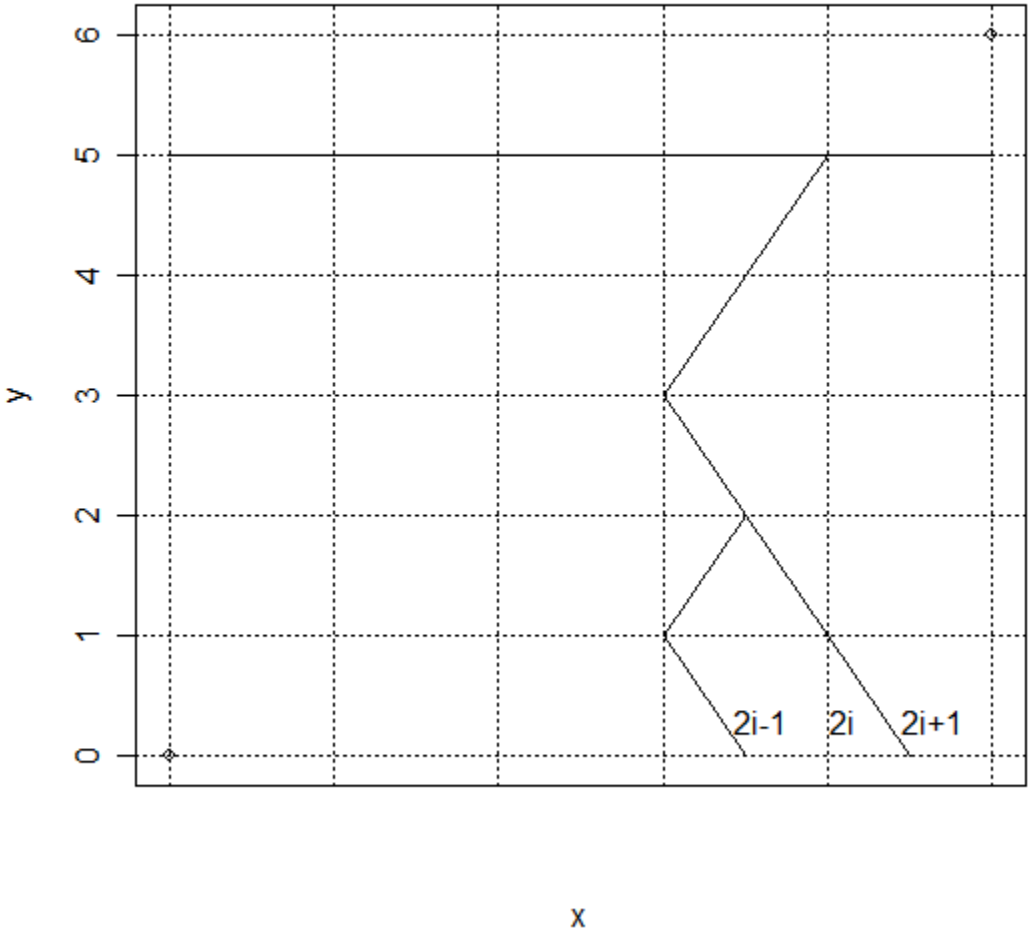
EXAMPLE:

```
symbols( c(0, 6, 1, 2, 2,          2, 3, 3, 3, 3,          4,4,5),
         c( 0, 6, 3, 2, 3,          4, 1, 2.5, 3.5, 5,   2.5, 3.5, 3 ),
  circles= c(.01, .01, .2, .2, .2,    .2,.2,.2,.2,.2,         .2,.2,.2 ),
inches=FALSE, xaxt="n", yaxt="n", ann=FALSE)
text(1,3,”A”); text(2,2,”D”); text(2, 3,”C”); text(2,4,”B”); text(3,1,”H”);
text(3,2.5,”G”); text(3,3.5,”F”); text(3,5,”E”); text(4,2.5,”J”)
text(4,3.5,”I”);  text(5,3,”K”)
lines(c(1.2,1.8),c(3,2)); lines(c(1.2,1.8),c(3,3));lines(c(1.2,1.8),c(3,4));
lines(c(2.2,2.8),c(4,5));lines(c(2.2,2.8),c(4,3.5));lines(c(2.2,2.8),c(4,2.5))
lines(c(2.2,2.8),c(4,1));
lines(c(2.2,2.8),c(3,5));lines(c(2.2,2.8),c(3,3.5));lines(c(2.2,2.8),c(3,2.5))
lines(c(2.2,2.8),c(3,1));
lines(c(2.2,2.8),c(2,5));lines(c(2.2,2.8),c(2,3.5));lines(c(2.2,2.8),c(2,2.5))
lines(c(2.2,2.8),c(2,1));
lines(c(3.2,3.8),c(5,3.5));lines(c(3.2,3.8),c(3.5,3.5));lines(c(3.2,3.8),c(2.5,3.5));
lines(c(3.2,3.8),c(1,3.5));
lines(c(3.2,3.8),c(5,2.5));lines(c(3.2,3.8),c(3.5,2.5));lines(c(3.2,3.8),c(2.5,2.5));
lines(c(3.2,3.8),c(1,2.5));
lines(c(4.2,4.8),c(3.5,3));lines(c(4.2,4.8),c(2.5,3));
text(1,5.5,”stage1”); text(2,5.5,”stage2”); text(3,5.5,”stage3”);
text(4,5.5,”stage4”); text(5,5.5,”stage5”);
```



