R Textbook Companion for Schaum's Outline Series - Theory and Problems of Statistics by Murray R. Spiegel[1]

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Book Description

Title: Schaum's Outline Series - Theory and Problems of Statistics

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R numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means an R code whose theory is explained in Section 2.3 of the book.

Contents

List of R Codes

Chapter 1

Variables And Graphs

R code Exa 1.1.3 rounding off the numbers

```
#page=8
a<-round(48.6,digits=0)
a
b<-round(136.5,digits=0)
b
c<-round(2.484,digits=2)
c
d<-round(0.0435,digits=3)
d
e<-round(4.50001,digits=0)
e
f<-round(143.95,digits=0)
f
g<-round(368,digits=-2)
g
h<-round(24448,digits=-3)
h
library(plyr)
i<-round_any(5.56500,5.56,f=floor)
i
j<-round(5.56501,digits=2)
```

```
j
```

R code Exa 1.1.4 Adding the numbers

```
#page=8
x<-c(4.35,8.65,2.95,12.45,6.65,7.55,9.75)
sum(x)
len=length(x)
s1=0
s2=0
library(plyr)
len=length(x)
for ( i in 1:len)
{
  if (i%%2!=0)
  {
    a=round_any(x[i], 0.1, ceiling)
    s1=s1+a
  }
  else
 {
    b=round_any(x[i], 0.1,floor)
    s2=s2+b
}
}
s3=s1+s2
s3

s4=0
for( i in 1:len)
{
  c=round_any(x[i], 0.1, ceiling)
  s4=s4+c
}
s4
```

R code Exa 1.1.5 Without using powers of 10

```r
#PAGE=9
a=4.823*10^7
cat(a)
b=8.4*10^(-6)
ran2 <- c(b)
options("scipen"=100)
cat(ran2)
c=3.8*10^(-4)
cat(c)
d=1.86*10^5
cat(d)
e=300*10^8
cat(e)
f=70000*10^(-10)
cat(f)
```

R code Exa 1.1.6 Significant figures

```r
#PAGE=9
sigfigs <- function(x){
  orig_scipen <- getOption("scipen")
  options(scipen = 999)
  on.exit(options(scipen = orig_scipen))

  x <- as.character(x)
  x <- sub("\\.", "", x)
  x <- gsub("(^0+|0+$)", "", x)
  nchar(x)
}
```

```
a <- 149.8
sigfigs(a)

b<-149.80
sigfigs(b)+1

c<-0.0028
sigfigs(c)

d1=1
d=0.00280
sigfigs(d)+d1

e1=1
e=1.00280
sigfigs(e)+e1

f=9
sigfigs(f)

g<-1/0
g

h1=1
h=4*10^3
sigfigs(h)+h1

i1=2
i=7.58400*10^(-5)
sigfigs(i)+i1
#"The answer may vary due to difference in
    representation."
```

R code Exa 1.1.7 Maximum Error

```r
#PAGE=9
sigfigs <- function(x){
  orig_scipen <- getOption("scipen")
  options(scipen = 999)
  on.exit(options(scipen = orig_scipen))

  x <- as.character(x)
  x <- sub("\\.", "", x)
  x <- gsub("(^0+|0+$)", "", x)
  nchar(x)
}
a=73.854
a1=a+0.0005
a2=a-0.0005
a1
a2
cat(sigfigs(a2)-1)

b=0.09800
b1=b-0.000005
b2=b+0.000005
cat(sigfigs(b2)-1)

c=3.867*10^8
c1=c-0.0005*10^8
c2=c+0.0005*10^8
cat(sigfigs(c2)-1)
```

R code Exa 1.1.8 Scientific Notation

```r
#page=9
a<-24380000
b<-0.000009851
c<-7300000000
d<-0.00018400
```

```
formatC(a,format='e',digits=3)
formatC(b,format='e',digits=3)
formatC(c,format='e',digits=4)
formatC(d,format='e',digits=4)
```

R code Exa 1.1.9 Product of numbers

```
#PAGE=9

sigdigs<-function(a) {
  d<-0
  while(signif(a,digits=d) != a) {
    d<-d+1
    next
  }
  return(d)
}
cat(5.74*3.8)
a=sigdigs(5.74)
b=sigdigs(3.8)
a1=5.74-5/10^a
a2=5.74+5/10^a

b1=3.8-5/10^b
b2=3.8+5/10^b

cat(a1*b1)
cat(a2*b2)
```

R code Exa 1.1.10 Addition

```
#page=10
a<-c(4.19355,15.28,5.9561,12.3,8.472)
```

```
sum(a)
x=round(a,digits=2)
a=sum(x)
```

R code Exa 1.1.11 Scientific Figures

```
#page=10
a<-475000000
b<-12684000
c<-1372410
d<-a+b-c
d
e=round(a,digits=-5)
e
f=round(b,digits=-5)
f
g=round(c,digits=-5)
g
h<-e+f-g
h
```

R code Exa 1.1.12 Performing indicated operations

```
#PAGE=11
A<-48.0*943
round(A,digits=-2)
b<-8.35/98
round(b,digits=3)
c<-28*4193*182
formatC(c,format='e',digits=1)
d<-(526.7*0.001280)/0.000034921
formatC(d,format='e',digits=3)
e<-((1.47562-1.47322)*4895.36)/0.000159180
```

```r
formatC(e,format='e',digits=2)
f<-(4.38**2)/5+(5.482**2)/6
round(f,digits=2)
g<-3.1416*sqrt(71.35)
round(g,digits=2)
h<-sqrt(128.5-89.24)
round(h,digits=2)
```

R code Exa 1.1.13 Evaluating

```r
#page=11
x<-3
y<--5
a<-4
b<--7
z<-2*x-3*y
z
z<-4*y-8*x+28
z
z<-(a*x+b*y)/(b*x-a*y)
z
z<-x**2-3*x*y-2*y**2
z
z<-2*(x+3*y)-4*(3*x-2*y)
z
z<-(x**2-y**2)/(a**2-b**2+1)
z
z<-sqrt(2*x*x-y*y-3*a*a+4*b*b+3)
z
z<-sqrt(6*a*a/x+2*b*b/y)
z
round(z,digits=2)
```

R code Exa 1.1.15 tonnes of potatoes and straw

```
#PAGE=13
y=c(1975:1985)
a=c(200,185,225,250,240,195,210,225,250,230,235)
b=c(75,90,100,85,80,100,110,105,95,110,100)

a1=which(y==1981)
a2=a[a1]
a2

b1=which(y==1978)
b1=b[b1]
b1
b2=which(y==1984)
b2=b[b2]
b2

c1=which(a==225)
c1=y[c1]
c1

d1=which(y==1979)
d1=a[d1]
d1

e1=which(y==1983)
e1=b[e1]
e1

f1=which(a==210)
f1=b[f1]
f1

g1=y
g1
```

R code Exa 1.1.16 Determining the variables

```
#PAGE=13
x=c(3,-2,1.5)
y1=2*x-3
cat(y1)

x=c(-2,-1,0,1,2,3,4)
y2=2*x-3
y3 <- matrix(c(x,y2),ncol=7,byrow=TRUE)
colnames(y3) <- c(" "," "," "," "," "," "," ")
rownames(y3) <- c("X","Y")
y3 <- as.table(y3)
y3

x=2.4
cat(2*x-3)
x=0.8
cat(2*x-3)

y=15
cat((y+3)/2)
```

R code Exa 1.1.17 Finding corresponding z value

```
#PAGE=14
X<-2
Y<-5
Z=16+4*X-3*Y
Z
X<--3
Y<--7
```

```
Z=16+4*X-3*Y
Z
X<--4
Y<-2
Z=16+4*X-3*Y
Z
```

R code Exa 1.1.18 Locate values on X axis

```
#PAGE=14
x=c(4,-3,2.5,-4.3,0.4)
y=c(0,0,0,0,0)
plot(x,y,xaxt="n")
axis(1, at = seq(-5, 5, by = 1), las=2)
```

R code Exa 1.1.19 Ball bearing in millimeters

```
#PAGE=14
x=4.58
x1=x-0.005
x2=x+0.005
x=c(x1,x2)
y=c(0,0)
plot(x,y,type='l',xlim=c(4.54,4.59))
```

R code Exa 1.1.20 Rectangular coordinate

```
#PAGE=15
x=c(5,2,-3,1,3,-2.5,0,4)
y=c(2,5,1,-3,-4,-4.8,-2.5,0)
```

```
plot(x, y, xlim=c(-6, 6), ylim=c(-6, 6))
abline(h=0)
abline(v=0)
```

R code Exa 1.1.21 Graph the equation

```
#PAGE=15
x=c(-3,-2,-1,0,1,2,3,4)
y=2*x-3
plot(x, y,type='b', xlim=c(-6, 6), ylim=c(-6, 6))
abline(h=0)
abline(v=0)
```

R code Exa 1.1.22 Graph the equation

```
#PAGE=16
x=c(-3,-2,-1,0,1,2,3,4,5)
y=x^2-2*x-8
plot(x, y,type='b', xlim=c(-9, 9), ylim=c(-9, 9))
abline(h=0)
abline(v=0)
```

R code Exa 1.1.23 US population graph

```
#PAGE=16
y=c
   (1860,1870,1880,1890,1900,1910,1920,1930,1940,1950,1960,1970,1980
p=c
   (31.4,39.8,50.2,62.9,76,92,105.7,122.8,131.7,151.1,179.3,203.3,22
```

```
plot(y,p,type='b',xlab='Year',ylab='Population of
    the U.S.(millions)')
```

R code Exa 1.1.24 bar graph and line graph

```
#PAGE=17
a=c(1975:1985)
b=c(200,185,225,250,240,195,210,225,250,230,235)
c=c(75,90,100,85,80,100,110,105,95,110,100)

plot(a, ylim=range( b, c), col='black',xlab = 'Year'
    ,ylab='Number of Tonnes')
lines(b,type = 'b')
lines(c,type='b')

v=c(c,b)

library(ggplot2)

df2 <- data.frame(supp=rep(c("Potatoes", "Straw"),
    each=11),Year=a,Number_of_Tonnes=v)
df2

ggplot(data=df2, aes(x=Year, y=Number_of_Tonnes,
    fill=supp)) +
  geom_bar(stat="identity")
ggplot(data=df2, aes(x=Year, y=Number_of_Tonnes,
    fill=supp)) +
  geom_bar(stat="identity", position=position_dodge
      ())
```

R code Exa 1.1.25 Potatoes and straw

```r
#PAGE=18
a=c(1975:1985)
b=c(200,185,225,250,240,195,210,225,250,230,235)
c=c(75,90,100,85,80,100,110,105,95,110,100)

s1=b+c
a1=b/s1
a1=a1*100
a1=round(a1,1)
a2=100-a1

y1 <- matrix(c(a,a1,a2),ncol=11,byrow=TRUE)
colnames(y1) <- c(" "," "," "," "," "," "," "," "," "," "," ")
rownames(y1) <- c("Year","Percentage potatoes","Percentage straw")
y1 <- as.table(y1)
y1
```

