# Chapter 5 Problems

5.1 $\underset{\sim}{\bar{X}} = \begin{bmatrix} 6 \\ 10 \end{bmatrix}$ $\quad E = \begin{bmatrix} -4 & 2 \\ 2 & -1 \\ 0 & -1 \\ 2 & 0 \end{bmatrix}$ $\quad E'E = \begin{bmatrix} 24 & -10 \\ -10 & 6 \end{bmatrix}$

$$S = \frac{1}{3}E'E = \begin{bmatrix} 8 & -\frac{10}{3} \\ -\frac{10}{3} & 2 \end{bmatrix} \quad S^{-1} = \frac{1}{16 - \frac{100}{9}} \begin{bmatrix} 2 & \frac{10}{3} \\ \frac{10}{3} & 8 \end{bmatrix}$$

$$\Rightarrow S^{-1} = \frac{9}{44} \begin{bmatrix} 2 & \frac{10}{3} \\ \frac{10}{3} & 8 \end{bmatrix}$$

$$H_0 : \mu_0 = \begin{bmatrix} 7 \\ 11 \end{bmatrix} \qquad \underset{\sim}{\bar{X}} - \underset{\sim}{\mu_0} = \begin{bmatrix} 6 \\ 10 \end{bmatrix} - \begin{bmatrix} 7 \\ 11 \end{bmatrix} = \begin{bmatrix} -1 \\ -1 \end{bmatrix}$$

$$T^2 = n(\bar{X} - \mu_0)' S^{-1} (\bar{X} - \mu_0) = 4 \begin{bmatrix} -1 & -1 \end{bmatrix} \left(\frac{9}{44}\right) \begin{bmatrix} 2 & \frac{10}{3} \\ \frac{10}{3} & 8 \end{bmatrix} \begin{bmatrix} -1 \\ -1 \end{bmatrix}$$

$$= \frac{9}{11} \begin{bmatrix} -\frac{16}{3} & -\frac{34}{3} \end{bmatrix} \begin{bmatrix} -1 & -1 \end{bmatrix} = \frac{9}{11} \begin{bmatrix} \frac{50}{3} \end{bmatrix} = \frac{150}{11} = 13.636$$

$$T^2 \sim \frac{(n-1)p}{n-p} F_{p,n-p} = \frac{(4-1)(2)}{4-2} F_{2,4-2} = 3F_{2,2}$$

$$F_{2,2}(.05) = 19.00 \qquad 3F_{2,2}(.05) = 57.00$$

T.S. $T^2 = 13.636$ RR: $T^2 \geq 57.00$ Do not reject $H_0$.

5.2

$$X = \begin{bmatrix} x_1' \\ x_2' \\ x_3' \end{bmatrix} = \begin{bmatrix} 6 & 9 \\ 10 & 6 \\ 8 & 3 \end{bmatrix}$$

$$C = \begin{bmatrix} 1 & -1 \\ 1 & +1 \end{bmatrix} \qquad Cx_1 = \begin{bmatrix} 6-9 \\ 6+9 \end{bmatrix} = \begin{bmatrix} -3 \\ 15 \end{bmatrix}$$

$$Cx_2 = \begin{bmatrix} 4 \\ 16 \end{bmatrix} \qquad Cx_3 = \begin{bmatrix} 5 \\ 11 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} -3 & 4 & 5 \\ 15 & 16 & 11 \end{bmatrix}' \qquad C\underset{\sim}{\mu}_0 = \begin{bmatrix} 1 & -1 \\ 1 & +1 \end{bmatrix}\begin{bmatrix} 9 \\ 5 \end{bmatrix}$$

$$CX = \begin{bmatrix} -3 & 15 \\ 4 & 16 \\ 5 & 11 \end{bmatrix} \qquad \overline{CX} = \begin{bmatrix} 2 \\ 14 \end{bmatrix}$$

$$S = \begin{bmatrix} 4 & -3 \\ -3 & 9 \end{bmatrix} \qquad S^{-1} = \begin{bmatrix} \frac{9}{27} & \frac{3}{27} \\ \frac{3}{27} & \frac{4}{27} \end{bmatrix}$$

$$CSC' = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} 4 & -3 \\ -3 & 9 \end{bmatrix}\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 7 & -12 \\ 1 & 6 \end{bmatrix}\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix} = \begin{bmatrix} 19 & -5 \\ -5 & 7 \end{bmatrix}$$

$$(CSC')^{-1} = \frac{1}{133-25}\begin{bmatrix} 7 & 5 \\ 5 & 19 \end{bmatrix} = \frac{1}{108}\begin{bmatrix} 7 & 5 \\ 5 & 19 \end{bmatrix}$$