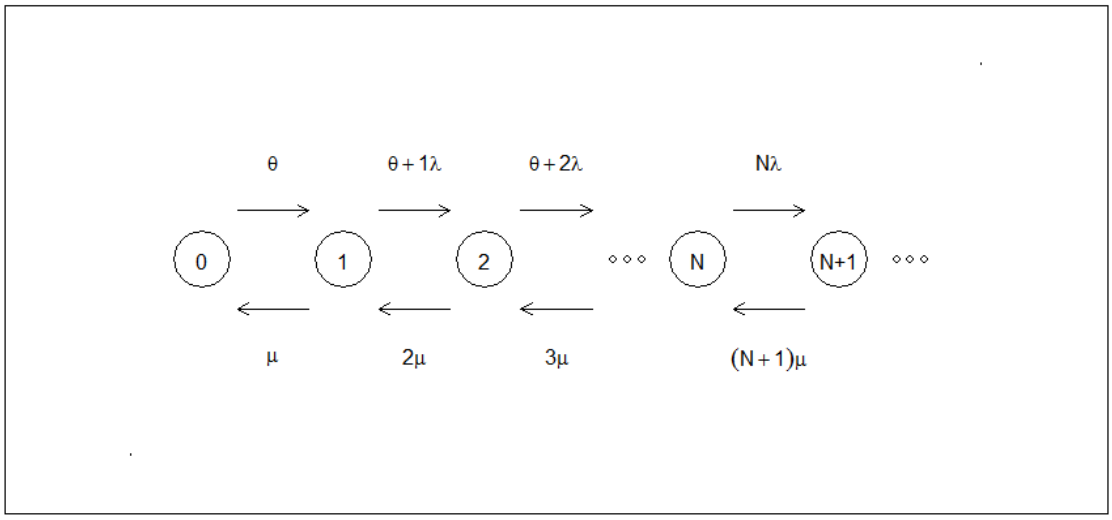
EXAMPLE: Note the use of grid and spacing or overlays.

```
x=c(0,10); y=c(0,6)
plot(x,y, xaxt=”no”)
lines(c(6,7),c(1,0))
lines(c(6,7),c(1,2))
lines(c(6,9),c(3,0))
lines(c(6,8),c(3,5))
grid(col="black")
lines(c(0,10),c(5,5))
text(9.3,.3,”2i+1”)
text(8.2,.3,”2i”)
text(7.2,.3, “2i-1”)
```



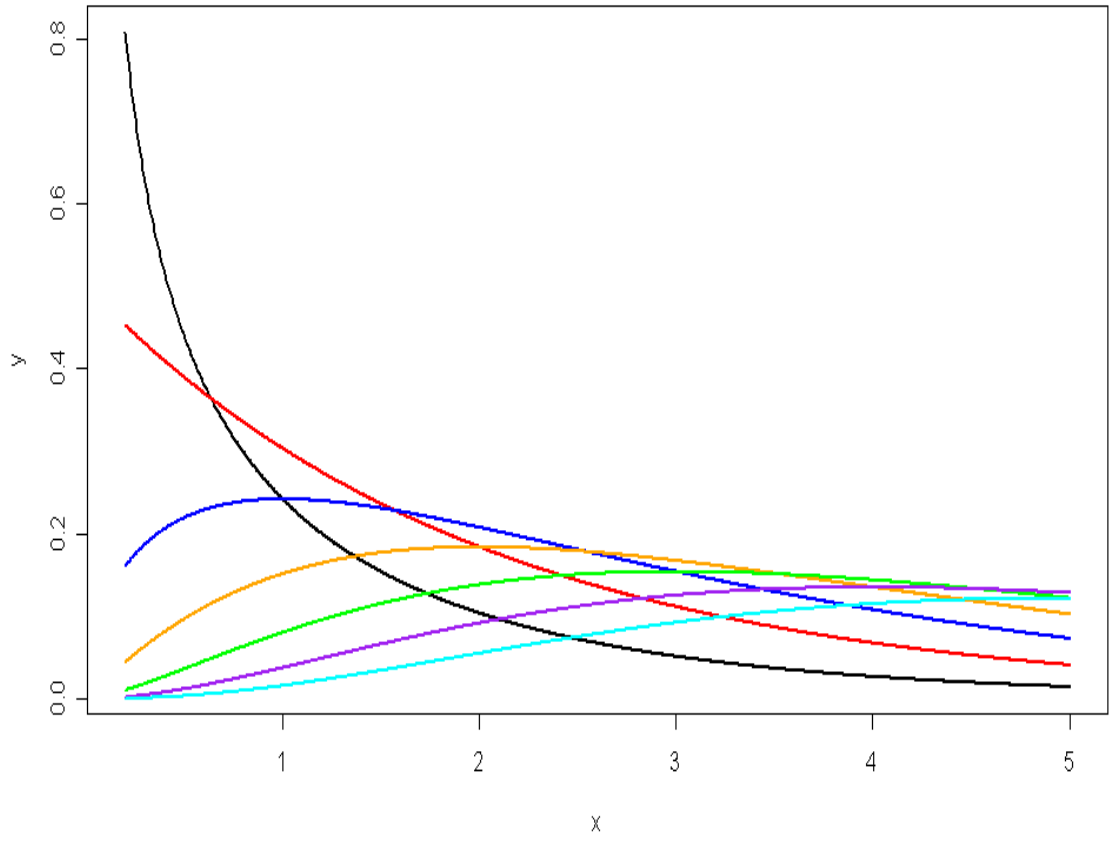
EXAMPLE: Another flow chart.

```
symbols(c(0,12,1,3,5,8,10,6.8,7,7.2,10.8,11,11.2),c(0,4,2,2,2,2,2,2,2,2,2,2,2),circles=c(.01,.01,.4,.4,.4,.4,.4,.
05,.05,.05,.05,.05,.05),inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
arrows(1.5,2.5,2.5,2.5,length=.1); arrows(3.5,2.5,4.5,2.5,length=.1);
arrows(5.5,2.5,6.5,2.5,length=.1); arrows(8.5,2.5,9.5,2.5,length=.1);
arrows(9.5,1.5,8.5,1.5,length=.1); arrows(6.5,1.5,5.5,1.5,length=.1);
arrows(4.5,1.5,3.5,1.5,length=.1); arrows(2.5,1.5,1.5,1.5,length=.1);
text(1,2,0); text(3,2,1);  text(5,2,2);  text(8,2,"N"); text(10,2,"N+1")
text(2,3,expression(theta)); text(4,3,expression(theta+1* lambda));
text(6,3,expression(theta+2*lambda)); text(9,3,expression(N* lambda));
text(2,1,expression(mu)); text(4,1,expression(2*mu));
text(6,1,expression(3*mu)); text(9,1,expression((N+1)*mu));
```