R code Exa 1.1.26 Line graph

```r
#PAGE=18
a=c(1975:1985)
b=c(200,185,225,250,240,195,210,225,250,230,235)
c=c(75,90,100,85,80,100,110,105,95,110,100)

plot(a,b,type = 'b',ylim=range(0,250),xlab = 'Year',ylab='Number of Tonnes')
```

R code Exa 1.1.27 Continents and area

```r
#page 21
```

```
continent<-c('Africa','Asia','Europe','North America','Oceanic','South America','U.S.S.R')

area<-c(30.3,26.9,4.9,24.3,8.5,17.9,20.5)

barplot(area,ylab="continent",xlab="Area ",names.arg=c("AFRICA","ASIA","EUROPE","N.A","OCEANIC","S.A","U.S.S.R"),horiz =TRUE)

pie(area,label=as.character(continent),border="black",clockwise=TRUE)
```

R code Exa 1.1.28 Simple pendulum

```
#PAGE=22
L=c(101,162,222,338,420,534,667,745,866,1000)
T=c(0.64,0.81,0.95,1.17,1.30,1.47,1.65,1.74,1.87,2.01)
plot(L,T,type='b',xlim=c(100,1000),ylim=c(0.1,2.0))

b=(0.81-0.64)/(162-101)*400+0.15
b=round(b,2)
cat(b,'seconds')
```

R code Exa 1.1.29 Solving equations

```
#PAGE=23
a=solve(4,28)
cat(a)

b=solve(5,24-4)
cat(b)
```

```

c=solve(-8,16)
cat(c)

d=solve(1,10)
cat(d)
```

R code Exa 1.1.30 Solving simultaneous equations

```
#PAGE=23
A <- matrix(data=c(3, -2, 5, 7), nrow=2, ncol=2,
    byrow=TRUE)
b <- matrix(data=c(11, 39), nrow=2, ncol=1, byrow=
    FALSE)
round(solve(A, b), 2)

A <- matrix(data=c( 5, 14,7,3), nrow=2, ncol=2,
    byrow=TRUE)
b <- matrix(data=c(78, -7), nrow=2, ncol=1, byrow=
    FALSE)
round(solve(A, b), 2)

A <- matrix(data=c(3,2,5,7,-3,2,5,1,-4), nrow=3,
    ncol=3, byrow=TRUE)
b <- matrix(data=c(15,52,2), nrow=3, ncol=1, byrow=
    FALSE)
round(solve(A, b), 3)
```

R code Exa 1.1.33 Rearranging the numbers

```
#PAGE=24
x=c(3.42,-0.6,-2.1,1.45,-3)
a=sort(x)
```

```
a
b=sort(x,decreasing = TRUE)
b
#"The answer may vary due to difference in
   representation."
```

R code Exa 1.1.34 Corresponding Inequality

```
#PAGE=25
a1=2
a2=6
a3=a2/a1
cat('X <',a3)

b1=3
b2=-8
b3=4
b4=(b3-b2)/b1
cat('X >=', b4)

c1=6
c2=-4
c3=-2
c4=(c1-c3)/(-c2)
cat('X >', c4)

d1=-3
d2=3
d3=2
d4=5
d5=(d1*d3)+d4
d6=(d2*d3)+d4
cat(d5,'< X <',d6)

e1=-1
```

```
e2=7
e3=5
e4=3
e5=2
e6=(((e1*e3)-e4)/e5)*(-1)
e7=(((e2*e3)-e4)/e5)*(-1)
cat(e7,'<= X <=',e6)
```

R code Exa 1.1.35 Common logarithm

```
#PAGE=25
y=c(57,57.4,5.63,35.63,982.5,7824,186000,0.71,0.7314,0.0325,0.0071,0
a=log(y,base=10)
c=floor(a)
c[8]=c[8]+10
c[9]=c[9]+10
c[10]=c[10]+10
c[11]=c[11]+10
c[12]=c[12]+10
cat(c[1],c[2],c[3],c[4],c[5],c[6],c[7],c[8],'- 10',c[9],'- 10',c[10],'- 10',c[11],'- 10',c[12],'- 10')
```

R code Exa 1.1.36 Logarithms

```
#PAGE=25
a=87.2
a=log(a,base=10)
a=round(a,digits = 4)
a

```

```
b=37300
b=log(b,base=10)
b=round(b,digits = 4)
b

c=753
c=log(c,base=10)
c=round(c,digits = 4)
c

d=9.21
d=log(d,base=10)
d=round(d,digits = 4)
d

e=54.5
e=log(e,base=10)
e=round(e,digits = 4)
e

f=0.382
f=log(f,base=10)
f=round(f,digits = 4)
f=10+f
cat(f,'-10')

g=0.00159
g=log(g,base=10)
g=round(g,digits = 4)
g=10+g
cat(g,'-10')

h=0.0753
h=log(h,base=10)
h=round(h,digits = 4)
h=10+h
cat(h,'-10')
```

```r
i=0.000827
i=log(i,base=10)
i=round(i,digits = 4)
i=10+i
cat(i,'-10')

j=0.0503
j=log(j,base=10)
j=round(j,digits = 4)
j=10+j
cat(j,'-10')

k=4.638
k=log(k,base=10)
k=round(k,digits = 4)
k

l=6.753
l=log(l,base=10)
l=round(l,digits = 4)
l

m=183.2
m=log(m,base=10)
m=round(m,digits = 4)
m

n=43.15
n=log(n,base=10)
n=round(n,digits = 4)
n

o=876400
o=log(o,base=10)
o=round(o,digits = 4)
o

p=0.2548
```

```
p=log(p,base=10)
p=round(p,digits = 4)
p=10+p
cat(p,'-10')

q=0.04372
q=log(q,base=10)
q=round(q,digits = 4)
q=10+q
cat(q,'-10')

r=0.009848
r=log(r,base=10)
r=round(r,digits = 4)
r=10+r
cat(r,'-10')

s=0.0001788
s=log(s,base=10)
s=round(s,digits = 4)
s=10+s
cat(s,'-10')
```

R code Exa 1.1.37 Antilogarithms

```
#PAGE=26
c2=9.9058
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
c5=c5*10^2
cat(c5)

c2=7.8531
```

```
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,6)
c5
c5=c5*10^6
cat(c5)

c2=8.1875
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
c5=c5*10^4
cat(c5)



c2=10.4997
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,2)
cat(c5)

c2=6.9360
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,6)
c5=c5*10^8
cat(c5)


c2=7.8657
c3=10
c5=c2-c3
c5=(10**c5)
```

```
c5=round(c5,5)
cat(c5)


c2=9.8267
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
cat(c5)

c2=8.3927
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
cat(c5)

c2=9.3842
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
cat(c5)

c2=8.6715
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,6)
c5=c5*100^2
cat(c5)


c2=6.1853
c3=10
c5=c2-c3
c5=(10**c5)
```

```
c5=round(c5,10)
c5=c5*100^4
c5=round(c5,2)
cat(c5)

c2=10.9245
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,3)
cat(c5)

c2=9.6089
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
cat(c5)

c2=8.8907
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,6)
cat(c5)

c2=9.2000
c3=10
c5=c2-c3
c5=(10**c5)
c5=round(c5,4)
c5=c5*100
cat(c5)


#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 1.1.38 Calculating logarithms

```
#PAGE=27
a=3.81
b=43.4
a=log(a,base=10)
b=log(b,base=10)
c=b+a
c=round(c,digits = 4)
c=10**c
c=round(c,digits = 1)
c
```

R code Exa 1.1.39 Calculating logarithms

```
#PAGE=27
a=73.42
b=0.004620
d=0.5143
a=log(a,base=10)
b=log(b,base=10)
b=10+b
d=log(d,base=10)
d=10+d
c=b+a+d
e=10*2
c=round(c,digits = 4)
c=10**c
c=round(c,digits = 1)
c2=10**e
c1=c/c2
c1=round(c1,digits = 4)
```

```
c1
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 1.1.40 Calculating logarithms

```
#PAGE=27
a=784.6
b=0.0431
c=28.23
a=log(a,base=10)
b=log(b,base=10)
b=10+b
c=log(c,base=10)
d=a+b-c
f=10
p=d-f
p=round(p,digits = 4)
p=10**p
p=round(p,digits = 3)
p
```

R code Exa 1.1.41 Calculating logarithms

```
#PAGE=28
a=5.395
b=8
c=log(a,base=10)
c=c*b
c=round(c,digits = 3)
c=10**c
c=round(c,digits = -2)
c
```

R code Exa 1.1.42 Calculating logarithms

```
#PAGE=28
a=387.2
b=log(a,base=10)
b=b/2
b=round(b,digits = 3)
b
c=10**b
c=round(c,digits = 2)
c
```

R code Exa 1.1.43 Calculating logarithms

```
#PAGE=28
a=0.08317
n=5
a1=log(a,base=10)
a1=10+a1
a1=round(a1,digits = 2)
a1=a1+40
a1=a1/n
a1
c=10**a1
c
d=-10
c1=10**d
c2=c*c1
c2=round(c2,digits = 4)
c2
```

R code Exa 1.1.44 Calculating logarithms

```
#PAGE=28
a=0.003654
b=18.37
c=8.724
d=743.8

a1=log(a,base=10)
a1=10+a1
a1=a1+10
a1=round(a1,digits = 4)
a1=a1/2

b1=log(b,base=10)
b1=3*b1
b1=round(b1,digits = 4)

e=a1+b1

c1=log(c,base=10)
c1=4*c1
c1=round(c1,digits = 4)

d1=log(d,base=10)
d1=d1/4

f=c1+d1

g=e-f

p=10**g
q=-10
q=10**q
```

```
p1=p*q
p1=round(p1,digits = 5)
p1
```

R code Exa 1.1.45 Calculating logarithms

```
#PAGE=28
a=874.3
b=0.03816
c=28.53
d=1.754
e=0.007352
a=log(a,base=10)
b=log(b,base=10)
b=10+b
c=log(c,base=10)
c=c*3
f=a+b+c
d=log(d,base=10)
d=d*4
e=log(e,base=10)
e=10+e
g=d+e
p=f-g
p=p/2
p=round(p,digits = 4)
p1=10**p
p1=round(p1,digits = 0)
p1
#"The answer may slightly vary due to rounding off
  values."
```

R code Exa 1.3 Scientific notation

```
#PAGE=2
 a=10
 b=1
 c=2
 d=5
 e=8

 print(a**b)
 print(a**c)
 print(a**d)
 print(a**e)
```

R code Exa 1.4 Scientific notation

```
#PAGE=2

a=10
b=-1
c=-2
d=-5
e=0

print(a**e)
print(a**b)
print(a**c)
print(a**d)
```