$$C(\bar{X}-\mu_0) = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} 8-9 \\ 6-5 \end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} -1 \\ 1 \end{bmatrix} = \begin{bmatrix} -2 \\ 0 \end{bmatrix}$$

$$T^2 = 3\begin{bmatrix} -2 & 0 \end{bmatrix}\frac{1}{108}\begin{bmatrix} 7 & 5 \\ 5 & 19 \end{bmatrix}\begin{bmatrix} -2 \\ 0 \end{bmatrix} = \frac{3}{108}\begin{bmatrix} -14 & -10 \end{bmatrix}\begin{bmatrix} -2 \\ 0 \end{bmatrix} = \frac{84}{108}$$

$$= \frac{7}{9}$$

5.3 Equation (5-15):

$$T^2 = \frac{(n-1)\,|\hat{\Sigma}_0|}{|\hat{\Sigma}|} - (n-1)$$

a)

$$= \frac{(n-1)\,\left|\sum_{j=1}^{n}(x_j - \mu_0)(x_j - \mu_0)'\right|}{\left|\sum_j (x_j - \bar{x})(x_j - \bar{x})'\right|} - (n-1)$$

$$X = \begin{bmatrix} 2 & 12 \\ 8 & 9 \\ 6 & 9 \\ 8 & 10 \end{bmatrix} \qquad \bar{X} = \begin{bmatrix} 6 \\ 10 \end{bmatrix} \qquad \underset{\sim}{\mu}_0 = \begin{bmatrix} 7 \\ 11 \end{bmatrix}$$

$$E'E = \sum_j (x_j - \bar{x})(x_j - \bar{x})' = \begin{bmatrix} 24 & -10 \\ -10 & 6 \end{bmatrix}$$

$$E_0 = \begin{bmatrix} -5 & 1 \\ 1 & -2 \\ -1 & -2 \\ 1 & -1 \end{bmatrix} \qquad E_0'E_0 = \begin{bmatrix} 28 & -6 \\ -6 & 10 \end{bmatrix}$$

$$|E_0'E_0| = 28(10) - (-6)^2 = 280 - 36 = 244$$

$$|E'E| = 24(6) - (-10)^2 = 144 - 100 = 44$$

$$\Rightarrow T^2 = \frac{(4-1)\,(244)}{44} - (4-1) = 16.636 - 3 = 13.636$$

**5.36)** Equation (5-13)

$$\Lambda = \left(\frac{|\hat{\Sigma}|}{|\hat{\Sigma}_0|}\right)^{n/2} = \left(\frac{|\sum_j (x_j-\bar{x})(x_j-\bar{x})'|}{|\sum_j (x_j-\mu_0)(x_j-\mu_0)'|}\right)^{n/2}$$

$$= \left(\frac{44}{244}\right)^{4/2} = .03251814$$

$$\text{Wilk's lambda} \equiv \Lambda^{2/n} = (.03251814)^{2/4} = .18033$$

~~(put on separate pages)~~

**5.5** Transformed Microwave Data

$$\bar{x} = \begin{bmatrix} .564 \\ .603 \end{bmatrix} \qquad S = \begin{bmatrix} .0144 & .0117 \\ .0117 & .0146 \end{bmatrix} \qquad S^{-1} = \begin{bmatrix} 203.018 & -163.391 \\ -163.391 & 200.228 \end{bmatrix}$$

$$H_0: \mu = \begin{bmatrix} .55 \\ .60 \end{bmatrix} \qquad \bar{x}-\mu_0 = \begin{bmatrix} .014 \\ .003 \end{bmatrix} \qquad n = 42$$

$$T^2 = (42)\begin{bmatrix} .014 & .003 \end{bmatrix}\begin{bmatrix} 203.018 & -163.391 \\ -163.391 & 200.228 \end{bmatrix}\begin{bmatrix} .014 \\ .003 \end{bmatrix}$$

