R and *RStudio*

Math functions
Data sources

Setting up *R* and *R Studio*

This only applies to your own computers!
Lab computers have both installed.

Windows and Mac
R home page: http://cran.r-project.org/

Download and install R.

RStudio home page: https://www.rstudio.com/products/rstudio/download/

Download and install R Studio

Start R Studio
(Vista Users: Right-click the icon and choose Compatibility, run as administrator)

R and *R Studio*

On the Lab computers

- you can install packages (necessary!) - **every time**
  Tools|Install Packages| [*type in name*]
- then you load the library using: **`library(`*`name`*`)`**
- **you can load data** from a USB or web
- **you can save text** from commands, etc. to a USB

On your computer

- you can install packages - **needed only once**
  Tools|Install Packages| [*type in name*]
- then you load the library using: **`library(`*`name`*`)`**
- **you can load data** from local drives or web
- **you can save text** from commands, etc. to local drive

Start RStudio

The bottom left should show the console

try entering: (notice the **BOLD BLACK** text)

`2 + 2` (`or:` **`2+2`**) **and hit enter**

`[1] 4` <--- by convention, output will usually be black, not bolded in slides

Commands: the Console

The bottom left should show the Console

First commands:

try addition:

```
2 + 2
[1] 4
```

subtract: `2 - 2 # notice I can add a comment on this line`

multiply: `2 * 2; I can also add a semicolon at the end`

divide: `2 / 2`

raise to a power 2^3: `2^3  # OR: 2**3`

raise to a power 0.3^2: `0.3^2`

raise to a power $9^{1/2}$ or $9^{0.5}$: `9^1/2` *???* `9^(1/2) or 9^0.5`

raise to a power $3459^{1/7}$: `3459^(1/7) # [1] 3.203055`

Commands

```
# (notice the #) Comment: get an average of 5 numbers
# Parentheses are very important!
(1 + 3 + 2 + 12 + 8)/5
[1] 5.2

# watch parentheses!
(1 + 3 + 2 + 12 + 8/5
+
```

+ means you forgot something (usually a right parenthesis)

```
)
[1] 19.6
# nested parentheses
( (2 - 1)^2 + (1 - 3)^2 ) ^(1/2)

((2-1)^2+(1-3)^2)^(1/2)

( (2-1)^2 + (1-3)^2 ) ^(1/2)
```

Commands

```
# Errors need some interpretation
2^^2
Error: unexpected '^' in "2^^"
```

$(2^2)^2$

```
# 2 squared, then squared
# so it is 4 squared or 2 x 2 x 2 x 2  =
```

$2^{2+2} = 2^4 = 2^{2^2}$

```
2^2^2
[1] 16
```

When copying and pasting code...

CAUTION: Microsoft's "smart quotes" are dumb!!!!!

```
install.packages(“sqldf", dependencies=TRUE)
Error: unexpected input in "install.packages(“"
```

Commands

Command history: use the up arrow to get to a previous command

(may be several lines)

- then, use left/right first, then up/down within that command

```
#this is a multi-line set of commands
# assign a variable to a value: use a left arrow (<-)
# if copying and pasting, you may need a semi-colon at end of line
x <- 3  # or x = 3;
y <- 5  # or y = 5;
x * y;
[1] 15

x <- 20 # reassign x
x * y
[1] 15
```

You can also see the commands in the top right pane, on the History page

To re-enter lines, highlight them and click on "To Console"

Functions

Functions: name of function then parentheses

- example: Square root

```
sqrt(9)
[1] 3

# Logs of numbers - default uses the natural log , base = e
log(90)
[1] 4.49981
#get the inverse, using exp (e to some power)
exp(4.49981)
[1] 90.00003

#what is e, though?
exp(1)
[1] 2.718282
```

```
#exact answer:
exp(log(90))
```

hmm - where does *e* come from? $e = 1 + \frac{1}{1} + \frac{1}{1 \cdot 2} + \frac{1}{1 \cdot 2 \cdot 3} + \cdots$

Functions

Another function: log using base 10

```
# Base 10 Logs - notice there are two numbers separated by a comma
log(100,10)
[1] 2

log(90,10)
[1] 1.954243

#get the inverse of a base 10 log
10^1.954243
[1] 90.00001
```

```
#exact answer:
10^(log(90,10))
```

Scientific notation: base number >1 and < 10, and power of 10

```
1.2413234234 / 2353463456756476578678
[1] 5.274454e-22
```

= 0.000000000000000000005274454

12345678901234567890

1111111111222

Commands

Use variable names easy to recognize and remember

```
ControlN <- 55
TreatmentN   <- 27

# or cmn and tmn?
```

But everything in R is case-sensitive!