R code Exa 1.5 Scientific notation

```
#PAGE=2

a=864000000
formatC(a,format="e")
```

```
b=0.00003416
formatC(b,format="e")
```

R code Exa 1.6 Scientific notation

```
#PAGE=2
a=10**3
b=10**2
c=a*b
formatC(c,format="e")

a=10**6
b=10**4
c=a/b
formatC(c,format="e")
```

R code Exa 1.7 Scientific notation

```
#PAGE=2
a=4000000
b=0.0000000002
c=a*b
formatC(c,format="e")
```

R code Exa 1.8 Scientific notation

```
#PAGE=3
a=((0.006)*(80000))/(0.04)
print(a)
```

R code Exa 1.9 Significant figures

```
#PAGE=3

sigdigs<-function(a) {
  d<-0
  while(signif(a,digits=d) != a) {
    d<-d+1
    next
  }
  return(d)
}
sigdigs(1.67)
```

R code Exa 1.10 Significant figures

```
#PAGE=3
x=4.5300
x_new2 <- paste0(round(x, 4), "00")
x_new2
a=nchar(x_new2)

matched_commas <- gregexpr(".",x_new2 , fixed = TRUE
   )
n_commas <- length(matched_commas[[1]])
n_commas

ans=a-n_commas
cat(ans)
```

R code Exa 1.11 Significant figures

```
#PAGE=3

sigdigs<-function(a) {
  d<-0
  while(signif(a,digits=d) != a) {
    d<-d+1
    next
  }
  return(d)
}
sigdigs(0.0018)
```

R code Exa 1.12 Significant figures

```
#PAGE=3

sigdigs<-function(a) {
  d<-0
  while(signif(a,digits=d) != a) {
    d<-d+1
    next
  }
  return(d)
}
a=sigdigs(0.001800)*2
cat(a)
```

R code Exa 1.13 Computation

```
#PAGE=3
a=73.24
```

```
b=4.52
c=a*b
round(c,0)
```

R code Exa 1.14 Computation

```
#PAGE=3
a=1.648
b=0.023
c=a/b
round(c,0)
```

R code Exa 1.15 Computation

```
#PAGE=3
a=38.7
b=sqrt(a)
round(b,2)
```

R code Exa 1.16 Computation

```
#PAGE=3
a=8.416
b=50
c=a*b
print(c)
```

R code Exa 1.17 Computation

```
#PAGE=3
a=3.16
b=2.7
c=a+b
round(c,1)
```

R code Exa 1.18 Computation

```
#PAGE=3
a=83.42
b=72
c=a-b
ans=round(c,0)
cat(ans)
```

R code Exa 1.19 Computation

```
#PAGE=3
a=47.816
b=25
c=a-b
print(c)
```

R code Exa 1.22 Solution to equation

```
#PAGE=5
a=9
b=3
```

```
c=2
d=a-b
solve(c,d)
```

R code Exa 1.31 Logarithm

```
#PAGE=6
a=2.36
b=log10(a)
round(b,4)
```

R code Exa 1.32 Logarithm

```
#PAGE=6
a=2.36
b=a*10
c=b*10
d=c*10

a=log10(a)
round(a,4)
b=log10(b)
round(b,4)
c=log10(c)
round(c,4)
d=log10(d)
round(d,4)
```

R code Exa 1.33 Logarithm

```
#PAGE=6
a=2.36
b=a/10
c=b/10

a=log10(a)
round(a,4)
b=log10(b)
round(b,4)
c=log10(c)
round(c,4)
```

R code Exa 1.34 Logarithm

```
#PAGE=6
x=c(2360,236,23.6,2.36)
y=log10(x)
round(y,4)
```

R code Exa 1.35 Logarithm

```
#PAGE=7
log(0.236)
log(0.0236)
log(0.00236)
a=log10(0.236)
a=round(a,0)
a
b=log10(0.0236)
b=round(b,0)
b
c=log10(0.00236)
c=round(c,0)
```

```
c

c2=9.3729
c3=10
c5=c2-c3
c5=(10**c5)
round(c5,4)

c2=8.3729
c3=10
c5=c2-c3
c5=(10**c5)
round(c5,4)

c2=7.3729
c3=10
c5=c2-c3
c5=(10**c5)
round(c5,5)
```

R code Exa 1.36 Antilogarithms

```
#PAGE=7
c2=8.6284
c3=10
c5=c2-c3
c5=(10**c5)
round(c5,4)

c6=3.6284
c6=10**c6
c6=round(c6,0)
cat(c6)

c7=5.6284
```

```
c7=10**c7
c7=round(c7,-2)
cat(c7)
```

Chapter 2

Frequency Distributions

R code Exa 2.2.1 arrange the numbers

```
#PAGE=41
c=c(17,45,38,27,6,48,11,57,34,22)
a=sort(c)
a
b=sort(c, decreasing = TRUE)
b

r=max(c)-min(c)
r
```

R code Exa 2.2.2 Final grades

```
#PAGE=41
n=c(68,84,75,82,68,90,62,88,76,93,
    73,79,88,73,60,93,71,59,85,75,
    61,65,75,87,74,62,95,78,63,72,
    66,78,82,75,94,77,69,74,68,60,
    96,78,89,61,75,95,60,79,83,71,
```

```
    79,62,67,97,78,85,76,65,71,75,
    65,80,73,57,88,78,62,76,53,74,
    86,67,73,81,72,63,76,75,85,77)
a=max(n)
a
b=min(n)
b
c=a-b
c
d= head(sort(n,decreasing = TRUE),5)
d
e=head(sort(n),5)
e
f=(sort(n,TRUE)[10])
f
g=length(n[n >= 75])
g
h=length(n[n < 85])
h
i1=length(n[n > 65 & n<=85])
i=i1/length(n)
i=i*100
i=round(i,1)
i
j1=0:100
j=setdiff(j1,n)
j
```

R code Exa 2.2.3 Frequency distribution

```
#PAGE=42
a=c(250,260,270,280,290,300,310)
b=c
  (259.99,269.99,279.99,289.99,299.99,309.99,319.99)
```

```
n=c(8,10,16,14,10,5,2)
n1=sum(n)

a1=a[6]
cat('$',a1)

b1=b[4]
cat('$',b1)

c1=(a[3]+b[3])/2
c1=round(c1,digits = 0)
cat('$',c1)

d1=(a[5]+b[4])/2
cat('$',d1)
d2=(a[6]+b[5])/2
cat('$',d2)

e1=b[5]-b[4]
cat('$',e1)

s=which(a==270)
f=n[s]
f

g=f/n1
g=g*100
g=round(g,digits = 1)
cat(g,'%')

h=which.max(n)
h1=a[h]
h2=b[h]
cat('$',h1,'- $',h2)

n2=n[1]+n[2]+n[3]
i=n2/n1
i=i*100
```

```
i=round(i,digits = 1)
cat(i,'%')

j1=which(a==290)
j2=which(a==260)
j=0
for(i in j2:j1)
{
  j=j+n[i]
}
j=j/n1
j=j*100
j=round(j,digits = 1)
cat(j,'%')
```

R code Exa 2.2.4 Frequency distribution

```
#PAGE=43
x=c(128,137,146,155,164,173,182)
a=x[2]-x[1]
cat(a,'s')

a1=(x[1]+x[2])/2
a2=(x[2]+x[3])/2
a3=(x[3]+x[4])/2
a4=(x[4]+x[5])/2
a5=(x[5]+x[6])/2
a6=(x[6]+x[7])/2
a0=a1-a
a7=a6+a
b=c(a0,a1,a2,a3,a4,a5,a6,a7)
cat(b,'s')

b1=b-0.5
b2=b+0.5
```

```
cat(b2[1],'-',b1[2])
cat(b2[2],'-',b1[3])
cat(b2[3],'-',b1[4])
cat(b2[4],'-',b1[5])
cat(b2[5],'-',b1[6])
cat(b2[6],'-',b1[7])
cat(b2[7],'-',b1[8])
```

R code Exa 2.2.5 Graphical Representation

```
#PAGE=44
set.seed(0815)
x=c(128,137,146,155,164,173,182)
a=x[2]-x[1]

a1=(x[1]+x[2])/2
a2=(x[2]+x[3])/2
a3=(x[3]+x[4])/2
a4=(x[4]+x[5])/2
a5=(x[5]+x[6])/2
a6=(x[6]+x[7])/2
a0=a1-a
a7=a6+a
b=c(a0,a1,a2,a3,a4,a5,a6,a7)
b
b1=b-0.5
b2=b+0.5
b1
b2
df <- data.frame(x =b,
                 F =runif(b),
                 L =runif(b1),
                 U =runif(b2))
df
x11()
```

```r
require(ggplot2)
ggplot(df, aes(x = x, y = F)) +
  geom_point(size = 4) +
  geom_errorbar(aes(ymax = 0.75, ymin = 0.25))
#The answer may vary due to difference in
    representation.
```

R code Exa 2.2.6 150 measurements

```r
#PAGE=44
n=150
s=51.8
l=74.4
r=l-s
r1=r/5
r2=r/20
r1=round(r1,1)
r2=round(r2,1)
a=seq.int(r2+1,r1)
a=round(a,0)
a1=a-0.1
a11=seq.int(51,74,by=a[1])
a12=a11+a1[1]
n1=length(a11)
for (i in 1:n1){
  cat(a11[i],'-',a12[i])
  cat("\n")
}

b11=seq.int(51,74,by=a[2])
b12=b11+a1[2]
b12
n1=length(b11)
for (i in 1:n1){
  cat(b11[i],'-',b12[i])
```

```
  cat("\n")
}

c11=seq.int(51,74,by=a[3])
c12=c11+a1[3]
n1=length(c11)
for (i in 1:n1){
  cat(c11[i],'-',c12[i])
  cat("\n")
}

a21=a11-0.05
a22=a12+0.05
n1=length(a21)
for (i in 1:n1){
  cat(a21[i],'-',a22[i])
  cat("\n")
}

b21=b11-0.05
b22=b12+0.05
n1=length(b21)
for (i in 1:n1){
  cat(b21[i],'-',b22[i])
  cat("\n")
}

c21=c11-0.05
c22=c12+0.05
n1=length(c21)
for (i in 1:n1){
  cat(c21[i],'-',c22[i])
  cat("\n")
}

aa=(a11+a12)/2
cat(aa)
bb=(b11+b12)/2
```

```
cat(bb)
cc=(c11+c12)/2
cat(cc)
```

R code Exa 2.2.8 Frequency distribution

```
#PAGE=45
c<-c(138,164,150,132,144,125,149,157,
     146,158,140,147,136,148,152,144,
     168,126,138,176,163,119,154,165,
     146,173,142,147,135,153,140,135,
     161,145,135,142,150,156,145,128)
c

b1=seq(117,182,by=5)
table2.7=cut(c,b1)
Frequency=table(table2.7)
a1=cbind(Frequency)
a1

b1=seq(117,182,by=9)
table2.7=cut(c,b1)
Frequency=table(table2.7)
a1=cbind(Frequency)
a1
```