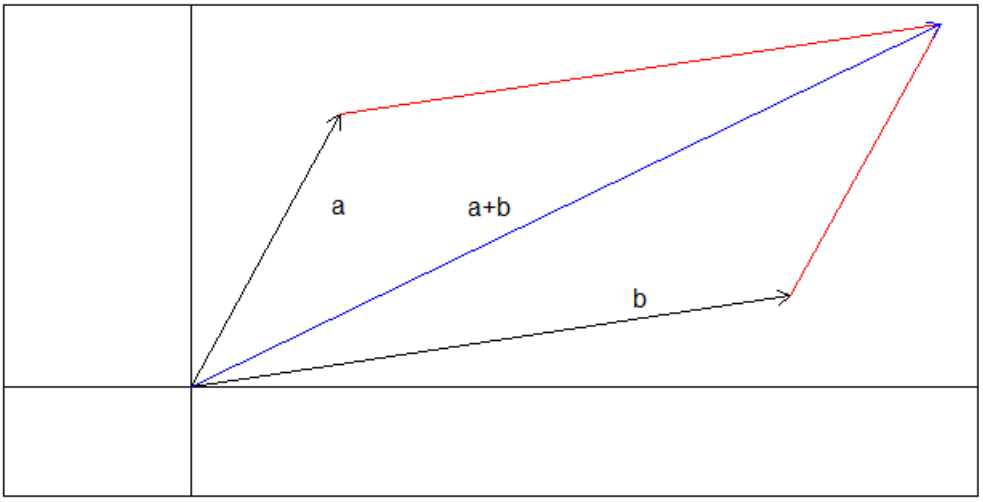
EXAMPLE: Colors and thick lines. We plot the chi-square pdf for various parameters.

```
x=(40:1000)/200
y1=dchisq(x,1)
plot(x,y1, ylab=”y”,type=”l”,lwd=2)
y2=dchisq(x,2)
lines(x,y2, col=”red”,lwd=2)
y3=dchisq(x,3)
lines(x,y3, col=”blue”,lwd=2)
y4=dchisq(x,4)
lines(x,y4, col=”orange”,lwd=2)
y5=dchisq(x,5)
lines(x,y5, col=”green”,lwd=2)
y6=dchisq(x,6)
lines(x,y6, col=”purple”,lwd=2)
y7=dchisq(x,7)
lines(x,y7,col=”cyan”,lwd=2)
label(3,4,expression(chi^2 pdf)
```



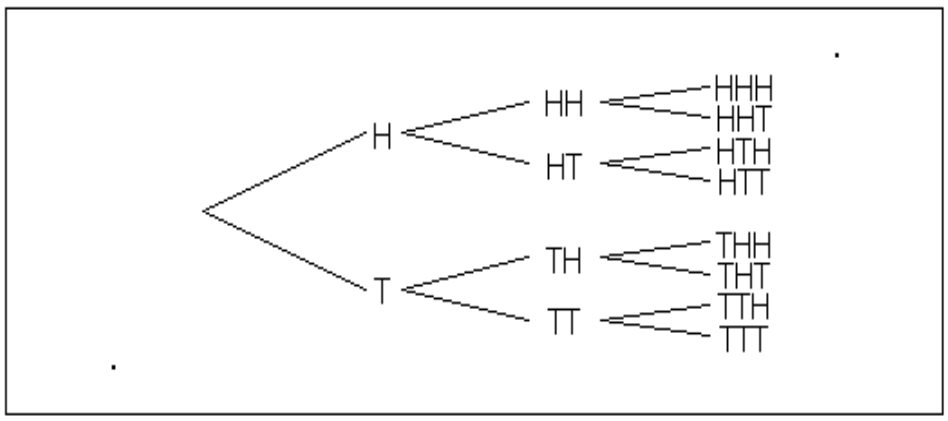
EXAMPLE: Draw a vector diagram

```
>  plot(c(-1,5),c(-1,4),t="n",xaxt="n",yaxt="n",ann=FALSE)
  % This sets the frame size and removes all labels.
> abline(0,0)
> abline(0,1000000)  % One way of getting a vertical axis
> arrows(0,0,1,3,length=.1)
> arrows(0,0,4,1,length=.1)
> lines(c(1,5),c(3,4),col="red")
> lines(c(4,5),c(1,4),col="red")
> arrows(0,0,5,4,length=.1, col="blue")
> text(1,2,"a")
> text(2,2,"a+b")
> text(3,1,"b")
```