`cmn` is not the same as `CMN` or `Cmn`

```
# some variable names are reserved for constants (pi)
pi
[1] 3.141593
pi <- 5
pi
[1] 5
```

OOPS!!!!!!!!!!

You can also see the history in the top right pane

To re-enter lines, highlight them and click on "To Console"

Functions

Assign multiple numbers to list (a vector: one row of numbers)

- use the c function (combine)

NOTE: you will get nothing back unless you ask for it

(unless there is an error!)

```
x <- c(74, 122, 235, 111, 292)

# what did I do? Check:
x
[1]  74 122 235 111 292
# use the mean function
mean(x)
[1] 166.8
# which is equivalent to using two other functions
# sum adds the elements up; length counts the elements
sum(x) / length(x)
[1] 166.8
# vectors have an index for each value in it : note brackets [ ]
x[3]
[1] 235
```

Functions

Functions can act on vectors

x is now a vector, will add elements

```
x
[1]  74 122 235 111 292
x + x
[1] 148 244 470 222 584
2*x
[1] 148 244 470 222 584
sqrt(x)
[1]  8.602325 11.045361 15.329710 10.535654 17.088007

x-mean(x)
[1] -92.8 -44.8  68.2 -55.8 125.2
sum(x-mean(x)) # should be zero - and IS (rounding); a nested function
[1] -5.684342e-14

round(sum(x-mean(x)),10) # a nested function, rounding to 10 digits
[1] 0
```

Functions

Median: 50th percentile

Get the median of our vector

```
x
[1]  74 122 235 111 292
median(x)
[1] 122

# get a statistical summary of our vector
summary(x)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   74.0   111.0   122.0   166.8   235.0   292.0
```

Built-in functions need parentheses:

mean(), median(), sum(), min(), max()

NA, NULL, NaN, Inf answers

NA is used for missing data

```
x[7]  # only 5 items
[1] NA
```

NULL is used for an undefined action or undefined value

```
babies$ID # oops, case-sensitive ; babies$id will work
NULL
```

NaN means not a number, an undefined number

```
0/0
[1] NaN
```

Inf means infinity, usually division by zero

```
1/0
[1] Inf
```

Help!

You can get help with a question mark in front of something

```
?median
```

Also, the bottom right pane shows a number of things

One is a Help tab

Look up median (top right of pane)

- provides explanation of function and gives examples

```
x
[1]  74 122 235 111 292
median(x)
[1] 122

# get a statistical summary of our vector
summary(x)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   74.0   111.0   122.0   166.8   235.0   292.0
```

Data

```
# an easy way to load data: type into console:
babies <- read.csv("http://math.mercyhurst.edu/~sousley/STAT_139/data/babies.csv", header=T)
```

top left pane shows datasets

babies

```
...
431  6101       5       1 1382       280   1 146      1    0  23  2 61 145     0   25   2  99 999       1  98     0    0      0
432  6112       5       1 1406       283   1 112      0    0  21  3 62 102     0   23   2  72 165       1   5     1    1      1
433  6114       5       1 1404       269   1 115      2    6  30  2 62 115     5   29   1  67 130       1   1     9   98     98
434  6120       5       1 1676       278   1 132      2    0  20  1 64 150     9   24   1  99 999       1   4     1    1      5
 [ reached getOption("max.print") -- omitted 802 rows ]
```

```
# get the first few records
head(babies)
```

```
   id pluralty outcome date gestation sex  wt parity race age ed ht wt1 drace dage ded dht dwt marital inc smoke time number
1  15       5       1 1411       284   1 120      1    8  27  5 62 100     8   31   5  65 110       1   1     0    0      0
2  20       5       1 1499       282   1 113      2    0  33  5 64 135     0   38   5  70 148       1   4     0    0      0
3  58       5       1 1576       279   1 128      1    0  28  2 64 115     5   32   1  99 999       1   2     1    1      1
4  61       5       1 1504       999   1 123      2    0  36  5 69 190     3   43   4  68 197       1   8     3    5      5
5  72       5       1 1425       282   1 108      1    0  23  5 67 125     0   24   5  99 999       1   1     1    1      5
6 100       5       1 1673       286   1 136      4    0  25  2 62  93     3   28   2  64 130       1   4     2    2      2
```

```
# get the last few records
tail (babies)
```

