Math 3070 § 1. Treibergs | **Aqueduct Example: Two Sample Test for Differences of Variances** | Name: Example | June 3, 2011

Data File Used in this Analysis:

```
# Math 3070 - 1   Concrete Compressive Strength Example   June 3, 2011
# Treibergs
#
# Taken from Levine, Ramsey, Smidt, "Applied Statistics for Engineers and
# Scientists," Prentice Hall 2001.
#
# Data from California Dept. of Water Resources. The compressive strength
# of concrete used at pumping sites along the California Coastal Aqueduct
# was measured.
#
# Variables
#      Strength  (in psi)
#      Site      Pass = Polonio Pass; Den = Devi;'s Den
Strength Site
3520 Pass
3470 Pass
4090 Pass
4380 Pass
4210 Pass
4670 Pass
3770 Pass
3950 Pass
3600 Pass
3660 Pass
3780 Pass
3420 Pass
4030 Pass
4020 Pass
4600 Pass
3880 Pass
3690 Pass
5210 Pass
4380 Pass
5200 Pass
4700 Den
4610 Den
4470 Den
4915 Den
4900 Den
3550 Den
4010 Den
3940 Den
4090 Den
3960 Den
4750 Den
4100 Den
3550 Den
```

```
3830 Den
3950 Den
3600 Den
4030 Den
5330 Den
5460 Den
3760 Den
```

R Session:

```
R version 2.11.1 (2010-05-31)
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  Natural language support but running in an English locale

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Type 'q()' to quit R.

[R.app GUI 1.34 (5589) i386-apple-darwin9.8.0]