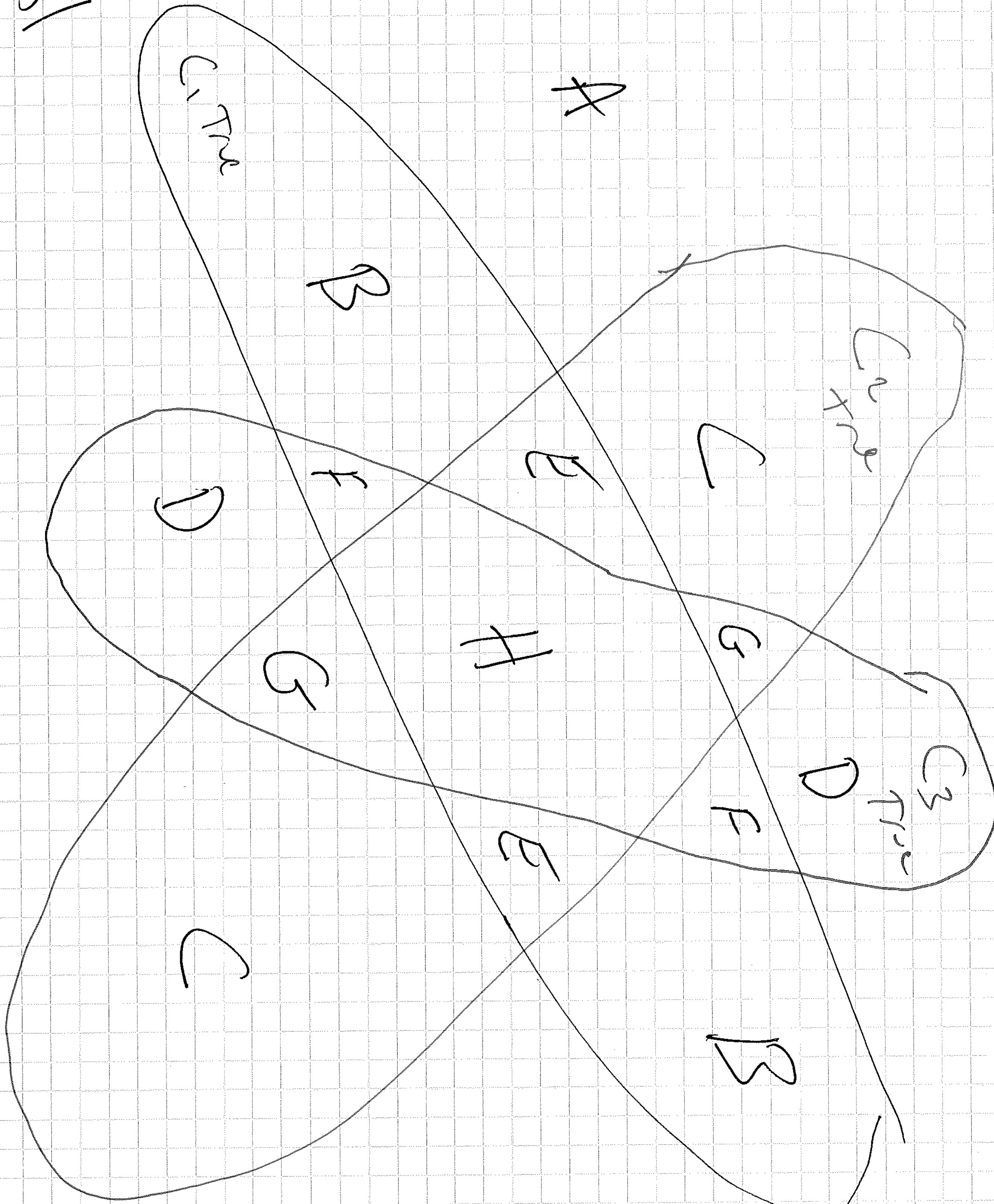
$$= 42\begin{bmatrix} 2.352 & -1.687 \end{bmatrix}\begin{bmatrix} .014 \\ .003 \end{bmatrix} = 42(.028) = 1.170$$

$$RR: T^2 \geq \frac{(42-1)(2)}{42-2} F_{2,42-2}(.05) = 2.05(3.232) = 6.626$$

Do not reject Ho.

5.6

5.5



**5.6. Continued** $\quad C_i \equiv C_i$ True $\quad \bar{C}_i \equiv C_i$ false

In venn Diagram: $A \equiv \bar{C}_1\bar{C}_2\bar{C}_3 \quad B \equiv C_1\bar{C}_2\bar{C}_3 \quad C \equiv \bar{C}_1 C_2 \bar{C}_3$

$D \equiv \bar{C}_1\bar{C}_2 C_3 \quad E \equiv C_1 C_2 \bar{C}_3 \quad F \equiv C_1\bar{C}_2 C_3 \quad G \equiv \bar{C}_1 C_2 C_3 \quad H \equiv C_1 C_2 C_3$

$$P(\text{All } C_i \text{ True}) = H = 1-(A+B+C+D+E+F+G)$$

$$P(C_1 \text{ False}) = A+C+D+G \qquad P(C_2 \text{ False}) = A+B+D+F$$

$$P(C_3 \text{ False}) = A+B+C+E$$

$$1-\sum_i P(C_i \text{ False}) = 1-\left[(A+C+D+G)+(A+B+D+F)+(A+B+C+E)\right]$$

$$= 1-\left[A+B+C+D+E+F+G+(2A+B+C+D)\right]$$

$$= 1-(A+B+C+D+E+F+G)-(2A+B+C+D)$$

$$\Rightarrow P(\text{All } C_i \text{ True}) \geq 1-\sum_i P(C_i \text{ False})$$