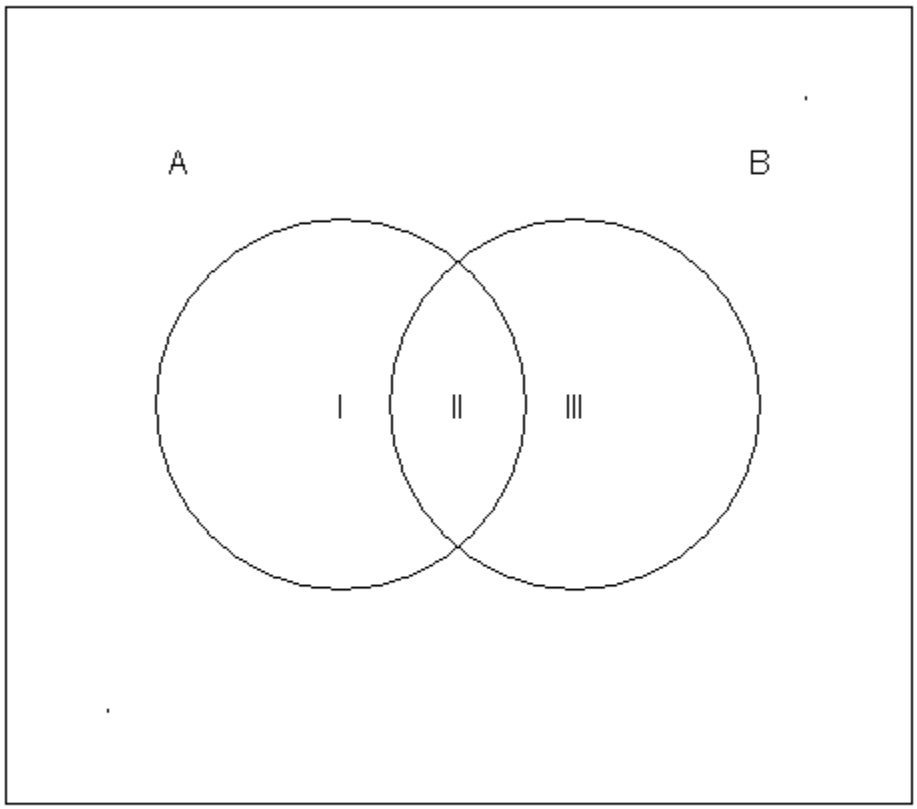
EXAMPLE: Draw a probability tree.

```
symbols( c( -.5,3.5),c(-
5,5),squares=c(.01,.01),inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
> lines(c(0,.9),c(0,2.5)); lines(c(0,.9),c(0,-2.5));
> text(1,2.5,"H"); text(1,-2.5,"T")
> lines(c(1.1,1.8),c(2.5,3.5)); lines(c(1.1,1.8),c(2.5,1.5));lines(c(1.1,1.8),c(-2.5,-1.5));
lines(c(1.1,1.8),c(-2.5,-3.5));
> text(2,3.5,"HH");  text(2,1.5,"HT");  text(2,-1.5,"TH");  text(2,-3.5,"TT");
> lines(c(2.2,2.8),c(3.5,4)); lines(c(2.2,2.8),c(3.5,3));lines(c(2.2,2.8),c(1.5,2));
lines(c(2.2,2.8),c(1.5,1));
> lines(c(2.2,2.8),c(-1.5,-1)); lines(c(2.2,2.8),c(-1.5,-2));lines(c(2.2,2.8),c(-3.5,-3));
lines(c(2.2,2.8),c(-3.5,-4));
> text(3,4,"HHH");  text(3,3,"HHT");  text(3,2,"HTH");  text(3,1,"HTT");
> text(3,-1,"THH");  text(3,-2,"THT");  text(3,-3,"TTH");  text(3,-4,"TTT");
```