[Workspace restored from /home/1004/ma/treibergs/.RData]

> tt <- read.table("M3074AqueductData.txt", header=T)
> attach(tt)
> tt
   Strength Site
1      3520 Pass
2      3470 Pass
3      4090 Pass
4      4380 Pass
5      4210 Pass
6      4670 Pass
7      3770 Pass
8      3950 Pass
9      3600 Pass
10     3660 Pass
11     3780 Pass
12     3420 Pass
13     4030 Pass
14     4020 Pass
```
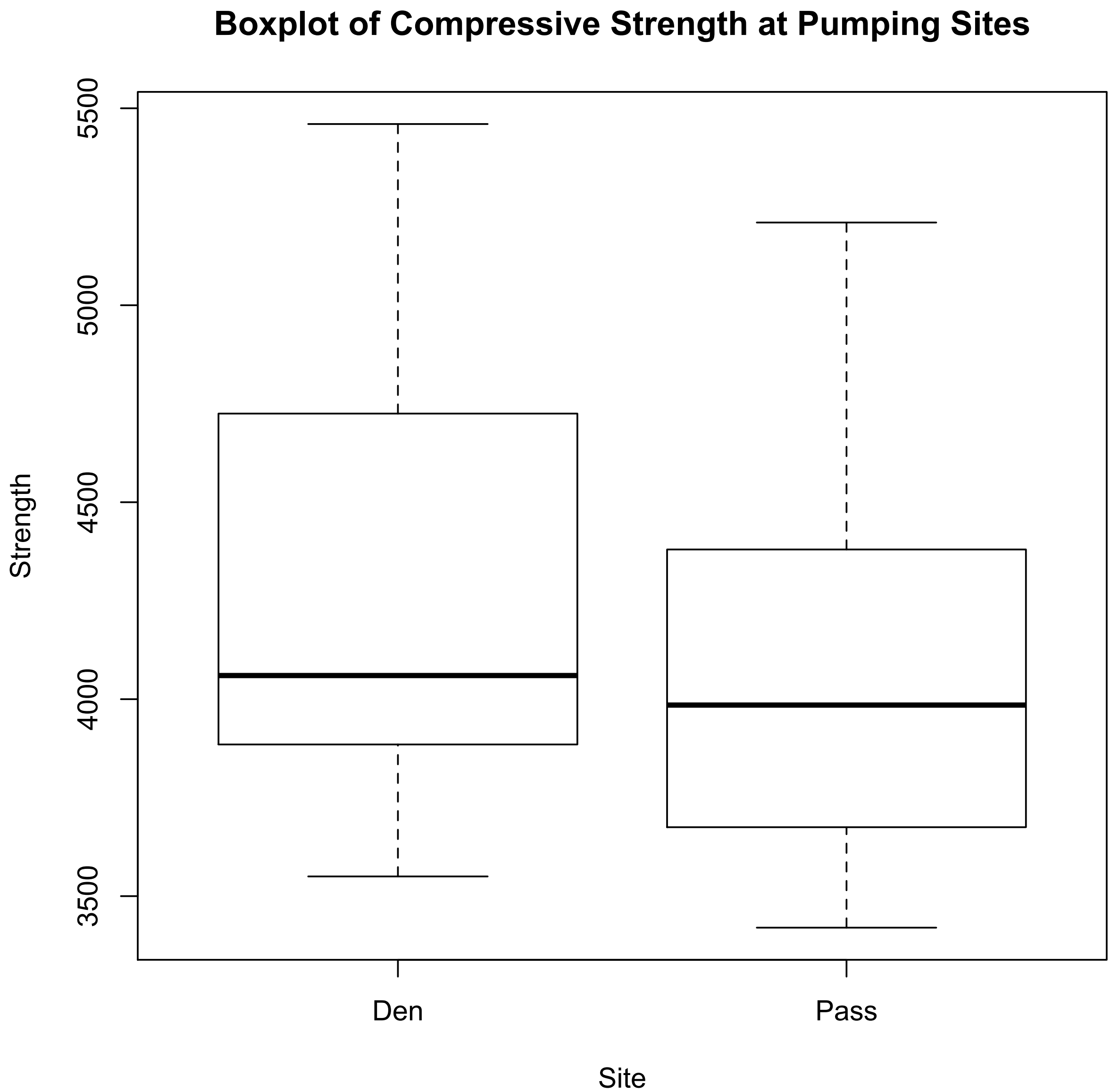
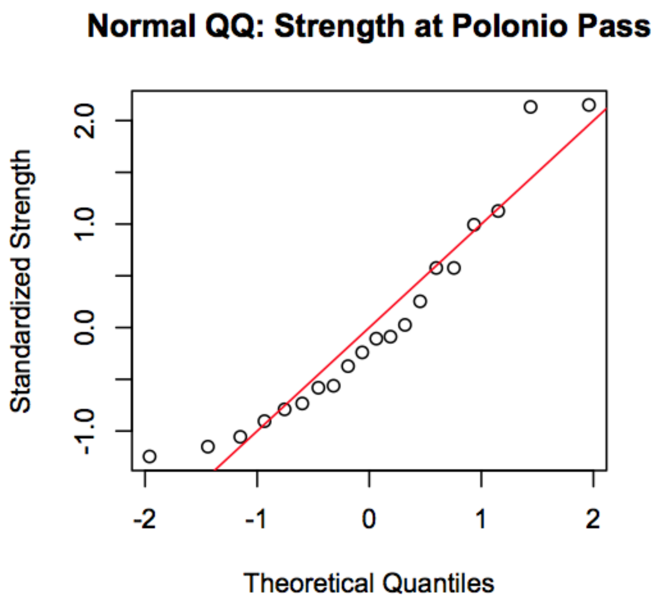
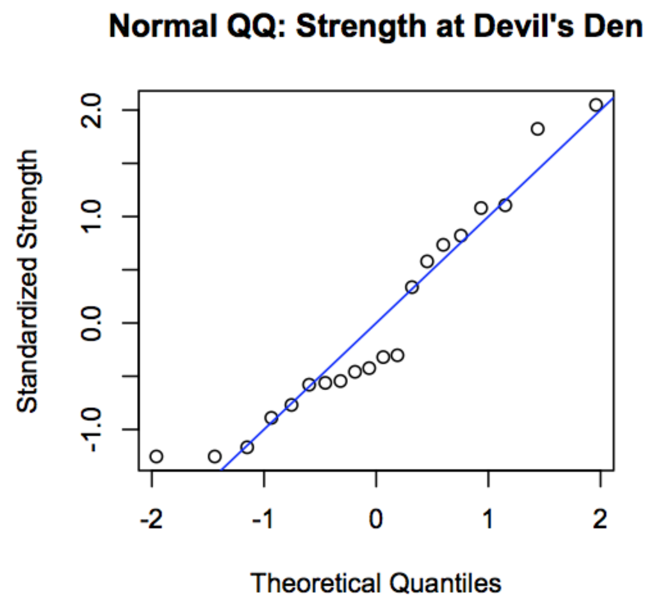

```
15      4600 Pass
16      3880 Pass
17      3690 Pass
18      5210 Pass
19      4380 Pass
20      5200 Pass
21      4700  Den
22      4610  Den
23      4470  Den
24      4915  Den
25      4900  Den
26      3550  Den
27      4010  Den
28      3940  Den
29      4090  Den
30      3960  Den
31      4750  Den
32      4100  Den
33      3550  Den
34      3830  Den
35      3950  Den
36      3600  Den
37      4030  Den
38      5330  Den
39      5460  Den
40      3760  Den

>
> ####################### GET A SENSE OF THESE DATA #####################################
> tapply(Strength,Site,summary)
$Den
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   3550    3912    4060    4275    4712    5460

$Pass
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   3420    3682    3985    4076    4380    5210

> # Their variances?