**5.7** **Result 5.3** $\quad a'\bar{X} \pm \sqrt{\frac{p(n-1)}{n(n-p)} F_{p,n-p}(\alpha)\, a'Sa}$

$p=3,\ n=20$

$$\bar{X} = \begin{bmatrix} 4.640 \\ 45.400 \\ 9.965 \end{bmatrix} \qquad S = \begin{bmatrix} 2.879 & 10.010 & -1.810 \\ 10.010 & 199.788 & -5.640 \\ -1.810 & -5.640 & 3.628 \end{bmatrix}$$

$$\frac{3(20-1)}{20(20-3)} F_{3,20-3}(.05) = .16765(3.197) = .5360 \qquad a_1' = [1\,0\,0] \quad a_2' = [0\,1\,0] \quad a_3' = [0\,0\,1]$$

$\mu_1: \ 4.640 \pm \sqrt{.5360(2.879)} = 4.640 \pm 1.243 = (3.397,\ 5.883)$

$\mu_2: \ 45.400 \pm \sqrt{.5360(199.788)} = 45.400 \pm 10.347 = (35.053,\ 55.747)$

$\mu_3: \ 9.965 \pm \sqrt{.5360(3.628)} = 9.965 \pm 1.430 = \cancel{(9.165,\ 10.765)}$
$(8.535,\ 11.395)$

## 5.7 Continued

Bonferroni: $\bar{x}_i \pm t_{n-1}\left(\frac{\alpha}{2p}\right) s\{\bar{x}_i\}$ $\quad s\{\bar{x}_i\} = \sqrt{\frac{s_{ii}}{n}}$

$$t_{19}\left(\frac{.05}{2(3)}\right) = 2.625$$

$$\mu_1: \quad 4.640 \pm 2.625\sqrt{\frac{2.879}{20}} \equiv 4.640 \pm 0.996 \equiv (3.644, 5.636)$$

$$\mu_2: \quad 45.400 \pm 2.625\sqrt{\frac{199.788}{20}} \equiv 45.400 \pm 8.297 \equiv (37.103, 53.697)$$

$$\mu_3: \quad 9.965 \pm 2.625\sqrt{\frac{3.628}{20}} \equiv 9.965 \pm 1.118 \equiv (8.847, 11.083)$$

## 5.8 Transformed Microwave Data

$$\bar{X} = \begin{bmatrix} .564 \\ .603 \end{bmatrix} \quad S^{-1} = \begin{bmatrix} 203.018 & -163.391 \\ -163.391 & 200.228 \end{bmatrix} \quad \mu_0 = \begin{pmatrix} .55 \\ .60 \end{pmatrix}$$

$$\underline{a} = S^{-1}(\bar{X} - \mu_0) = S^{-1}\begin{bmatrix} .014 \\ .003 \end{bmatrix} = \begin{bmatrix} 203.018(.014) - 163.391(.003) \\ -163.391(.014) + 200.228(.003) \end{bmatrix}$$

$$\Rightarrow \underline{a} = \begin{bmatrix} 2.352 \\ -1.687 \end{bmatrix} \qquad \underline{a}'\mu_0 = 2.352(.55) - 1.687(.60) = 0.281$$

$$a'\bar{X} = 2.352(.564) - 1.687(.603) = 0.309$$

$$a'Sa = \begin{bmatrix} 2.352(.0144) + 1.687(.0117) & 2.352(.0117) - 1.687(.0146) \end{bmatrix} \begin{bmatrix} 2.352 \\ -1.687 \end{bmatrix}$$

$$= \begin{bmatrix} .0141 & .0029 \end{bmatrix} \begin{bmatrix} 2.352 \\ -1.687 \end{bmatrix} = .0283$$

$$t^2 = \frac{n(a'\bar{X} - a'\mu_0)^2}{a'Sa} = \frac{42(0.309 - 0.281)^2}{.0283} = 1.164 \approx 1.170$$

(Rounding)