R code Exa 2.2.9 histogram and frequency polygon

```
#PAGE=46
c<-c(138,164,150,132,144,125,149,157,
     146,158,140,147,136,148,152,144,
     168,126,138,176,163,119,154,165,
     146,173,142,147,135,153,140,135,
```

```
    161,145,135,142,150,156,145,128)
b1=seq(118,182,by=8)
table2.7=cut(c,b1)
a=table(table2.7)
a1=cbind(a)
a1
l=length(a1)
f=a1[0:l]
f=c(f,0)
hist(c, breaks=8,xlab = 'Time(seconds)',ylab='Frequency')
plot(b1,f,type='l',xlim=c(110,180),ylim=c(0,12),xlab='Time(seconds)',ylab='Frequency')
#"The answer may vary due to difference in representation."
```

R code Exa 2.2.10 relative frequency

```
#PAGE=46
a=c(250,260,270,280,290,300,310)
b=c(259.99,269.99,279.99,289.99,299.99,309.99,319.99)
c=c(a,b)
n=c(8,10,16,14,10,5,2)
n1=sum(n)
n1
n2=(n/n1)*100
n2=round(n2,digits = 1)
n2

n3=(b+a)/2
n3=n3-200
n3=round(n3,digits = 0)
n4=rep(n3,n)
```

```
h=hist(n4,xlab='Wages')
h

mp=c(min(h$mids) - (h$mids[2] - h$mids[1]), h$mids, max(h$mids) + (h$mids[2] -h$mids[1]))
mp
freq = c(0, h$counts, 0)
freq
lines(mp, freq, type = "b", pch = 20, col = "red", lwd = 3)


n4=rep(n3,n2)
h=hist(n4,ylab='Relative Frequency',xlab='Wages')
mp=c(min(h$mids) - (h$mids[2] - h$mids[1]), h$mids, max(h$mids) + (h$mids[2] -h$mids[1]))
mp
freq = c(0, h$counts, 0)
freq
lines(mp, freq, type = "b", pch = 20, col = "red", lwd = 3)
```

R code Exa 2.2.12 P and R company

```
#PAGE=48
a=c(250,250,250,250,250,250,250,250,260,260,260,260,260,260,260,260,
  270,270,270,270,270,270,270,270,270,270,270,270,270,270,270,270,
  280,280,280,280,280,280,280,280,280,280,280,280,290,290,290,290,
  290,290,290,290,300,300,300,300,300,310,310)
a=c(a,285.34,316.83,335.78,356.21,374.5)
a
```

```
b1=seq(249,380,by=10)
table2.7=cut(a,b1)
Frequency=table(table2.7)
a1=cbind(Frequency)
a1

b1=seq(249,390,by=20)
table2.7=cut(a,b1)
Frequency=table(table2.7)
a1=cbind(Frequency)
a1
```

R code Exa 2.2.13 Histogram for frequency distribution

```
#PAGE=49
a=c(250,260,270,280,290,300,320)
b=c(259.99,269.99,279.99,289.99,299.99,319.99,379.99)
f=c(8,10,16,15,10,8,3)
f[8]=3
f[9]=3
f[10]=3

c=(a+b)/2
c=round(c,digits = 0)
c[7]=320
c[8]=330
c[9]=340
c[10]=350
c
n4=rep(c,f)
n4
hist(n4,xlab='Wages')
```

R code Exa 2.2.14 cumulative frequency

```
#PAGE=49
a=c(250,260,270,280,290,300,310,320)
n=c(8,10,16,14,10,5,2)
t=table(n)
s=0
c=0
for (x in n) {
  s=s+x
  c=c(c,s)
}
s1=c/s
s1=s1*100
s1=round(s1,1)
w=c('Less than $250.00','Less than $260.00','Less
   than $270.00','Less than $280.00','Less than $
   290.00','Less than $300.00','Less than $310.00','
   Less than $320.00')
class.df<- data.frame(w,c,s1)
colnames(class.df) <- c('Wages','Cumulative
   Frequency','Percentage Cumulative Distribution')
class.df

w=c(250,260,270,280,290,300,310,320)
plot(w,c,type='b',xlab='Wages (in dollars)',ylab='
   Cumulative Frequency')
plot(w,s1,type='b',xlab='Wages (in dollars)',ylab='
   Percentage Cumulative Frequency')
```

R code Exa 2.2.15 Frequency distribution

```
#PAGE=50
a=c(250,260,270,280,290,300,310)
b=c(259.99,269.99,279.99,289.99,299.99,309.99,319.99)
c=c(a,320)
c
n=c(8,10,16,14,10,5,2)
n=c(n,0)
n1=sum(n)
n4=rep(c,n)
n4
d0=n[7]
d1=n[7]+n[6]
d2=d1+n[5]
d3=n[4]+d2
d4=n[3]+d3
d5=n[2]+d4
d6=n[1]+d5

d=c(0,d0,d1,d2,d3,d4,d5,d6)
d=rev(d)
d
c
e=c('or more','or more','or more','or more','or more','or more','or more','or more')
y <- matrix(c(c,e,d),ncol=3,byrow=FALSE)
colnames(y) <- c("Wages"," ","or more cf")
rownames(y) <- c(" "," "," "," "," "," "," "," ")
y <- as.table(y)
y

n4=rep(c,d)
n4

plot(table(n4),type='c',xlab = 'WAGES',ylab='CF')
```

R code Exa 2.2.16 Ogive estimation

```
#PAGE=51
w=c(250,260,270,280,290,300,310,320)
f=c(65,57,47,31,17,7,2,0)

a1=approx(w,f,288)
a1=round(a1$y,0)
a2=f[1]-a1
cat(a2)

b=approx(w,f,296)
b

c1=approx(w,f,275)
c2=approx(w,f,263)
c2$y-c1$y
```

R code Exa 2.2.17 five pennies were tossed 1000 times

```
#PAGE=51
n=c(0:5)
a=1000
f=c(38,144,342,287,164,25)
c=rep(n,f)
plot(table(c))
n1=sum(f)
d<-seq(0,6,by=1)
f=c(0,f)
e1=f[1]+f[2]
e2=e1+f[3]
e3=e2+f[4]
```

```
e4=e3+f[5]
e5=e4+f[6]
e6=e5+f[7]
e7=e6+f[8]
e=c(0,e1,e2,e3,e4,e5,e6)
e

g=e/10
g
n=c(n,6)
h=c('Less than','Less than','Less than','Less than',
   'Less than','Less than','Less than')
y <- matrix(c(h,n,e,g),ncol=4,byrow=FALSE)
colnames(y) <- c(" ","No.of heads","No.of tosses","
   percentage no.of tosses")
rownames(y) <- c(" "," "," "," "," "," "," ")
y <- as.table(y)
y


plot(n,g,type='l',xlab='Number of heads',ylab='
   Percentage of tosses')
```

R code Exa 2.2.18 100 male students at XYZ college

```
#PAGE=53
w1=c(60,63,66,69,72)
w2=w1+2
n=c(5,18,42,27,8)
t=sum(n)

a1=(w1+w2)/2
a=a1[1]-3
b=a1[length(a1)]+3
for (x in a1) {
```

```
  a=c(a,x)
}

c=c(a,b)
n=c(0,n,0)
c1=c+1.5

smoothingSpline = smooth.spline(c, n, spar=0.35)
plot(c,n,type='o',xlab='Weight(kg)',ylab='Relative
    Frequency(in percentage)')
lines(smoothingSpline)

n=c(5,18,42,27,8)
c=0
s=0
for (x in n) {
  s=s+x
  c=c(c,s)
}

s1=c/s
s1=s1*100
s1=round(s1,1)
c1=c1[1:length(c1)-1]

smoothingSpline = smooth.spline(c1, s1, spar=0.35)
plot(c1,s1,type='o',xlab='Weight(kg)',ylab='
    Cumulative Frequency(in percent)')
lines(smoothingSpline)

a=65
b=70
a=a-0.5
b=b+0.5
c=82
d=18
e=c-d
m=e*1546/100
```

```
m=round(m,0)
m
cat(e,'%')
```

Chapter 3

The Mean Median Mode And Other Measures Of Central Tendency

R code Exa 3.3.4 Calculating the given variables

```
#PAGE=64
x=c(2,-5,4,-8)
y=c(-3,-8,10,6)
a=sum(x)
a
b=sum(y)
b
c=x*y
c=sum(c)
c
d=x**2
d=sum(d)
d
e=y**2
e=sum(e)
e
f=a*b
```

```
f
g=y**2
g=x*g
g=sum(g)
g
h=d-e
h
```

R code Exa 3.3.5 Calculating the given equation

```
#PAGE=64
s1=-4
s2=10
f=6
a=2*s1+f*3
a

b=s2-s1
b

c=s2-10*s1+25*f
c
```

R code Exa 3.3.6 mean of grades of student

```
#page=65
x=c(84,91,72,68,87,78)
mean(x)
```

R code Exa 3.3.7 mean of diameter of cylinders

```
#PAGE=65
a=c
  (38.8,40.9,39.2,39.7,40.2,39.5,40.3,39.2,39.8,40.6)
x=mean(a)
x=round(x,digits = 1)
cat(x, 'mm')
```

R code Exa 3.3.8 annual salaries of four men

```
#PAFE=65
salary=c(15000,16000,16500,40000)
a=mean(salary)
cat('$',a)
```

R code Exa 3.3.9 arithmetic mean of a set of numbers

```
#PAGE=65
x=c(5,3,6,5,4,5,2,8,6,5,4,8,3,4,5,4,8,2,5,4)
mean(x)
```

R code Exa 3.3.10 arithmetic mean of numbers

```
#PAGE=65
x=c(4,5,6,7)
a=c(20,40,30,10)
weighted.mean(x,a)
```

R code Exa 3.3.11 Average grade for four subjects and their respective credits

```
#page=66
grades=c(82,86,90,70)
credits=c(3,5,3,1)
a=weighted.mean(grades,credits)
a=round(a,digits=0)
a
```

R code Exa 3.3.12 Mean of earning of employees

```
#PAGE=66
emp=c(60,20)
earn=c(7,4)
a=weighted.mean(earn,emp)
cat('$',a)
```

R code Exa 3.3.13 mean weight of all the students

```
#PAGE=66
students=c(15,20,10,18)
weigths=c(74,67,70,63)
a=weighted.mean(weigths,students)
cat(a,'kg')
```

R code Exa 3.3.14 Mean annual income of two groups

```
#PAGE=67
x=c(1,12)
```

```
y=c(9000,15000)
a=weighted.mean(y,x)
a=round(a,digits=-2)
cat('$',a)
```