>
> tapply(Strength,Site,var)
     Den     Pass
334540.7 277676.6
>
> title("Boxplot of Compressive Strength at Pumping Sites")
```




```
> # Pick off the measurements at the two sites.
>
> y1 <- tt[Site=="Pass",1]
> y1
  [1] 3520 3470 4090 4380 4210 4670 3770 3950 3600 3660 3780 3420 4030 4020 4600
 [16] 3880 3690 5210 4380 5200
> y2 <- tt[Site=="Den",1]; y2
  [1] 4700 4610 4470 4915 4900 3550 4010 3940 4090 3960 4750 4100 3550 3830 3950
 [16] 3600 4030 5330 5460 3760

> qqnorm((y1-mean(y1))/sd(y1),main="Normal QQ: Strength at Polonio Pass",
+ ylab="Standardized Strength")
```

```
> abline(0,1,col=2)
> qqnorm((y2-mean(y2))/sd(y2),main="Normal QQ: Strength at Devil's Den",
+ ylab="Standardized Strength")
> abline(0,1,col=4)
> # M3074Aqueduct2.pdf
```






```
> #  Neither data shows nonnormal tendencies. We may assume both samples are normal.
>
```

```
> ############################## TEST WHETHER VARIANCES ARE DIFFERENT #########################
>
> var.test(y1,y2)

F test to compare two variances

data:  y1 and y2
F = 0.83, num df = 19, denom df = 19, p-value = 0.6888
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.3285333 2.0970130
sample estimates:
ratio of variances
         0.8300233

> # High p-value: we cannot reject null hypothesis that the ratio of variances is one.

> ##################### TEST WHETHER VARIANCES ARE DIFFERENT  BY HAND #########################
> n1 <- length(y1); n1
[1] 20
> n2 <- length(y2); n2
[1] 20
>
> # ratio of variances.
>
> F <- var(y1)/var(y2); F
[1] 0.8300233

> # For two sided test, the lower and upper critical values are
> alpha <- .05
> critf1 <- qf(alpha/2,n1-1,n2-1);critf1
[1] 0.3958122
> critf2 <- qf(alpha/2,n1-1,n2-1,lower.tail=F);critf2
[1] 2.526451
>
> # Note that since n1=n2, critf2 = 1/ critf21
> 1/critf2
[1] 0.3958122

> # 2-sided CI on F = (s2^2/sigma1^2)/(s2^2/sigma2^2) ~ f(num df=n1-1, denom df = n2-1)
> # so with significance alpha, critf1 < F < critf2. Solve ineq for sigma1^2/sigma2^2:


> c(F/critf2,F/critf1)
[1] 0.3285333 2.0970130
>
> # The two sided p-value = P(f below F or above 1/F)
> pv <- pf(F,n1-1,n2-1)+  pf(1/F,n1-1,n2-1,lower.tail=F);pv
[1] 0.6888292>
```