5/8

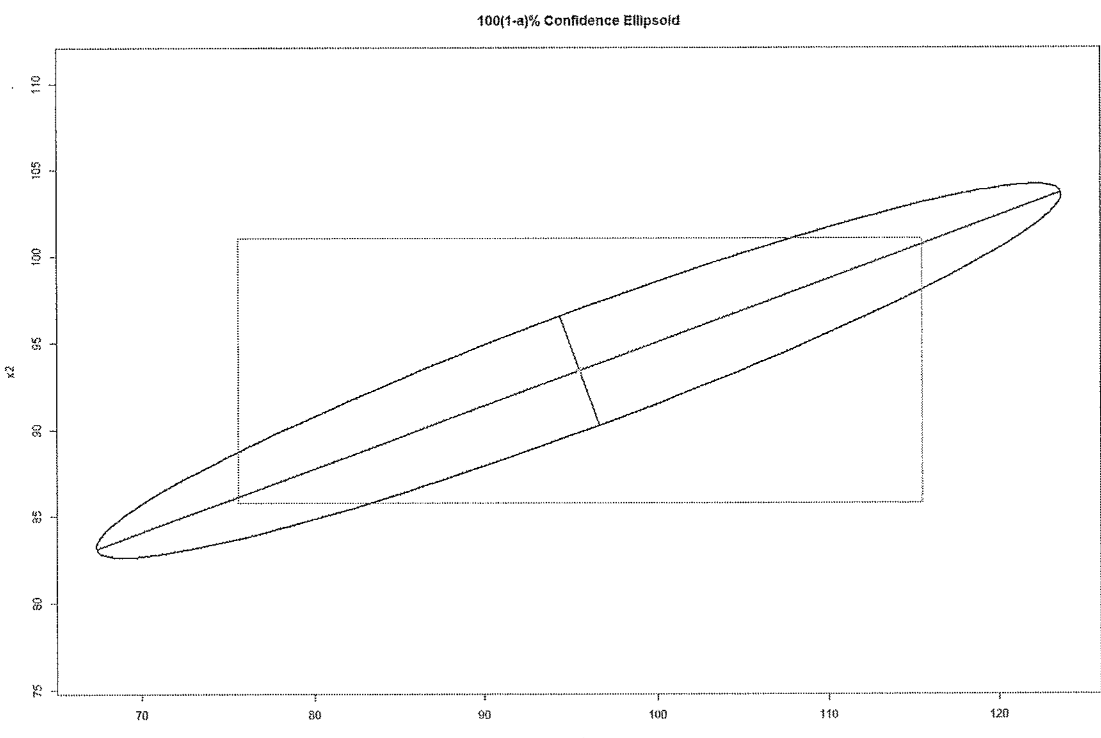
Problem 5.9

| xbar | | S | | | | | |
|---|---|---|---|---|---|---|---|
| 95.52 | | 3266.46 | 1343.97 | 731.54 | 1175.5 | 162.68 | 238.37 |
| 164.38 | | 1343.97 | 721.91 | 324.25 | 537.35 | 80.17 | 117.73 |
| 55.69 | | 731.54 | 324.25 | 179.28 | 281.17 | 39.15 | 56.8 |
| 93.39 | | 1175.5 | 537.35 | 281.17 | 474.98 | 63.73 | 94.85 |
| 17.98 | | 162.68 | 80.17 | 39.15 | 63.73 | 9.95 | 13.88 |
| 31.13 | | 238.37 | 117.73 | 56.8 | 94.85 | 13.88 | 21.26 |

a), c), e)

| Variable | Mean | S_ii | SimCIHW | SimLB | SimUB | BonCIHW | BonLB | Bon_UB |
|---|---|---|---|---|---|---|---|---|
| Wt | 95.52 | 3266.46 | 28.19901 | 67.32099 | 123.719 | 19.96669 | 75.55331 | 115.4867 |
| BodyLen | 164.38 | 721.91 | 13.25674 | 151.1233 | 177.6367 | 9.386612 | 154.9934 | 173.7666 |
| Neck | 55.69 | 179.28 | 6.606343 | 49.08366 | 62.29634 | 4.677709 | 51.01229 | 60.36771 |
| Girth | 93.39 | 474.98 | 10.75308 | 82.63692 | 104.1431 | 7.613862 | 85.77614 | 101.0039 |
| HeadLen | 17.98 | 9.95 | 1.556348 | 16.42365 | 19.53635 | 1.101993 | 16.87801 | 19.08199 |
| HeadWid | 31.13 | 21.26 | 2.274976 | 28.85502 | 33.40498 | 1.610827 | 29.51917 | 32.74083 |
| HW-HL | 13.15 | 3.45 | | | | 0.648899 | 12.5011 | 13.7989 |

b), d)



## 5.13

In general: $\# \text{parms} = \overbrace{p}^{\mu's} + \overbrace{p}^{\sigma_{ii}'s} + \overbrace{\frac{p(p-1)}{2}}^{\sigma_{ij}} = 3+3+3=9$