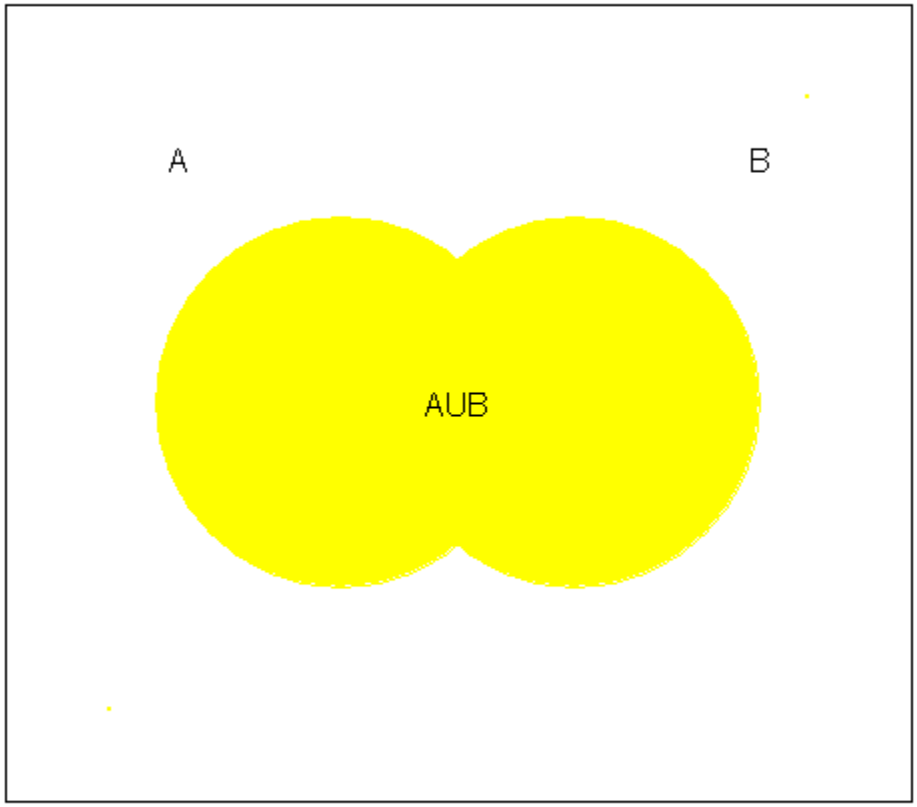
EXAMPLE: Venn Diagram

```
symbols(c(1,2,3,4),c(1,2,2,3),circles=c(.01,.8,.8,.01),
            inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
text(2,2, "I"); text(3,2, "III"); text(2.5,2, "II"); text(1.3,2.8, "A"); text(3.8,2.8, "B")
```



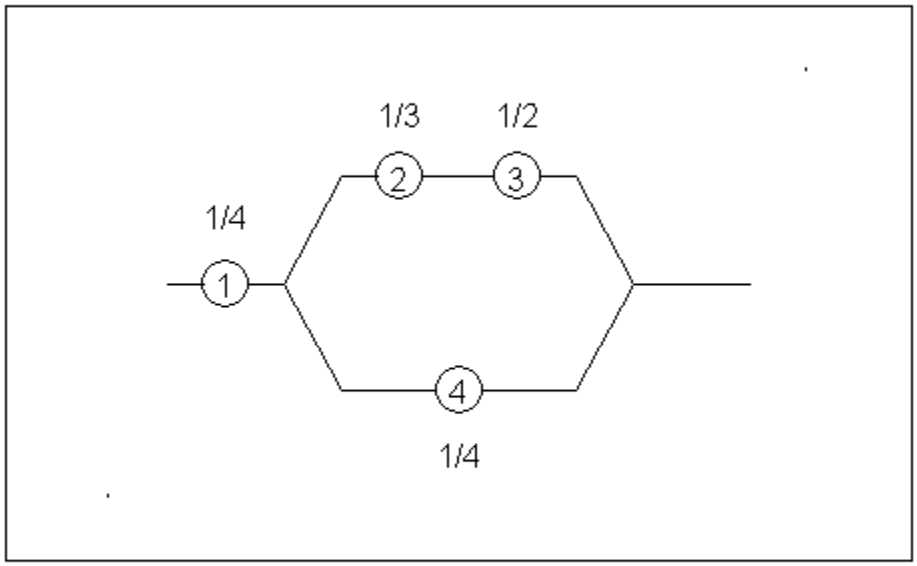
EXAMPLE: Another Venn diagram with color 7 (yellow)

```
symbols(c(1,2,3,4),c(1,2,2,3),circles=c(.01,.8,.8,.01),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE, bg=7,fg=7)
text(2.5,2,”AUB”,col=1);text(1.3,2.8, "A"); text(3.8,2.8, "B")
```



