R is free software available from (https://cran.r-project.org/), and is heavily used in statistics research and actuarial mathematics. *SAS* is the industry standard for statistics but is expensive. So a small company will often have *R* instead of *SAS*. *R* is also used in probability research and financial mathematics. The **CRAN** link gives *R* support. See (http://parker.ad.siu.edu/Olive/survch5.pdf) for some more information on *R*. Useful websites:

```
https://www.r-project.org/#doc
www.stat.cmu.edu/~larry/=stat326.02/
```

The *R* software is available in the Math computer lab in Neckers 258 (2 doors from my office). You can get the lab opened by me. Certain hours are reserved, check at the door. The lab is not open on weekends, holidays or final exam week. Computers 11-25 likely have *R* with a desktop icon with an *R* symbol.

Every fall, the initial login to one of these computers can take 10 minutes, and that is 10 minutes for each different computer. The computer on button is in the upper left corner while the monitor on button is in the lower right corner. You may need to press a computer keyboard key to get the login and password bars to appear.

The computer lab login is like logging into salukinet. If necessary, hit Ctrl, enter your AD\siu8... (dawg tag) and your password. Left click the lower left icon, or near the lower left icon, search for R.

Click the internet icon and search for David Olive. His personal page (http://parker.ad.siu.edu/Olive/Personal.html) has a Links for Students which has information on Math 473, Math and Statistics Texts, and the SIU Actuarial program. *R* code for Math 473 homework (HW) is on this page and at (http://parker.ad.siu.edu/Olive/survhw.txt). The source code near the top of this file gets *R* programs needed for some of the homework into *R* quickly. **You can copy and paste the *R* code for each problem part from** (http://parker.ad.siu.edu/Olive/survhw.txt) into *R*.

Having a flashdrive to save *R* output may be useful.

There are two common errors: 1) *R* says it can't find a function because you forgot to copy and paste the following command that is near the top of the above link. This command gets functions written by Dr. Olive.

```
source("http://parker.ad.siu.edu/Olive/survpack.txt")
```

2) *R* says it can't find a function because you forgot to copy and paste the following command that is near the top of the above link. This function gets the survival analysis functions that come with *R*.

```
library(survival)
```

Click the lower left icon to see programs in the icons Window. You can click on the desktop icon to escape. If you click on something and can't get out of the information window, there is a Windows key that looks like 4 rectangles and is on the lower left of the keyboard near the Ctrl key. This Windows key can get you back to icons Windows. The computer may have an *R* icon as a shortcut. Then typing *q()* gets you out of *R*.

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

Type the following commands:

```
z <- rexp(100)
hist(z)
z2 <- rexp(100,rate=.1)
zt <- pmin(z,z2)
hist(zt)
z2 <- rexp(100,rate=2)
zt <- pmin(z,z2)
hist(zt)
```

The first line simulates 100 iid EXP(1) random variables.

To put a graph in "Word", hold down the *Ctrl* and *c* buttons simultaneously. Then in the *Word*, press *Ctrl* and *v* to paste the commands into *R*.

```
library(survival)
time <- c(9,13,13,18,23,28,31,34,45,48,161)
status <- c(1,1,0,1,1,0,1,1,0,1,0)
z <-  survfit(Surv(time, status)~1, conf.type = "plain")
summary(z)
#plot KM estimator hat(S)_K(t) and the CIs for S(t)
plot(z)
#now get plus four CIs based on KM estimator
tp4 <- c(7,8,time,162,163)
sp4 <- c(1,1,status,0,0)
zp4 <- survfit(Surv(tp4,sp4)~1,conf.type="plain")
summary(zp4)

zy <- rexp(20)
zz <- rexp(20,rate=.2)
zt <- pmin(zy,zz)
zdelta <- as.numeric(zz>zy)
out <- survfit(Surv(zt, zdelta)~1, conf.type = "plain")
st <- exp( - out$time)
plot(out)
points(out$time,st)
#repeat with n = 200
zy <- rexp(200)
zz <- rexp(200,rate=.2)
zt <- pmin(zy,zz)
zdelta <- as.numeric(zz>zy)
out <- survfit(Surv(zt, zdelta)~1, conf.type = "plain")
st <- exp( - out$time)
plot(out)
points(out$time,st)
```