*R* is widely used free software similar to *Splus.* (The link **Cran** gives *R* support.) *R* can be downloaded from (www.r-project.org/).

In the computer lab, click on the *Rgui* icon to get into *R.* Then typing *q()* gets you out of *R.*

Least squares is used to fit linear models such as ANOVA. The function *lm* can be used, and much of the output can be obtained with the function **lsfit**. The main *R* function for obtaining ANOVA models is **aov**.

*help(fn)* and *args(fn)* give information about function fn, eg if fn = *aov.*

The following data set considers the number of warp breaks per loom, where the factor is tension (low, medium or high).

Type the following commands:

```
help(warpbreaks)
out <- aov(breaks ~ tension, data = warpbreaks)
out
summary(out)
plot(out$fit,out$residuals)
title("Residual Plot")
```

Highlight the ANOVA table by pressing the left mouse key and dragging the cursor over the ANOVA table. Then use the menu commands "Edit> Copy." Enter *Word* and use the menu commands "Edit>Paste."

Click on the plot, hit the *Ctrl* and *c* keys at the same time. Enter *Word* and use the menu commands "Edit>Paste."

Type the following commands:

```
warpbreaks[1,]
plot(out$fit,warpbreaks[,1])
abline(0,1)
title("Response Plot")
```

Click on the plot, hit the *Ctrl* and *c* keys at the same time. Enter *Word* and use the menu commands "Edit>Paste."

The first term in the plot command is always the horizontal axis while the 2nd is the vertical axis. The terms *out$fit* and *out$resid* give the fitted values and residuals respectively.

**Making functions in R is easy.**

For example, type the following commands:

```
mysquare <- function(x){
# this function squares x
r <- x^2
r }
```

The second line in the function above is how you put comments into functions.

**Modifying your function is easy.**

Use the fix command: *fix(mysquare)* This will open an editor such as *Notepad* and allow you to make changes.

**To save data or a function,** when you exit, say *yes* to "save worksheet." When you reenter $R$, type *ls().* This will show you what is saved. You should hardly ever save anything. To remove unwanted items from the worksheet, eg $x$, type *rm(x).*
*pairs(x)* makes a scatterplot matrix of the columns of $x$.
*hist(y)* makes a histogram of $y$.
*boxplot(y)* makes a boxplot of $y$.
*stem(y)* makes a stem and leaf plot of y.
*scan(), source(),* and *sink()* are useful on a *Unix* machine.
To type a simple list, use $y <-$ *c(1,2,3.5).*
*mean(y), median(y), var(y)* are self explanatory.

Adding to scatterplot created by *plot(x,y).*
*lines(x,y), lines(lowess(x,y,f=.2))*
*identify(x,y)*
*abline(out$coef), abline(0,1)*

The command *par(mfrow=c(2,1))* allows one to put two graphs on one plot.

The usual arithmetic operators $2+4$, $3-7$, $8*4$, $8/4$, $2\hat{}\ 3$.

The $i$th element of vector $y$ is $y[i]$ while the ij element of matrix $x$ is $x[i,j]$. $x[2,]$ is the 2nd row of $x$. $x[,4]$ is the 4th column of x. *t(x)* is the transpose of $x$.
*apply(x,1,fn)* will compute the row means if fn = mean.
*apply(x,2,fn)* will compute the column variances if fn = var.

*cbind* and *rbind* allow one to add columns and rows to a matrix

Useful websites:

`http://www.stat.cmu.edu/~larry/=stat326.02/`
`https://cran.r-project.org/doc/contrib/Verzani-SimpleR.pdf`

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