EXAMPLE: Reliability diagram

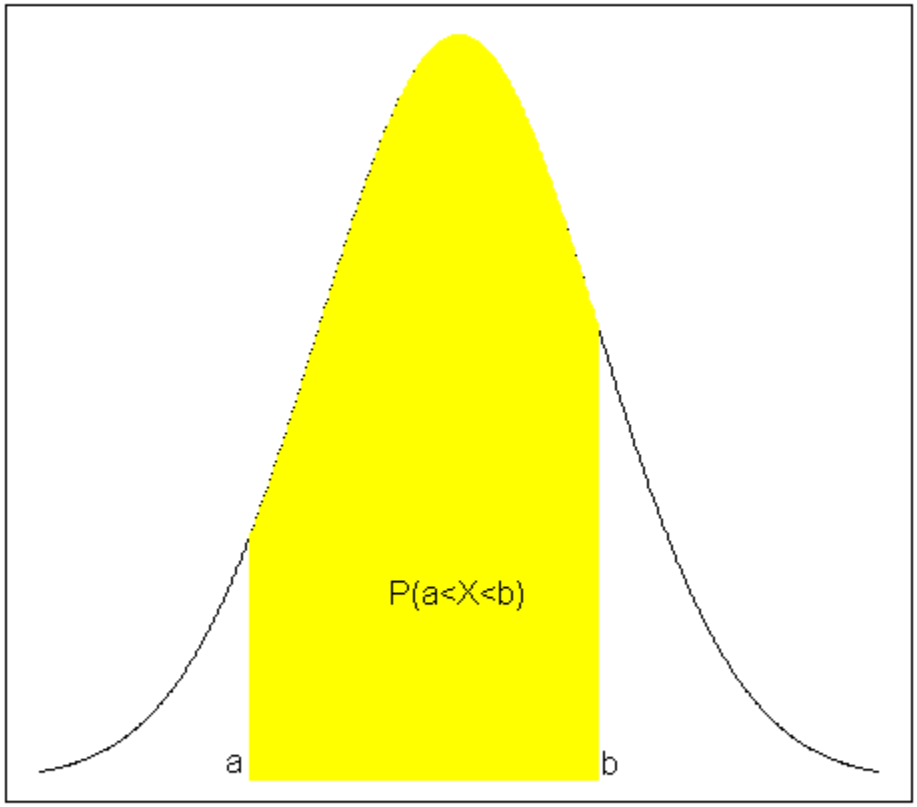
```
symbols(c(.5,6.5,1.5,3,3.5,4),c(0,2,1,1.5,.5,1.5),circles=c(.01,.01,.2,.2,.2,.2),
inches=FALSE,xaxt="n",yaxt="n",ann=FALSE)
lines(c(1,1.3),c(1,1)); lines(c(1,1.3),c(1,1)); lines(c(1.7,2,2.5,2.8),c(1,1,1.5,1.5));
lines(c(3.2,3.8),c(1.5,1.5));lines(c(4.2,4.5,5,6),c(1.5,1.5,1,1))
lines(c(2,2.5,3.3),c(1,.5,.5));          lines (c(3.7,4.5,5), c(.5,.5,1))
text(1.5,1,1); text(3,1.5,2);text(4,1.5,3);text(3.5,.5,4)
text(1.5,1.32,”1/4”); text(3,1.8,”1/3”);text(4,1.8,”1/2”);text(3.5,.2,”1/4”)
```



Example: Normal Plots

```
x=seq(-3,3,.01)
plot(x,dnorm(x),"l", xaxt="n",yaxt="n",ann=FALSE)
x=seq(-1.5,1,.01)
lines(x,dnorm(x),"h",col=7)
text(0,.1,"P(a<X<b)",col=1); text(-1.6,.01,"a"); text(1.1,.01,"b")
```

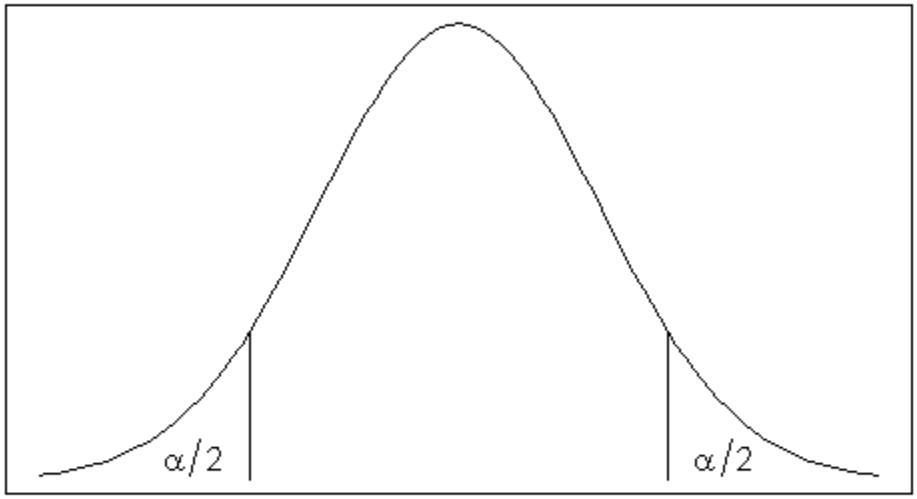
Here col=7 gives yellow color, xaxt=”n” gives no x axis marks.



Example: Normal Curve and areas.

```
curve(dnorm(x),-3,3,xaxt="n",yaxt="n",ann=FALSE)
lines(c(1.5,1.5),c(0,dnorm(1.5)))
lines(c(-1.5,-1.5),c(0,dnorm(1.5)))
text(1.9, .02, expression(paste(alpha/2)))
text(-1.9, .02, expression(paste(alpha/2)))
```