Under $H_0: \underset{\sim}{\mu} = \underset{\sim}{\mu_0}$ : $\# \text{parms} = 0 + p + \frac{p(p-1)}{2} = 3+3=6$

$$\Rightarrow -n \ln\left(\frac{|\hat{\Sigma}|}{|\hat{\Sigma}_0|}\right) \sim \chi^2_{6-3} = \chi^2_3$$

Note for $\alpha = .05$, $\chi^2_3(.05) = 7.815$

$$|\hat{\Sigma}| = 55617772148 \qquad |\hat{\Sigma}_0| = 84125606342$$

$$-n \ln\left(\frac{|\hat{\Sigma}|}{|\hat{\Sigma}_0|}\right) = -20 \ln(.661128) = 8.276$$

$\Rightarrow$ Reject $H_0$.

## 5.16

Bank Choice: Shorewood, B, C, D, Other

Multinomial w/ $q+1 = 5$ Categories $n = 355$

$$\hat{p} = \begin{bmatrix} \hat{p}_1 \\ \vdots \\ \hat{p}_5 \end{bmatrix} = \begin{bmatrix} .30 \\ .33 \\ .16 \\ .07 \\ .14 \end{bmatrix}$$

$$\hat{\Sigma} = \begin{bmatrix} .30(.70) = .210 & -.30(.33) = -.110 & -.048 & -.021 & -.042 \\ -.110 & .221 & -.053 & -.023 & -.046 \\ -.048 & -.053 & .134 & -.011 & -.022 \\ -.021 & -.023 & -.011 & .065 & -.010 \\ -.042 & -.046 & -.022 & -.010 & .120 \end{bmatrix}$$

## 5.1~~6~~ continued

Approx.

$(1-\alpha)100\%$ CI for $a'p$

a)

$$a'\hat{p} \pm \sqrt{\chi^2_q(\alpha)}\sqrt{\frac{a'\Sigma a}{n}} \qquad \chi^2_5(.05) = 11.0705$$

$a'p_1$: $.30 \pm \sqrt{11.0705\left(\frac{.210}{355}\right)} \equiv .30 \pm .081 \equiv (.219, .381)$

$a'p_2$: $.33 \pm \sqrt{11.0705\left(\frac{.221}{355}\right)} \equiv .33 \pm .083 \equiv (.247, .413)$

$a'p_3$: $.16 \pm \sqrt{11.0705\left(\frac{.134}{355}\right)} \equiv .16 \pm .065 \equiv (.095, .225)$

$a'p_4$: $.07 \pm \sqrt{11.0705\left(\frac{.065}{355}\right)} \equiv .07 \pm .045 \equiv (.025, .115)$

$a'p_5$: $.14 \pm \sqrt{11.0705\left(\frac{.120}{355}\right)} \equiv .14 \pm .061 \equiv (.079, .201)$

b) $\underset{\sim}{a}'p = p_1 - p_2 \qquad a'\Sigma a = .210 + .221 - 2(-.110) = .651$

$a'\hat{p} = .30 - .33 = -.03$

$\Rightarrow$ 95% CI: $-.03 \pm \sqrt{11.0705\left(\frac{.651}{355}\right)} \equiv -.03 \pm .142$

$\equiv (-.172, .112)$ Cannot conclude population proportions differ.

Problem 5.18

R Program

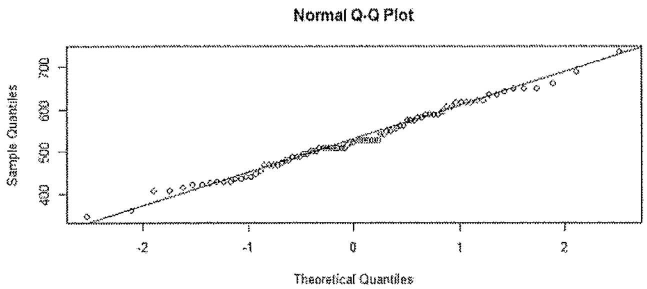
```
prob5.18 <- read.table("http://www.stat.ufl.edu/~winner/sta4702/data/wichern/T5-
2.DAT",
     header=F,col.names=c("social","verbal","science"))
attach(prob5.18)

n <- length(social)
X <- cbind(social, verbal, science)
p <- ncol(X)
one_n <- rep(1,n)
I_n <- diag(n)
J_n <- matrix(rep(1,n^2),ncol=n)

xbar <- (1/n) * t(X) %*% one_n
S <- (1/(n-1)) * (t(X) %*% (I_n - (1/n)*J_n) %*% X)

mu0 <- matrix(c(500,50,30),ncol=1)

(Tsquare <- n * (t(xbar-mu0) %*% solve(S) %*% (xbar-mu0)))
(crit.val <- (((n-1)*p)/(n-p))*qf(.95,p,n-p))

#### Part B

eigen_5.18 <- eigen(S)
lambda <- eigen_5.18$val
P.eigen <- eigen_5.18$vec

(center <- xbar)
(direction <- P.eigen)
(length <- 2*sqrt(lambda*((p*(n-1))/(n*n-p))*qf(.95,p,n-p)))

### Part C
par(mfrow=c(2,2))
qqnorm(social); qqline(social)
qqnorm(verbal); qqline(verbal)
qqnorm(science); qqline(science)

par(mfrow=c(2,2))
plot(social,verbal); plot(social,science); plot(verbal,science)
```