R code Exa 3.3.15 Mean weight of students at XYZ university

```
#PAGE=67
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
len=length(w)
f=c(5,18,42,27,8)
a=sum(f)
b=0
for(i in 1:len)
{
  b=b+w[i]*f[i]
}
x=b/a
cat(x,'kg')
```

R code Exa 3.3.19 guessed and arithmetic mean

```
#69
```

```
guessed_mean<-9
data<-c(5,8,11,9,12,6,14,10)
len=length(data)
temp=0
sum=0
for (i in 1:len )
{
  temp[i]<-data[i]-guessed_mean
  print(temp[i])
  sum<-temp[i]+sum
}
sum<-sum/len
sample_mean=sum+guessed_mean
sample_mean

guessed_mean_2<-20
sum=0
temp=0
for (i in 1:len )
{
  temp[i]<-data[i]-guessed_mean_2
  print(temp[i])
  sum<-temp[i]+sum
}
sum<-sum/len
sample_mean=sum+guessed_mean_2
sample_mean
```

R code Exa 3.3.20 Mean weight of students at XYZ university using different method

```
#PAGE=69
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
```

```
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
a=median(w)
b=w-a
f=c(5,18,42,27,8)
c=sum(f)
x=b*f
y=sum(x)
result=a+y/c
cat(result,'kg')
```

R code Exa 3.3.22 Mean weight of all the students of XYZ university

```
#PAGE=70
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
w
f=c(5,18,42,27,8)
p=sum(f)
p
```

```
a=median(w)
a
b=w-a
b
c=3
b=b/c
b
d=f*b
d
e=sum(d)
e
x=a+(c*e)/p
cat(x,'kg')
```

R code Exa 3.3.23 mean weekly wage

```
#PAGE=70
w1=c(250,259.99)
w1=round(mean(w1),digits = 0)
w2=c(260,269.99)
w2=round(mean(w2),digits = 0)
w3=c(270,279.99)
w3=round(mean(w3),digits = 0)
w4=c(280,289.99)
w4=round(mean(w4),digits = 0)
w5=c(290,299.99)
w5=round(mean(w5),digits = 0)
w6=c(300,309.99)
w6=round(mean(w6),digits = 0)
w7=c(310,319.99)
w7=round(mean(w7),digits = 0)
w=c(w1,w2,w3,w4,w5,w6,w7)
f=c(8,10,16,14,10,5,2)
a=sum(f)
x=f*w
```

```
b=sum(x)
m1=b/a
m1=round(m1,digits=2)
cat('$',m1)


m=which.max(f)
z=w[m]
c=10
w=w-z
w=w/c
e=w*f
e=sum(e)
m2=z+(c*e)/a
m2=round(m2,digits=2)
cat('$',m2)
```

R code Exa 3.3.24 mean wage of employees

```
#PAGE=71
w1=c(250,259.99)
w1=round(mean(w1),digits = 0)
w2=c(260,269.99)
w2=round(mean(w2),digits = 0)
w3=c(270,279.99)
w3=round(mean(w3),digits = 0)
w4=c(280,289.99)
w4=round(mean(w4),digits = 0)
w5=c(290,299.99)
w5=round(mean(w5),digits = 0)
w6=c(300,319.99)
w6=round(mean(w6),digits = 0)
w7=c(320,379.99)
w7=round(mean(w7),digits = 0)
w=c(w1,w2,w3,w4,w5,w6,w7)
```

```
f=c(8,10,16,15,10,8,3)
a=sum(f)

b=w*f
e=sum(b)
x=e/a
cat('$',x)
```

R code Exa 3.3.25 median of grades

```
#PAGE=71
x=c(84,91,72,68,87,78)
median(x)
```

R code Exa 3.3.26 hourly wages of five employees

```
#PAGE=71
x=c(4.52,5.96,5.28,11.20,5.75)
a=median(x)
cat('$',a)
b=mean(x)
cat('$',b)
```

R code Exa 3.3.27 Numbers in an array

```
#PAGE=72
a=85
b=150

```

```
c<-ifelse(a%%2==0, floor(a/2+1), floor(a/2))
c=c+1
cat(c)

d1<-ifelse(b%%2==0, floor(b/2+1), floor(b/2))
d2=d1-1
cat(d2,'th',d1,'th')
```

R code Exa 3.3.28 40 male students solving a problem

```
#PAGE=72
t1=c(118,127,136,145,154,163,172)
t2=c(126,135,144,153,162,171,180)
f=c(3,5,9,12,5,4,2)
s1=sum(f)

n=4
a=0.5
a1=t1[n]-a
a2=t2[n]+a

a=a1+(a2-a1)/n
a=round(a,1)
cat(a,'s')

m=c
  (119,125,126,128,132,135,135,135,136,138,138,140,140,142,142,144,

m1=median(m)
cat(m1,'s')
```

R code Exa 3.3.29 Histogram and Ogive

```
#PAGE=73
t1=c(118,127,136,145,154,163,172)
t2=c(126,135,144,153,162,171,180)
t=(t1+t2)/2
f=c(3,5,9,12,5,4,2)

m=c
  (119,125,126,128,132,135,135,135,136,138,138,140,140,142,142,144,

x11()
hist(m,xlab='Time(seconds',ylab='Frequency')
abline(v = median(m),
       col = "red",
       lwd = 2)

t1=t1-0.5
c1=cumsum(f)
x11()
plot(t1,c1,type='b',xlab='Time(seconds',ylab='
  Cumulative Relative Frequency(%)')
abline(v = median(t1),
       col = "red",
       lwd = 2)

m2=median(t1)
n2=9/4
n1=m2+n2
cat(n1,'s')
```

R code Exa 3.3.30 P and R Company

```
#PAGE=74
n=65
n=n/2
```

```
f2=c(8,10,16,14,10,5,2)
s=c(f2[1],f2[2],f2[3])
s1=sum(s)
l=c(250,260,270,280,290,300,310)
f=c
  (259.99,269.99,279.99,289.99,299.99,309.99,319.99)

l1=length(s)
m=(l[l1]+f[l1-1])/2

f1=f2[l1-1]
s2=f2[1]+f2[2]

m1=m+((n-s2)/s[l1])*f1
m1=round(m1,2)
cat('$',m1)
```

R code Exa 3.3.31 mean median and mode

```
#PAGE=74
a1=c(3,5,2,6,5,9,5,2,8,6)
m1=mean(a1)
m2=median(a1)
getmode <- function(v) {
  uniqv <- unique(v)
  uniqv[which.max(tabulate(match(v, uniqv)))]
}
result <- getmode(a1)
cat(m1)
cat(m2)
cat(result)

b1=c(51.6,48.7,50.3,49.5,48.9)
```

```
m1=mean(b1)
m2=median(b1)
getmode <- function(v) {
  uniqv <- unique(v)
  uniqv[which.max(tabulate(match(v, uniqv)))]
}
result <- getmode(b1)
cat(m1)
cat(m2)
```

R code Exa 3.3.33 modal wage of employees

```
#PAGE=75
l=269.995
f=c(8,10,16,14,10,5,2)
f=sort(f,decreasing = TRUE)
d2=f[1]-f[2]
d1=f[1]-f[3]
c=10
mode=l+(d1*c)/(d1+d2)
mode=round(mode,digits = 2)
cat('$',mode)
```

R code Exa 3.3.34 Empirical formula

```
#PAGE=75
m1=279.77
m2=279.06
m=m1-3*(m1-m2)
cat('$',m)
```

R code Exa 3.3.35 geometric mean and arithmetic mean

```
#PAGE=75
x=c(3,5,6,6,7,10,12)
a=1
len=length(x)
for(i in 1:len)
{
  a=a*x[i]
}
a=a**(1/7)
a=round(a,digits = 2)
a

b=mean(x)
b
```

R code Exa 3.3.37 milk prices to bread prices

```
#PAGE=76
x=c(3,2)
a=mean(x)
a
y=1/x
y=round(y,digits = 3)
b=mean(y)
b=round(b,digits=3)
b
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 3.3.38 bacterial increase percentage

```
#PAGE=77
a=1000
b=4000
c=3
r=(b/a)**(1/c)-1
r=r*100
r=round(r,digits = 1)
r
```

R code Exa 3.3.39 harmonic mean

```
#PAGE=77
x=c(3,5,6,6,7,10,12)
len=length(x)
y=1/x
y=sum(y)
y=y*1/len
z=1/y
z=round(z,digits = 2)
z
```

R code Exa 3.3.40 average oil cost

```
#PAGE=78
a=4000
x=c(0.2,0.23,0.26,0.31)
y=a*x
z=sum(y)
b=z/(4*a)
cat('$',b,'/litre')

t=4
c=sum(1/x)
```

```
h=t/c
h=round(h,digits = 2)
cat('$',h,'/litre')
```

R code Exa 3.3.41 average speed for a trip

```
#PAGE=78
a=45
b=90
d=90
c=d/a
f=d/b
e=2*d
avg=e/(c+f)
cat(avg,'km/h')
```

R code Exa 3.3.42 quadratic mean

```
#PAGE=79
x=c(3,5,6,6,7,10,12)
len=length(x)
y=x**2
y=sum(y)
y=y/len
z=y^(1/2)
z=round(z,digits=2)
z
```

R code Exa 3.3.44 Quartiles q1 q2 and q3

```
#PAGE=79
a=c(250,260,270,280,290,300,310)
b=c
   (259.99,269.99,279.99,289.99,299.99,309.99,319.99)
n=c(8,10,16,14,10,5,2)

n1=65
n2=4
n3=n1/n2
n4=2
n5=n1/n4
n6=(3*n1)/n2
d=10

l=length(n)
n7=n3-(n[1])
n8=n5-(n[1]+n[2])
n9=n6-(n[1]+n[2]+n[3]+n[4])

c1=(a[2]+b[1])/2
c2=(a[3]+b[2])/2
c3=(a[5]+b[4])/2

q1=c1+(n7/n[2])*d
q2=c2+(n8/n[3])*d
q3=c3+(n9/n[5])*d


q1=round(q1,2)
q2=round(q2,2)
q3=round(q3,2)

cat('$',q1)
cat('$',q2)
cat('$',q3)

a=c(250,260,270,280,290,300,310)
```

```
b=c
   (259.99,269.99,279.99,289.99,299.99,309.99,319.99)
n=c(8,10,16,14,10,5,2)
n0=65

n1=(a[1]+249.99)/2+(n0/10)*(d/n[1])
cat('$',n1)
n2=(a[2]+b[1])/2+5*(d/n[2])
n2=round(n2,0)
cat('$',n2)
n3=((a[3]+b[2])/2)+(1.5*d/n[3])
n3=round(n3,2)
cat('$',n3)

n4=(a[3]+b[2])/2+(8)*(d/n[3])
n4=round(n4,2)
cat('$',n4)
n6=(a[3]+b[2])/2+(14.5)*(d/n[3])
n6=round(n6,2)
cat('$',n6)

n7=(a[3]+b[4])/2+(5)*(d/n[4])
n7=round(n7,2)
cat('$',n7)

n8=(a[3]+b[4])/2+(11.5)*(d/n[4])
n8=round(n8,2)
cat('$',n8)

n9=(a[4]+b[5])/2+(4)*(d/n[5])
n9=round(n9,0)
cat('$',n9)

n10=(a[5]+b[6])/2+(0.5)*(d/n[6])
n10=round(n10,0)
cat('$',n10)

```

```
#The answer may vary due to difference in representation.
```

R code Exa 3.3.45 Percentiles for the distribution