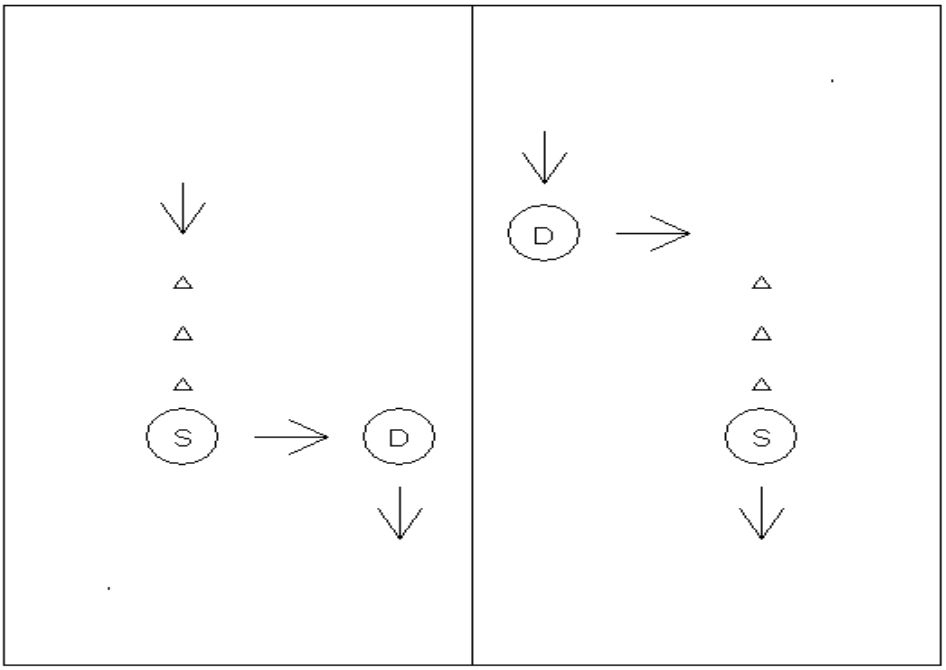
The result is



Example: A flow chart using pch symbol. Also use “points” to add points. Also use abline for a vertical division. In this case "pch=2" specifies a triangle symbol.

```
symbols(c(0,1,4,9,6,10),c(0,3,3,3,7,10),circles=c(.01,.5,.5,.5,.5,.01),inches=FALSE,xaxt="n",yaxt="n",ann
=FALSE)
text(1,3,expression(S))
text(4,3,expression(D))
text(9,3,expression(S))
text(6,7,expression(D))
arrows(4,2,4,1)
arrows(9,2,9,1)
arrows(2,3,3,3)
arrows(7,7,8,7)
points(9,4,pch=2)
points(9,5,pch=2)
points(9,6,pch=2)
points(1,4,pch=2)
points(1,5,pch=2)
points(1,6,pch=2)
arrows(1,8,1,7)
arrows(6,9,6,8)
abline(v=5)
```

Output is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D
D
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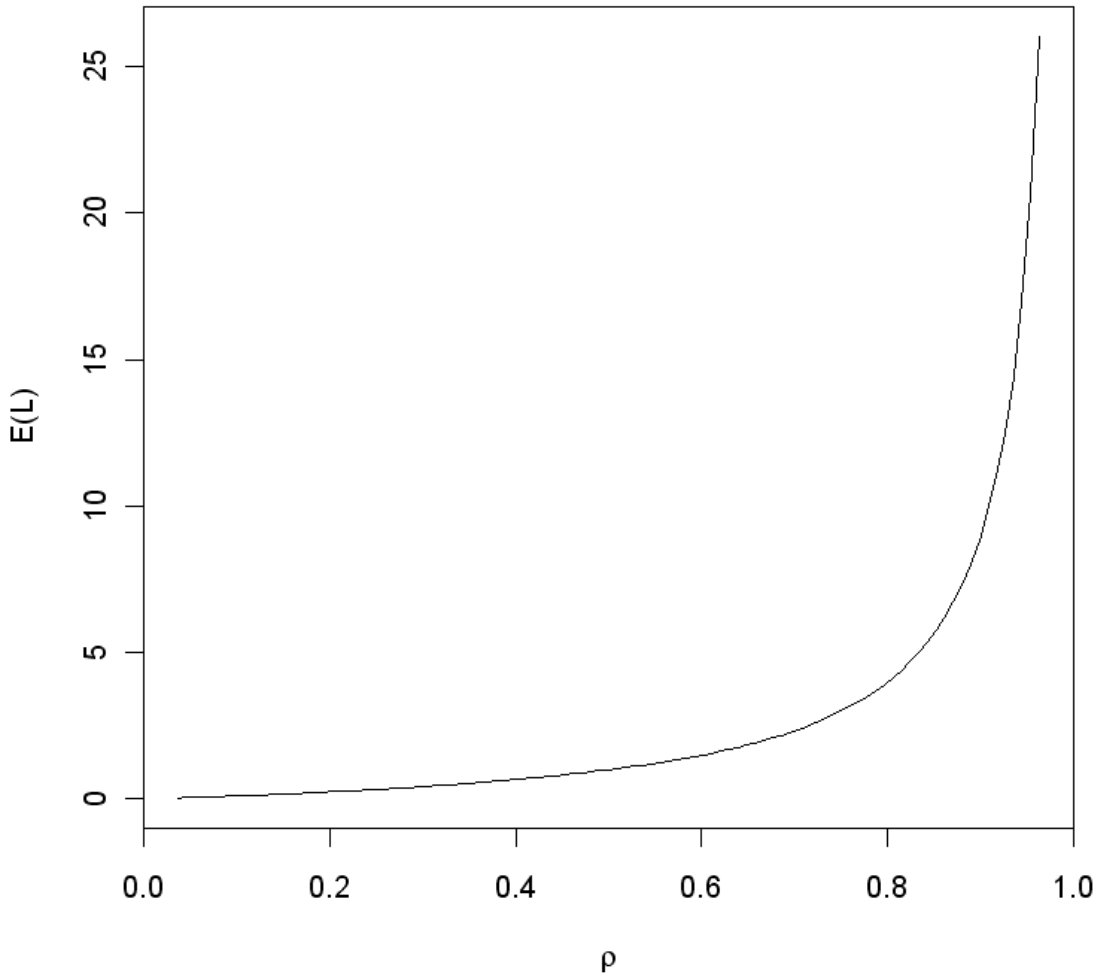
Example: A simple graph with labeled axes and Greek letters.