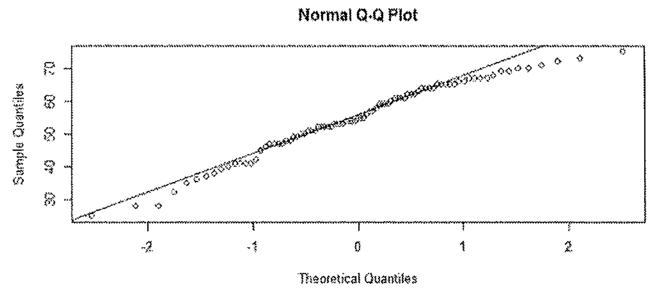
R Text Output

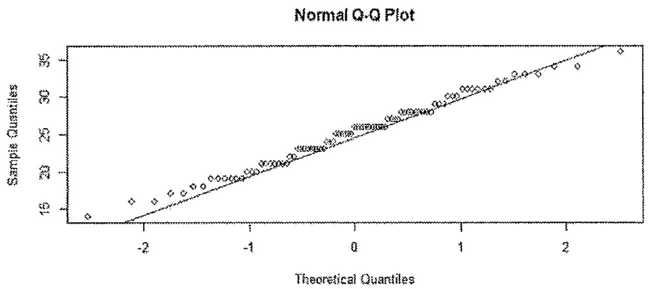
```
> (Tsquare <- n * (t(xbar-mu0) %*% solve(S) %*% (xbar-mu0)))
         [,1]
[1,] 223.3102
> (crit.val <- (((n-1)*p)/(n-p))*qf(.95,p,n-p))
[1] 8.333483

> (center <- xbar)
             [,1]
social  526.58621
verbal   54.68966
science  25.12644
> (direction <- P.eigen)
           [,1]         [,2]         [,3]
[1,] 0.99390539  0.103731534 -0.037307396
[2,] 0.10344339 -0.994589227 -0.009577815
[3,] 0.03809906 -0.005660238  0.999257936
> (length <- 2*sqrt(lambda*((p*(n-1))/(n*n-p))*qf(.95,p,n-p)))
[1] 46.643786  4.860484  2.324327
```