```
#PAGE=80
a=c(250,260,270,280,290,300,310)
b=c(259.99,269.99,279.99,289.99,299.99,309.99,319.99)
n=c(8,10,16,14,10,5,2)

n1=65
c1=(a[3]+b[2])/2
d=10
a1=35
a1=(a1*n1)/100
a1=a1-(n[1]+n[2])
a1=a1/n[3]
a1=a1*d
a1=c1+a1
a1=round(a1,2)
cat('$',a1)

c2=(a[4]+b[3])/2
e=5/n[4]
b1=c2+e*d
b1=round(b1,2)
cat('$',b1)
```

R code Exa 3.3.46 Percentage Ogive

```
#PAGE=80
```

```
a=c(250,260,270,280,290,300,310)
b=c
   (259.99,269.99,279.99,289.99,299.99,309.99,319.99)

n=c(8,10,16,14,10,5,2)

c1=cumsum(n)
c1
c2=c1/65*100

x11()
plot(a,c2,type='b',xlab='Wages(dollars)',ylab='
   Cumulative Relative Frequency(%)')
abline(h = quantile(a,c(0.25,0.5 ,0.75)),v =
   quantile(a,c(0.25,0.5 ,0.75)),
       col = "red",
       lwd = 2)

#"The answer may vary due to difference in
   representation."
```

R code Exa 3.4 arithmetic mean

```
#page=59
x=c(8,3,5,12,10)
mean(x)
```

R code Exa 3.5 Arithmetic Mean

```
#PAGE=59
x=c(5,8,6,2)
f=c(3,2,4,1)
len=length(x)
```

```
a=0
for(i in 1:len)
{
  a=x[i]*f[i]+a
}
a=a/sum(f)
a
```

R code Exa 3.6 weighted mean

```
#page=59
a=70
b=90
c=85
d=3
e=1
f=1
x=(a*e+b*f+c*d)/(e+f+d)
x
```

R code Exa 3.7 deviation and mean

```
#page=59
x=c(8,3,5,12,10)
len=length(x)
y=mean(x)
z=x-y
z
a=sum(z)
x=round(a,digits=0)
x
```

R code Exa 3.8 median

```
#PAGE=60
x=c(3,4,4,5,6,8,8,8,10)
median(x)
```

R code Exa 3.9 median

```
#PAGE=60
x=c(5,5,7,9,11,12,15,18)
median(x)
```

R code Exa 3.10 mode

```
#page=61
x=c(2,2,5,7,9,9,9,10,10,11,12,18)
mode <- function(v) {
  uniqv <- unique(v)
  uniqv[which.max(tabulate(match(v, uniqv)))]
}

a=mode(x)
a
```

R code Exa 3.11 mode

```r
#PAGE=61
x=c(3,5,8,10,12,15)
Mode = function(x){
  ta = table(x)
  tam = max(ta)
  if (all(ta == tam))
    mod = NA
  else
    if(is.numeric(x))
      mod = as.numeric(names(ta)[ta == tam])
  else
    mod = names(ta)[ta == tam]
  return(mod)
}
Mode(x)
```

R code Exa 3.12 bimodal

```r
#PAGE=61
x=c(2,3,4,4,4,5,5,7,7,7,9)

Mode = function(x){
  ta = table(x)
  tam = max(ta)
  if (all(ta == tam))
    mod = NA
  else
    if(is.numeric(x))
      mod = as.numeric(names(ta)[ta == tam])
  else
    mod = names(ta)[ta == tam]
  return(mod)
}
Mode(x)
```

R code Exa 3.13 Geometric mean

```
#PAGE=62
x=c(2,4,8)
len=length(x)
a=1
for(i in 1:len)
{
  a=a*x[i]
}
print(a)
a=a^(1/3)
a
```

R code Exa 3.14 harmonic mean

```
#PAGE=62
x=c(2,4,8)
a=sum(1/x)
a
len=length(x)
h=len/a
h=round(h,digits=2)
h
```

R code Exa 3.15 arithmetic geometric and harmonic mean

```
#page=62
x=c(2,4,8)
```

```
a=mean(x)
a=round(a,digits = 2)
a

len=length(x)
b=1
for(i in 1:len)
{
  b=b*x[i]
}
print(b)
b=b^(1/3)
b

a=sum(1/x)
a
len=length(x)
h=len/a
h=round(h,digits=2)
h
```

R code Exa 3.16 RMS

```
#PAGE=63
x=c(1,3,4,5,7)
x=x**2
x
y=sum(x)
len=length(x)
a=y/len
a=sqrt(a)
a=round(a,digits = 2)
a
```

Chapter 4

The Standard Deviation And Other Measures Of Dispersion

R code Exa 4.1 Range of a set of numbers

```
#PAGE=87
x=c(2,3,3,5,5,5,8,10,12)
a=max(x)
b=min(x)
c=a-b
c
```

R code Exa 4.2 mean deviation of a set of numbers

```
#PAGE=87
x=c(2,3,6,8,11)
len=length(x)
y=mean(x)
b=0
for(i in 1:5)
{
```

```
  a=abs(x[i]-y)
  b=b+a
}
b=b/len
b
```

R code Exa 4.4.1 Range of a set of numbers

```
#PAGE=92
x=c(12,6,7,3,15,10,18,5)
m=max(x)
n=min(x)
a=m-n
a

y=c(9,3,8,8,9,8,9,18)
m=max(y)
n=min(y)
b=m-n
b


x1=c(12,6,7,15,10,5)
m=max(x1)
n=min(x1)
a1=m-n
a1


y1=c(9,8,8,9,8,9)
m=max(y1)
n=min(y1)
b1=m-n
b1
```

R code Exa 4.4.2 Range of weights of students

```
#PAGE=92
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
a=max(w)
b=min(w)
c=a-b
cat(c,'kg')

a=60-0.5
b=74+0.5
c=b-a
cat(c,'kg')
```

R code Exa 4.4.3 Mean deviation of a set of numbers

```
#PAGE=92
x=c(12,6,7,3,15,10,18,5)
len=length(x)
y=mean(x)
y
b=0
```

```
for(i in 1:len)
{
  a=abs(x[i]-y)
  print(a)
  b=b+a
}
b=b/len
b

x=c(9,3,8,8,9,8,9,18)
len=length(x)
y=mean(x)
y
b=0
for(i in 1:len)
{
  a=abs(x[i]-y)
  print(a)
  b=b+a
}
b=b/len
b
```

R code Exa 4.4.4 mean deviation of weights of students of XYZ college

```
#PAGE=93
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
```

```
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
f=c(5,18,42,27,8)
s=sum(f)
y=w*f
s2=sum(y)
m=s2/s
x=abs(w-m)
z=x*f
a=sum(z)
md=a/s
cat(md,'kg')
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 4.4.5 Percentage of Students weights

```
#PAGE=93
a1=65.19
a2=69.71
a=(a1+a2)/2
b1=2.26
c1=a+b1
c2=a-b1
ans=42+(65.5-c2)*18/3+(c1-68.5)*27/3
ans=round(ans,0)
cat(ans)

a1=62.93
a2=71.97
a=(a1+a2)/2
b=2*b1
c1=a+b
c2=a-b
ans=18-(c2-62.5)*18/3+42+27+(c1-71.5)*8/3
```

```
ans=round(ans,0)
cat(ans)

a1=60.67
a2=74.23
a=(a1+a2)/2
b=b1*3
c1=a+b
c2=a-b
ans=5-(c2-59.5)*5/3+18+42+27+(74.5-c1)*8/3
ans=round(ans,0)
cat(ans)
#"The answer provided in the textbook is wrong."
```

R code Exa 4.4.6 Semi interquartile range

```
#PAGE=94
q1=65.5+(2*3)/42
q3=68.5+(10*3)/27
q=(q3-q1)/2
q2=(q3+q1)/2
q2=round(q2,2)
q=round(q,2)
cat(q2,'+',q,'kg')
cat(q2,'-',q,'kg')
```

R code Exa 4.4.7 Semi interquartile range for wages

```
#PAGE=94
q1=268.25
q2=290.75
q11=(q2-q1)/2
cat('$',q11)
```

```
q22=(q1+q2)/2
cat('$',q22)

cat(q11,'+-',q22,'kg')
```

R code Exa 4.4.8 Weights of students at XYZ University

```
#PAGE=94
a=62.5
b=68.5
c=3
d=5/18
e=25/27

p1=a+d*c
p1=round(p1,2)
cat(p1,'kg')

p2=b+e*c
p2=round(p2,2)
cat(p2,'kg')

q1=p2-p1
cat(q1,'kg')

q2=p2+p1
cat(q2,'kg')

q3=q1/2
q3=round(q3,2)
cat(q3,'kg')

q4=q2/2
q4=round(q4,2)
cat(q4,'kg')
```

```
cat(q4,'+-',q3,'kg')
```

R code Exa 4.4.9 standard deviation for each set of numbers

```
#PAGE=94
f=c(12,6,7,3,15,10,18,5)
n=length(f)
s=sum(f)/n
s1=f-s
s1=s1**2
s2=sum(s1)
ans=sqrt(s2/n)
ans=round(ans,2)
cat(ans)

f=c(9,3,8,8,9,8,9,18)
n=length(f)
s=sum(f)/n
s1=f-s
s1=s1**2
s2=sum(s1)
ans=sqrt(s2/n)
ans=round(ans,2)
cat(ans)
```

R code Exa 4.4.10 variance of a set of numbers

```
#PAGE=95
a=4.87
ans=round(a*a,2)
cat(ans)

```

```
a=3.87
ans=round(a*a,0)
cat(ans)
```

R code Exa 4.4.11 Standard deviation of weights of 100 male students

```
#PAGE=95
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
f=c(5,18,42,27,8)
s=sum(f)
y=w*f
s2=sum(y)
m=s2/s
x=abs(w-m)
x=x**2
z=x*f
a=sum(z)
sd=sqrt(a/s)
sd=round(sd,digits = 2)
cat(sd,'kg')
```

R code Exa 4.4.12 standard deviation of a set of numbers

```
#PAGE=95
x=c(12,6,7,3,15,10,18,5)
y=mean(x)
y=y**2
z=x**2
z=mean(z)
s=sqrt(z-y)
s=round(s,digits = 2)
s
```