Data

data.frame = table (rows and columns)

```
str(babies) # get the structure
'data.frame':     1236 obs. of  23 variables:
 $ id      : int  15 20 58 61 72 100 102 129 142 148 ...
 $ pluralty: int  5 5 5 5 5 5 5 5 5 5 ...
 $ outcome : int  1 1 1 1 1 1 1 1 1 1 ...
 $ date    : int  1411 1499 1576 1504 1425 1673 1449 1562 1408 1568 ...
 $ gestdays: int  284 282 279 999 282 286 244 245 289 299 ...
 $ sex     : int  1 1 1 1 1 1 1 1 1 1 ...
 $ bwt     : int  120 113 128 123 108 136 138 132 120 143 ...
 $ parity  : int  1 2 1 2 1 4 4 2 3 3 ...
 $ mrace   : int  8 0 0 0 0 0 7 7 0 0 ...
 $ mage    : int  27 33 28 36 23 25 33 23 25 30 ...
 $ med     : int  5 5 2 5 5 2 2 1 4 5 ...
 $ mht     : int  62 64 64 69 67 62 62 65 62 66 ...
 $ mwt     : int  100 135 115 190 125 93 178 140 125 136 ...
 $ frace   : int  8 0 5 3 0 3 7 7 3 0 ...
 $ fage    : int  31 38 32 43 24 28 37 23 26 34 ...
 $ fed     : int  5 5 1 4 5 2 4 4 1 5 ...
 $ fht     : int  65 70 99 68 99 64 99 71 70 99 ...
 $ fwt     : int  110 148 999 197 999 130 999 192 180 999 ...
 $ marital : int  1 1 1 1 1 1 1 1 0 1 ...
 $ inc     : int  1 4 2 8 1 4 98 2 2 2 ...
 $ msmoke  : int  0 0 1 3 1 2 0 0 0 1 ...
 $ time    : int  0 0 1 5 1 2 0 0 0 1 ...
 $ number  : int  0 0 1 5 5 2 0 0 0 4 ...
```

Dataframes

Data arranged in rows and columns

data(babies) # notice top right pane

Next, load Cavendish data (estimates of gravitational constant from 1798):

```
Cavendish <- read.csv("http://math.mercyhurst.edu/~sousley/STAT_139/data/Cavendish.csv", header=T)

head(Cavendish)
  density density2 density3
1    5.50     5.50       NA
2    5.61     5.61       NA
3    4.88     5.88       NA
4    5.07     5.07       NA
5    5.26     5.26       NA
6    5.55     5.55       NA

str(Cavendish)
'data.frame':  29 obs. of  3 variables:
 $ density : num  5.5 5.61 4.88 5.07 5.26 5.55 5.36 5.29 5.58 5.65 ...
 $ density2: num  5.5 5.61 5.88 5.07 5.26 5.55 5.36 5.29 5.58 5.65 ...
 $ density3: num  NA NA NA NA NA NA 5.36 5.29 5.58 5.65 ...
```

Dataframes

We can refer to a column in a dataframe using $:

```
Cavendish$Density   # case-sensitive, oops
NULL
Cavendish$density # case-sensitive
[1] 5.50 5.61 4.88 5.07 5.26 5.55 5.36 5.29 5.58 5.65 5.57 5.53 5.62 5.29 5.44 5.34
[17] 5.79 5.10 5.27 5.39 5.42 5.47 5.63 5.34 5.46 5.30 5.75 5.68 5.85
```

Get a general-purpose statistical summary of the column in a dataframe using $:

```
summary(Cavendish$density)
 Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  4.880   5.300   5.460   5.448   5.610   5.850

summary(Cavendish) # ALL columns
    density         density2        density3
 Min.   :4.880   Min.   :5.070   Min.   :5.100
 1st Qu.:5.300   1st Qu.:5.340   1st Qu.:5.340
 Median :5.460   Median :5.470   Median :5.460
 Mean   :5.448   Mean   :5.482   Mean   :5.483
 3rd Qu.:5.610   3rd Qu.:5.620   3rd Qu.:5.625
 Max.   :5.850   Max.   :5.880   Max.   :5.850
                                 NA's   :6
```

R sites:

BEST general sites with examples:

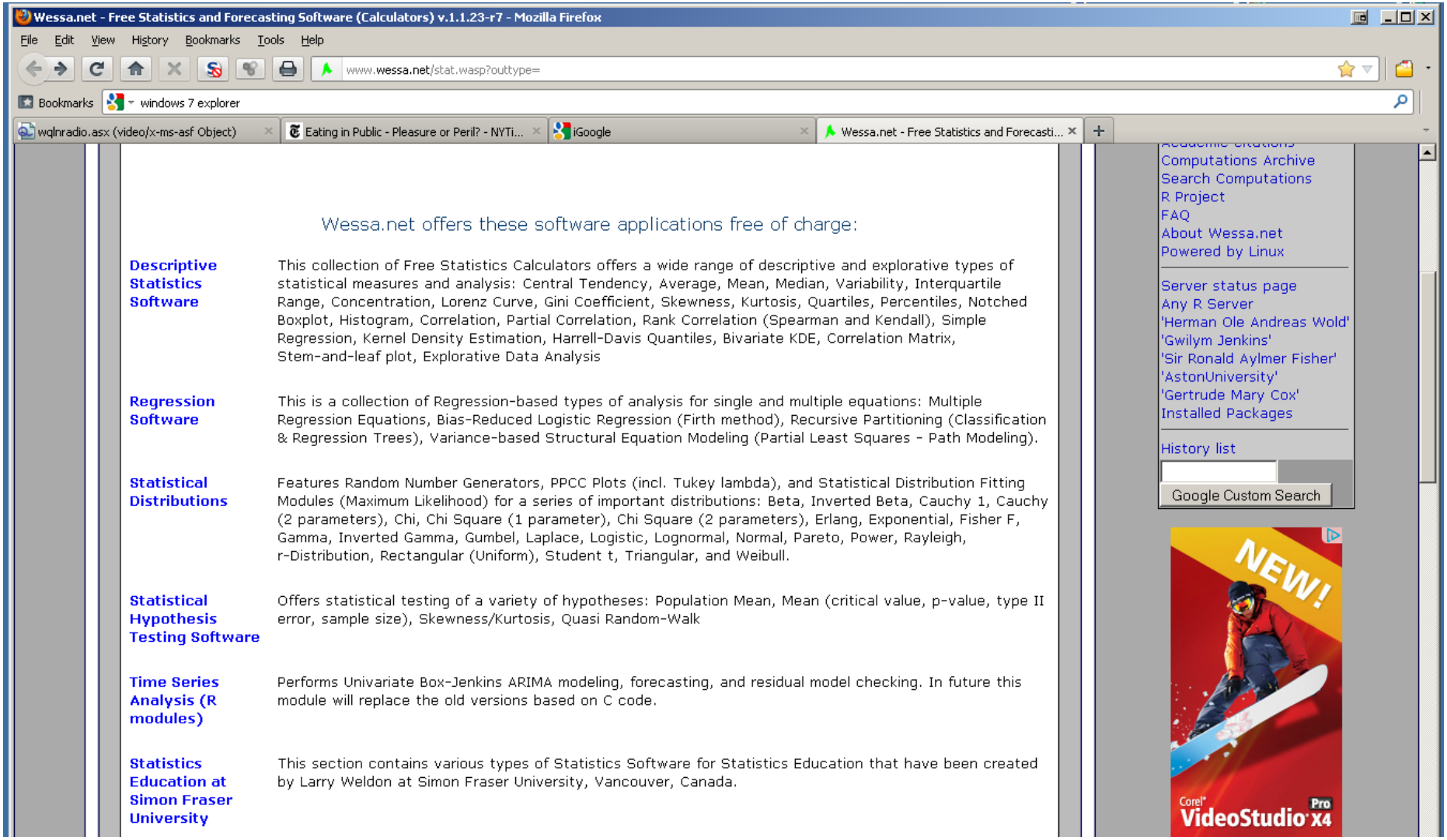
Quick-R:

http://www.statmethods.net/index.html

Tutorials:

http://thomasleeper.com/Rcourse/Tutorials/

http://www.wessa.net/stat.wasp?outtype=



Interactive examples with data!

Homework 1 due before the next class

Do problems from VCH1-2014 (page 18):

1.1 1.2 1.3 1.4 1.6 1.7 1.8 1.11 1.12

In general, data files can be found here:

http://math.mercyhurst.edu/~sousley/STAT_139/data/

```
exec.pay <- read.csv("http://math.mercyhurst.edu/~sousley/STAT_139/data/exec.pay.csv", header=T)
```

If not found:

```
install.packages("UsingR") # download package and many other linked packages
library(UsingR) #
exec.oay # will show the data
```

Orange data is part of R

Columns:

Tree: tree number (five trees measured at various ages)

age: number of days since December 31, 1968

circumference: trunk circumference in mm

Homework Procedures

IMPORTANT:

You will need to put your answers into a Word document with your name at the top and "Homework 1".

Include all R code and output with each answer.

Answer the question using a sentence and any appropriate units!

Name your file "[*LastName*]-Homework1" and include your full name in it. Example: Smith-Homework1.docx

Attach the Word file to an email to me with the subject:

"DATA 500 Homework 1"

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