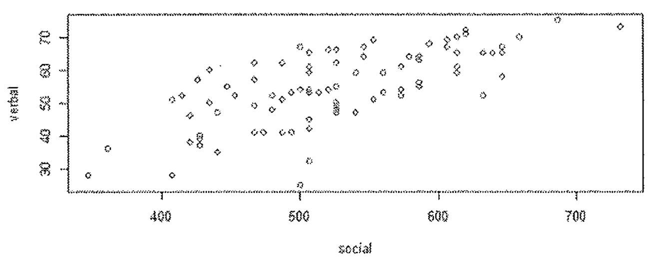
5.18

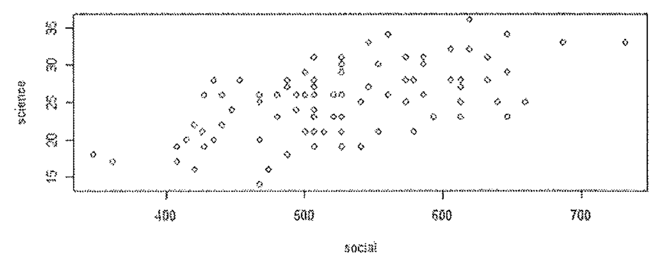
R Graphics Output

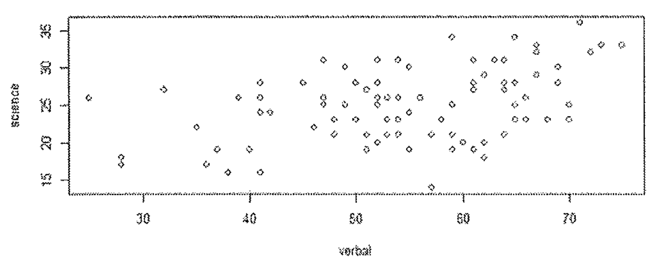


5.13

Problem 5.20

R Program

```
prob5.20 <- read.table("http://www.stat.ufl.edu/~winner/sta4702/data/wichern/T5-12.dat",
        header=F,col.names=c("tail","wing"))
attach(prob5.20)



#### Confidence Ellipse
x1 <- tail; x2 <- wing
n <- length(x1); p <- 2
alpha <- 0.05
crit.dist <- sqrt((p*(n-1)/(n*(n-p)))*qf(1-alpha,p,n-p))
A <- rbind(cbind(var(x1),cov(x1,x2)),cbind(cov(x1,x2),var(x2)))
mu.test <- c(190,275)

ctr <- c(mean(x1),mean(x2))
angles <- seq(0, 2*pi, length.out=200)


eigVal  <- eigen(A)$values
eigVec  <- eigen(A)$vectors
eigScl  <- eigVec %*% diag(sqrt(eigVal))  # scale eigenvectors to length = square-root
xMat    <- rbind(ctr[1] + eigScl[1, ]*crit.dist, ctr[1] - eigScl[1, ]*crit.dist)
yMat    <- rbind(ctr[2] + eigScl[2, ]*crit.dist, ctr[2] - eigScl[2, ]*crit.dist)
ellBase <- cbind(sqrt(eigVal[1])*crit.dist*cos(angles), sqrt(eigVal[2])*crit.dist*sin(angles))
# normal ellipse
ellRot  <- eigVec %*% t(ellBase)                                          # rotated ellipse

plot((ellRot+ctr)[1, ], (ellRot+ctr)[2, ], asp=1, type="l", lwd=2,
main="100(1-a)% Confidence Ellipsoid",
xlab="x1", ylab="x2")
matlines(xMat, yMat, lty=1, lwd=2, col="blue")
points(ctr[1], ctr[2], pch=4, col="orange", lwd=3)
points(mu.test[1],mu.test[2], pch=8, col="green")
bon11 <- ctr[1] - qt(1-alpha/(2*p),n-1)*sqrt(A[1,1]/n)
bon12 <- ctr[1] + qt(1-alpha/(2*p),n-1)*sqrt(A[1,1]/n)
bon21 <- ctr[2] - qt(1-alpha/(2*p),n-1)*sqrt(A[2,2]/n)
bon22 <- ctr[2] + qt(1-alpha/(2*p),n-1)*sqrt(A[2,2]/n)
rect(bon11,bon21,bon12,bon22,border="violetred3")

### Part B

T2_mu1_Lo <- mean(x1) - sqrt(((p*(n-1))/(n*(n-p)))*qf(.95,p,n-p)*var(x1))
T2_mu1_Hi <- mean(x1) + sqrt(((p*(n-1))/(n*(n-p)))*qf(.95,p,n-p)*var(x1))
T2_mu2_Lo <- mean(x2) - sqrt(((p*(n-1))/(n*(n-p)))*qf(.95,p,n-p)*var(x2))
T2_mu2_Hi <- mean(x2) + sqrt(((p*(n-1))/(n*(n-p)))*qf(.95,p,n-p)*var(x2))

Bon_mu1_Lo <- mean(x1) - qt(1-.025/2,n-1)*sqrt(var(x1)/n)
Bon_mu1_Hi <- mean(x1) + qt(1-.025/2,n-1)*sqrt(var(x1)/n)
Bon_mu2_Lo <- mean(x2) - qt(1-.025/2,n-1)*sqrt(var(x2)/n)
Bon_mu2_Hi <- mean(x2) + qt(1-.025/2,n-1)*sqrt(var(x2)/n)

cbind(T2_mu1_Lo, T2_mu1_Hi, Bon_mu1_Lo, Bon_mu1_Hi)
cbind(T2_mu2_Lo, T2_mu2_Hi, Bon_mu2_Lo, Bon_mu2_Hi)

### Part C
par(mfrow=c(2,2))
qqnorm(tail); qqline(tail)
qqnorm(wing); qqline(wing)
plot(tail,wing)
```

5.20

5.14

R Text Output

```
> cbind(T2_mu1_Lo, T2_mu1_Hi, Bon_mu1_Lo, Bon_mu1_Hi)
     T2_mu1_Lo T2_mu1_Hi Bon_mu1_Lo Bon_mu1_Hi
[1,]  189.4217  197.8227   189.8216   197.4229
> cbind(T2_mu2_Lo, T2_mu2_Hi, Bon_mu2_Lo, Bon_mu2_Hi)
     T2_mu2_Lo T2_mu2_Hi Bon_mu2_Lo Bon_mu2_Hi
[1,]  274.2564  285.2992   274.7819   284.7736
```

R Graphics Output