R code Exa 4.4.14 standard deviation of a set of data

```
#PAGE=97
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
f=c(5,18,42,27,8)
s=sum(f)
y=w*f
s2=sum(y)
m=s2/s
x=w**2
a=f*x
b=sum(a)
c=b/s
m=m**2
z=sqrt(c-m)
```

```
z=round(z,digits=2)
cat(z,'kg')
```

R code Exa 4.4.17 Standard deviation of weights of students of XYZ university

```
#PAGE=98
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
a=median(w)
f=c(5,18,42,27,8)
s=sum(f)
d=w-a
fd=d*f
e=sum(fd)
d=d**2
fd2=f*d
h=sum(fd2)
h=h/s
e=(e/s)**2
s=sqrt(h-e)
s=round(s,digits=2)
cat(s,'kg')


w=c(w1,w2,w3,w4,w5)
```

```
f=c(5,18,42,27,8)
s=sum(f)
d=(w-a)/3
fu=f*d
e=sum(fu)
fu2=f*d**2
h=sum(fu2)
s1=h/s-(e/s)**2
s1=sqrt(s1)
s1=3*s1
s1=round(s1,digits = 2)
cat(s1,'kg')
```

R code Exa 4.4.18 mean and standard deviation for wage distribution

```
#PAGE=99
w1=c(250,259.99)
w1=mean(w1)
w1=round(w1,digits=0)

w2=c(260,269.99)
w2=mean(w2)
w2=round(w2,digits=0)

w3=c(270,279.99)
w3=mean(w3)
w3=round(w3,digits=0)

w4=c(280,289.99)
w4=mean(w4)
w4=round(w4,digits=0)

w5=c(290,299.99)
w5=mean(w5)
w5=round(w5,digits=0)
```

```
w6=c(300,309.99)
w6=mean(w6)
w6=round(w6,digits=0)

w7=c(310,319.99)
w7=mean(w7)
w7=round(w7,digits=0)

w=c(w1,w2,w3,w4,w5,w6,w7)

f=c(8,10,16,14,10,5,2)
b=which.max(f)
a=w[b]
d=10
u=w-a
u=u/d

c=sum(f)
fu=f*u
e=sum(fu)
fu2=f*u**2
f=sum(fu2)

x=a+(d*e)/c
x=round(x,digits = 2)
cat('$',x)

m=f/c-(e/c)**2
m=sqrt(m)
m=m*10
m=round(m,digits = 2)
cat('$',m)
```

R code Exa 4.4.19 IQ of elementary school students

```
#PAGE=99
x=c
   (70,74,78,82,86,90,94,98,102,106,110,114,118,122,126)

f=c(4,9,16,28,45,66,85,72,54,38,27,18,11,5,2)
s=sum(f)
b=which.max(f)
a=x[b]
u=x-a
d=4
u=u/d
fu=f*u
s1=sum(fu)
fu2=f*u**2
s2=sum(fu2)


m=a+d*(s1/s)
m=round(m,digits=2)
m


n=(s2/s)-(s1/s)**2
n=sqrt(n)*d
n=round(n,digits=2)
n
```

R code Exa 4.4.20 Charlies Check

```
#PAGE=100
f=236
n=480
a=f+n
print(a)

```

```
fu=3404
b=fu+f*2+n
print(b)
```

R code Exa 4.4.21 standard deviation of data

```
#PAGE=100
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
a=median(w)
f=c(5,18,42,27,8)
s=sum(f)
d=w-a
fd=d*f
e=sum(fd)
d=d**2
fd2=f*d
h=sum(fd2)
h=h/s
e=(e/s)**2
s=sqrt(h-e)
s=round(s,digits=2)
s=s**2

c=3
```

```
c=c**2
cv=s-c/12
cv=sqrt(cv)
cv=round(cv,digits = 2)
cat(cv,'kg')


w1=c(250,259.99)
w1=mean(w1)
w1=round(w1,digits=0)

w2=c(260,269.99)
w2=mean(w2)
w2=round(w2,digits=0)

w3=c(270,279.99)
w3=mean(w3)
w3=round(w3,digits=0)

w4=c(280,289.99)
w4=mean(w4)
w4=round(w4,digits=0)

w5=c(290,299.99)
w5=mean(w5)
w5=round(w5,digits=0)

w6=c(300,309.99)
w6=mean(w6)
w6=round(w6,digits=0)

w7=c(310,319.99)
w7=mean(w7)
w7=round(w7,digits=0)

w=c(w1,w2,w3,w4,w5,w6,w7)

f=c(8,10,16,14,10,5,2)
```

```r
b=which.max(f)
a=w[b]
d=10
u=w-a
u=u/d

c=sum(f)
fu=f*u
e=sum(fu)
fu2=f*u**2
f=sum(fu2)

x=a+(d*e)/c
x=round(x,digits = 2)

m=f/c-(e/c)**2
m=sqrt(m)
m=m*10
m=round(m,digits = 2)
m=m**2
d=d**2
cv=m-d/12
cv=sqrt(cv)
cv=round(cv,digits=2)
cat('$',cv)


x=c
   (70,74,78,82,86,90,94,98,102,106,110,114,118,122,126)
f=c(4,9,16,28,45,66,85,72,54,38,27,18,11,5,2)
s=sum(f)
b=which.max(f)
a=x[b]
u=x-a
d=4
u=u/d
fu=f*u
```

```
s1=sum(fu)
fu2=f*u**2
s2=sum(fu2)

m=a+d*(s1/s)
m=round(m,digits=2)

n=(s2/s)-(s1/s)**2
n=sqrt(n)*d
n=round(n,digits=2)

d=d**2
n=n**2
n=round(n,digits=2)
cv=n-d/12
cv=sqrt(cv)
cv=round(cv,digits=2)
cv
```

R code Exa 4.4.22 second frequency distribution

```
#PAGE=101
x1=c(118,126)
x1=mean(x1)
x2=c(127,135)
x2=mean(x2)
x3=c(136,144)
x3=mean(x3)
x4=c(145,153)
x4=mean(x4)
x5=c(154,162)
x5=mean(x5)
x6=c(163,171)
x6=mean(x6)
x7=c(172,180)
```

```
x7=mean(x7)
x=c(x1,x2,x3,x4,x5,x6,x7)
f=c(3,5,9,12,5,4,2)
b=which.max(f)
a=x[b]
c=9
u=(x-a)
u=u/c
n=sum(f)
fu=f*u
m1=sum(fu)
fu2=f*u**2
m2=sum(fu2)

y=a+c*m1/n
y=round(y,digits = 0)
cat(y,'s')


s=(m2/n-(m1/n)**2)
s=sqrt(s)
s=s*c
s=round(s,digits = 1)
cat(s,'s')

s=s^2
c=c^2
cv=s-c/12
cv=round(cv,digits=0)
csd=sqrt(cv)
csd=round(csd,digits=1)
cat(csd,'s')

x=c
  (138,164,150,132,144,125,149,157,146,158,140,147,136,148,152,144,

len=length(x)
a=150
```

```
x=x-a
x
d=sum(x)
x=x**2
d2=sum(x)
s=d2/len-(d/len)**2
s=sqrt(s)
s=round(s,digits = 1)
cat(s,'s')
```

R code Exa 4.4.23 Distribution of weights of students at XYZ University

```
#PAGE=102
m=2.92

a1=2.26
a=a1/m
a=round(a,2)
cat(a)

b1=1.98
b=b1/m
b=round(b,2)
cat(b)
```

R code Exa 4.4.24 Percentage of Students IQ

```
#PAGE=102
a3=95.97+10.47
a4=95.97-10.47
n=4
a6=88
a7=104
```

```
a5=((a6-a4)/n)*45+66+85+72+54+((a3-a7)/n)*38
m1=a5/480
m1=round(m1,1)
cat(m1*100,'%')

b1=95.97+2*10.47
b2=95.97-2*10.47
b1=round(b1,1)
b2=round(b2,1)
b3=76
b4=116
b5=((b3-b2)/4)*9+16+28+45+66+85+72+54+38+27+18+((b1-
   b4)/4)*11
m2=b5/480
m2=round(m2,2)
cat(m2*100,'%')

c1=95.97+3*10.47
c2=95.97-3*10.47
c1=round(c1,1)
c2=round(c2,1)
c3=128
c4=480
c5=c4-((c3-c1)/4)*2
c5
c6=c5/c4
c6=round(c6,3)
cat(c6*100,'%')
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 4.4.25 Mean and variance of single and combined sets

```
#page 103
x<-c(2,5,8,11,14)
```

```
y<-c(2,8,14)
a<-mean(x)
print(a)
b<-mean(y)
print(b)

l1<-length(x)
l2<-length(y)
sum=0
for (i in 1:l1)
{
  sum<-sum+(x[i]-a)*(x[i]-a)
}
var1<-sum/l1
var1
sum=0
for (i in 1:l2)
{
  sum<-sum+(y[i]-b)*(y[i]-b)

}
var2<-sum/l2
var2


z<-c(x,y)
z
m<-mean(z)
m

len<-length(z)
sum=0
for (i in 1:len)
{
  sum<-sum+(z[i]-m)*(z[i]-m)
}
var<-sum/len
var
```

R code Exa 4.4.26 Set work problem

```
#PAGE=103
s1=c(2,5,8,11,14)
s2=c(10,16,22)
l1=length(s1)
l2=length(s2)

m2=mean(s1)
a1=0
a1=((s1-m2)**2)+a1
a1=sum(a1)/l1
cat(a1)

m3=mean(s2)
a2=0
a2=((s2-m3)**2)+a2
a2=sum(a2)/l2
cat(a2)

m1=(sum(s1)+sum(s2))/(l1+l2)
cat(m1)

s3=c(s1,s2)
s=0
s=((s3-m1)**2)+s
s=sum(s)/(l1+l2)
cat(s)

e=(a1*l1+a2*l2)/(l1+l2)
cat(e)
```

R code Exa 4.4.28 Television tubes A and B

```
#PAGE=104
x1=1495
x2=1875
s1=280
s2=310

y <- if(s1 < s2)  print(s1)
y

a=s1/x1
a=round(a,3)
cat(a*100,'%')

b=s2/x2
b=round(b,3)
cat(b*100,'%')
#"The answer may vary due to difference in
    representation."
```

R code Exa 4.4.29 Coefficients of variance

```
#PAGE=104
s1=2.92
s2=2.79
s3=67.45
a1=s1/s3
a1=round(a1,3)
cat(a1*100,'%')

a2=s2/s3
a2=round(a2,3)
cat(a2*100,'%')

```

```
m1=15.6
m2=15.33
m3=79.77
b1=m1/m3
b1=round(b1,3)
cat(b1*100,'%')

b2=m2/m3
b2=round(b2,3)
cat(b2*100,'%')
```

R code Exa 4.4.30 Measure of relative dispersion

```
#PAGE=104
q3=69.611
q1=65.64
v=(q3-q1)/(q3+q1)
v=round(v,3)
v=v*100
cat(v,'%')
```

R code Exa 4.4.31 Higher relative standing