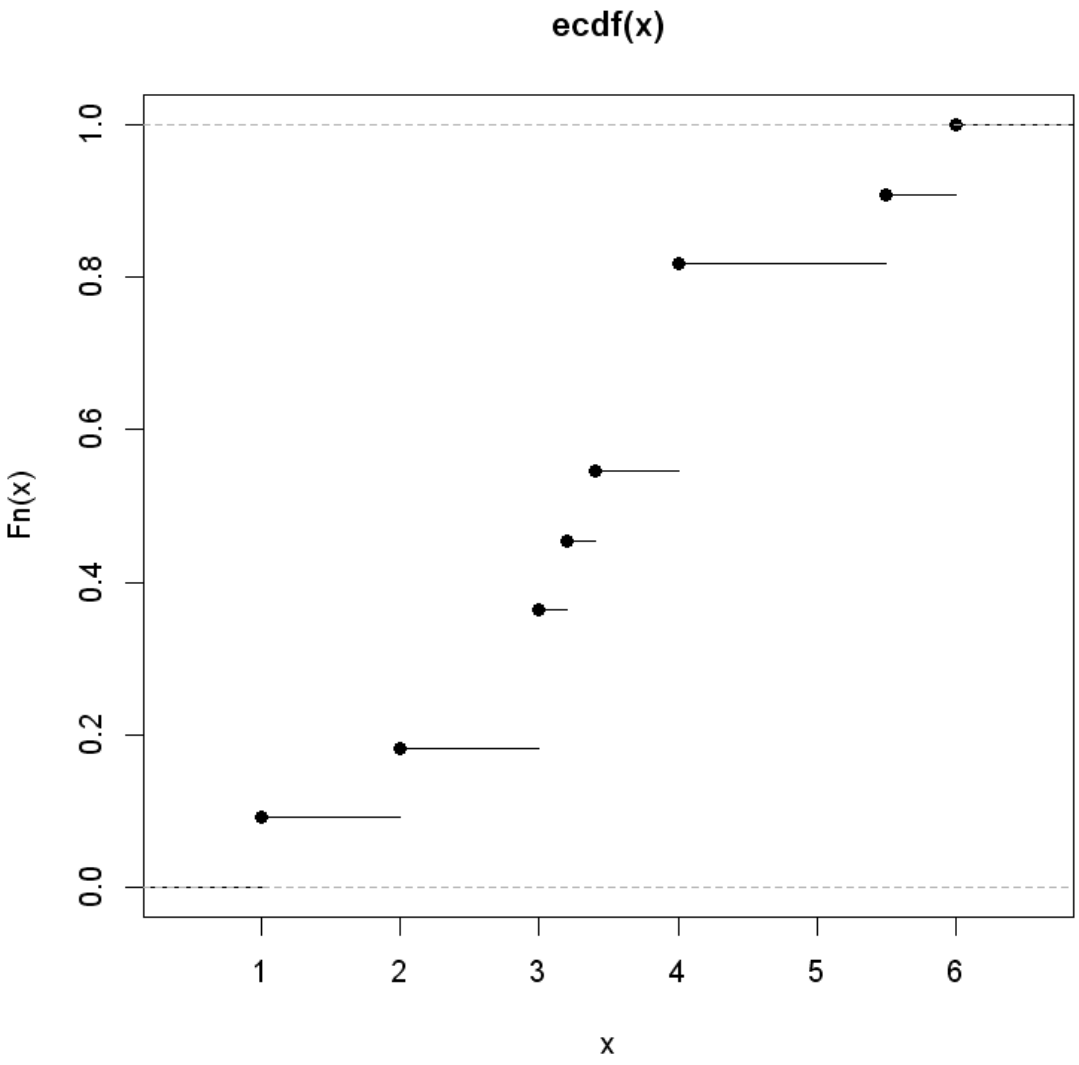
```
curve(x/(1-x),xlab=" ",ylab=" ")
title(xlab=expression(rho), ylab="E(L)")
```

The first line gives the graph with default units and no axis labels.
The second line adds axis labels including Greek letters.
Output is



Example: An empirical cdf (very simple to use)

```
> x=c(2,1,3,4,5.5,3.4,6,4,4,3.2,3)
> a=ecdf(x)
> plot(a)
```



Example: In this example we download an add-on package called Diagram and use the package to draw a transition diagram.

```
 install.packages("diagram")
 library("diagram")
# Create transition matrix
 #
 Numstates <- 6
 DiffMat <- matrix(data = 0, nrow = Numstates, ncol = Numstates)
 P <- as.data.frame(DiffMat)
 P[[1,2]] <- "lambda"
 P[[2,3]] <- "lambda"
 P[[3,4]] <- "lambda"
 P[[4,5]] <- "lambda"
 P[[5,6]] <- "lambda"
 #
 P[[2,1]] <- "mu[list(2,1)]"
 P[[3,2]] <- "mu[list(3,2)]"
 P[[4,3]] <- "mu[list(4,3)]"
 P[[5,4]] <- "mu[list(5,4)]"
 P[[6,5]] <- "mu[list(6,5)]"
 #
 name <- c(expression(1), expression(2), expression(3),
 expression(4), expression(5), expression(6))
 #
 plotmat(A = P, pos = 6, curve = 0.7, name = name, lwd = 2,
 arr.len = 0.6, arr.width = 0.25, my = -0.2,
 box.size = 0.05, arr.type = "triangle", dtext = 0.95,
 main = "State Diagram")
```

The output is

State Diagram