```
#PAGE=105
a=84
b=76
s=10
z=(a-b)/s
z

c=90
d=82
s1=16
```

```
z1=(c-d)/s1
z1

if(z1 < z)  print(TRUE)
#"The answer may vary due to difference in
   representation."
```

R code Exa 4.4.32 Converting the IQs into standard scores

```
#PAGE=105
x=c
   (70,74,78,82,86,90,94,98,102,106,110,114,118,122,126)

f=c(4,9,16,28,45,66,85,72,54,38,27,18,11,5,2)
a1=x[1]-4
a2=x[15]+4
x1=c(a1,x,a2)
m=96
s=10.5
x2=x1-m

z=x2/s
z=round(z,2)

a1=0
a2=0
f=c(a1,f,a2)
f1=sum(f)
f1

rf=f/f1
rf=round(rf,3)
rf=rf*100
rf1=sum(rf)
rf1=round(rf1,0)
```

```
rf1

y5 <- matrix(c(x1,x2,z,f,rf),nrow = 17,byrow=FALSE)
rownames(y5) <- c(" "," "," "," "," "," "," "," "," "," "," "," "," "," "," "," "," ")
colnames(y5) <- c("IQ(X)","X-X BAR","z",'Frequency','Relative Frequency')
y5 <- as.table(y5)
y5

x11()
plot(z,rf,type='l',xlab=" ",ylab='Relative Frequency')
```

Chapter 5

Moments Skewness And Kurtosis

R code Exa 5.5.1 moments

```r
#PAGE=113
x<-c(2,3,7,8,10)
len=length(x)
sum<-0
first=0
for (i in 1:len)
{
  sum=sum+x[i]
}
first=sum/len
first
sum=0
for (i in 1:len)
{
  sum=sum+x[i]**2
}
second=sum/len
second
```

```
sum=0
for (i in 1:len)
{
  sum=sum+x[i]**3
}
third=sum/len
third

sum=0
for (i in 1:len)
{
  sum=sum+x[i]**4
}
four=sum/len
four
```

R code Exa 5.5.2 moments about the mean

```
#PAGE=113
x=c(2,3,7,8,10)
len=length(x)
a=mean(x)
a
m1=x-a
m1=sum(m1)/len
m1
m2=(x-a)**2
m2=sum(m2)/len
m2
m3=(x-a)**3
m3=sum(m3)/len
m3
m4=(x-a)**4
m4=sum(m4)/len
m4
```

R code Exa 5.5.3 moments about the origin

```
#PAGE=114
x=c(2,3,7,8,10)
len=length(x)

m1=x-4
m1=sum(m1)/len
m1
m2=(x-4)**2
m2=sum(m2)/len
m2
m3=(x-4)**3
m3=sum(m3)/len
m3
m4=(x-4)**4
m4=sum(m4)/len
m4
```

R code Exa 5.5.4 relation between moments

```
#PAGE=114
x=c(2,3,7,8,10)
len=length(x)
a=mean(x)
m1=x-a
m1=sum(m1)/len
m2=(x-a)**2
m2=sum(m2)/len
m3=(x-a)**3
m3=sum(m3)/len
```

```
m4=(x-a)**4
m4=sum(m4)/len

m11=x-4
m11=sum(m11)/len
m22=(x-4)**2
m22=sum(m22)/len
m33=(x-4)**3
m33=sum(m33)/len
m44=(x-4)**4
m44=sum(m44)/len

a=m22-m11**2
a

b=m33-3*m11*m22+2*m11**3
b

c=m44-4*m11*m33+6*m11**2*m22-3*m11**4
c
```

R code Exa 5.5.6 first four moments about the weight

```
#PAGE=115
w1=c(60,62)
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
```

```
f=c(5,18,42,27,8)
n=sum(f)
b=which.max(f)
a=w[b]
w=w-a
d=3
w=w/d
fu=f*w
e=sum(fu)
fu2=f*w**2
g=sum(fu2)
fu3=f*w**3
h=sum(fu3)
fu4=f*w**4
i=sum(fu4)

m1=d*(e/n)
m1

m2=d**2*(g/n)
m2

m3=d**3*(h/n)
m3

m4=d**4*(i/n)
m4

x=c(w1,w2,w3,w4,w5)
z=mean(x)
m11=(x-z)
m11=m11/2
m11=sum(m11)
m11


m22=m2-m1**2
m22
```

```
m33=m3-3*m1*m2+2*m1**3
m33=round(m33,digits = 4)
m33

m44=m4-4*m1*m3+6*m1**2*m2-3*m1**4
m44
```

R code Exa 5.5.7 Moments for distribution

```
#PAGE=115
x=c
   (70,74,78,82,86,90,94,98,102,106,110,114,118,122,126)

f=c(4,9,16,28,45,66,85,72,54,38,27,18,11,5,2)
s=sum(f)
b=which.max(f)
a=x[b]
u=x-a
d=4
u=u/d
fu=f*u
s1=sum(fu)

fu2=f*u**2
s2=sum(fu2)

fu3=f*u**3
s3=sum(fu3)

fu4=f*u**4
s4=sum(fu4)

N=sum(f)

```

```
a1=d*s1/N
a1=round(a1,4)
a1

b1=(d**2)*(s2)/N
b1

c1=(d**3)*(s3)/N
c1

d1=(d**4)*(s4)/N
d1

e1=a1-a1**1
e1

f1=b1-a1**2
f1

g1=c1-3*a1*b1+2*a1**3
g1

h1=d1-4*c1*a1+6*(a1**2)*b1-3*a1**4
h1

i1=a+d*s1/N
i1=round(i1,2)
i1

j1=sqrt(f1)
j1=round(j1,2)
j1

k1=a**2+2*a*a1+b1
k1

l1=a**3+3*a**2*a1+3*a*b1+c1
l1=round(l1,-2)
```

```
l1
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 5.5.8 Charlies check

```
#PAGE=116
x=c
   (70,74,78,82,86,90,94,98,102,106,110,114,118,122,126)

x
f=c(4,9,16,28,45,66,85,72,54,38,27,18,11,5,2)
f
s=sum(f)
s
b=which.max(f)
a=x[b]
a
u=x-a
d=4
u=u/d
u
fu=f*u
fu
s1=sum(fu)
s1
fu2=f*u**2
fu2
s2=sum(fu2)
s2
fu3=f*u**3
fu3
s3=sum(fu3)
s3
fu4=f*u**4
```

```
fu4
s4=sum(fu4)
s4

u=u+1
u

f1=f*u
f1
y1=sum(f1)
y1
s1=s1+s
s1

f2=f*u**2
f2
y2=sum(f2)
y2
s2=s2+s
s2

f3=f*u**3
f3
y3=sum(f3)
y3
s3=s3+s
s3

f4=f*u**4
f4
y4=sum(f4)
y4
s4=s4+s
s4
```

R code Exa 5.5.9 Sheppards correction

```
#PAGE=117
m1=8.5275
c=3
l=12
m2=m1-(c**2)/l
m2
m3=199.3759
m4=m3-(c**2*m1)/2+(7*c**4)/240
m4


m3=109.5988
c=4
l=12
m5=m3-(c**2)/l
m5
m6=35627.2853
m7=m6-(c**2*m3)/2+(7*c**4)/240
m7
```

R code Exa 5.5.10 Pearsons

```
#PAGE=118
m1=279.76
m2=279.06
m3=277.5
s=15.6
a=(m1-m3)/s
a=round(a,digits = 2)
a

b=3*(m1-m2)/s
b=round(b,digits = 2)
```

```
b
```

R code Exa 5.5.11 Quartile and percentile

```
#PAGE=118
q1=268.25
q2=279.06
q3=290.75
d1=258.12
d2=301

a=(q3-2*q2+q1)/(q3-q1)
a=round(a,digits = 4)
a

b=(d2-2*q2+d1)/(d2-d1)
b=round(b,digits = 4)
b
```

R code Exa 5.5.12 Coefficient of skewness

```
#PAGE=118
m1=8.5275
m2=-2.6932
a=(m2)/sqrt(m1**3)
a=round(a,digits = 2)
a

g=7.7775
b=m2/sqrt(g**3)
b=round(b,digits = 2)
b

```

```
m3=202.8158
m4=109.5988
c=m3/(sqrt(m4)**3)
c=round(c,digits = 2)
c

h=108.2655
d=m3/(sqrt(h)**3)
d=round(d,digits = 2)
d
```

R code Exa 5.5.13 Coefficient of kurtosis

```
#PAGE=119
m4=199.3759
m2=8.5275
m3=163.3646
m1=7.7775

a=m4/(m2**2)
a=round(a,digits = 2)
a

b=m3/(m1**2)
b=round(b,digits = 2)
b

a1=35627.2853
a2=109.5988
a3=34757.9616
a4=108.2655

c=a1/(a2**2)
c=round(c,digits = 2)
c
```

```
d=a3/(a4**2)
d=round(d,digits = 2)
d
```

R code Exa 5.5.14 Percentile coefficient of Kurtosis

```
#PAGE=119
q3=290.75
q2=268.25
q=(q3-q2)/2
cat('$',q)

p1=301
p2=258.12
p=p1-p2
cat('$',p)

k=q/p
k=round(k,digits = 2)
k
```

Chapter 6

Elementary Probability Theory

R code Exa 6.1 Events and probability

```r
#PAGE=122
a=c(3,4)
b=c(1:6)
l1=length(a)
l2=length(b)
l=l1/l2
p=1-l
cat(p)
```

R code Exa 6.2 Tossing a coin

```r
#PAGE=122
a=529
b=1000
c=a/b
cat(c)

d=493
```

```
e=(a+d)
f=e/(2*b)
cat(f)
```

R code Exa 6.3 E1 and E2 events

```
#PAGE=123
p1=1/2
p2=1/2
p=p1*p2
cat(p)
```

R code Exa 6.4 Probability that A and B will be alive

```
#PAGE=123
n=20
p=0.7
q=0.5
a=p*q
cat(a)
```

R code Exa 6.5 White and black balls

```
#PAGE=123
w=3
b=2
t=w+b
a=b/t
b=(b-1)/(t-1)
p=a*b
cat(p)
```

R code Exa 6.6 Pair of fair dice

```
#PAGE=124
p1=4/52
p2=4/52
p=p1+p2
cat(p)
```

R code Exa 6.6.1 dice and coin and cards

```
#PAGE=128
a1=c(1,3,5)
n1=6
a=length(a1)/n1
a

b1=c(1,2,3)
b2=c(0,b1)
l1=length(b1)
l2=length(b2)
l=l1/l2
l

n=6
q=52
p=n/q
p

n=6
c=c(c(1,6),c(2,5),c(3,4),c(4,3),c(5,2),c(6,1))
l=length(c)
```

```
l=l/2
p=l/(l*n)
p

n3=100
h=56
h1=n3-h
p=h1/n3
p
```

R code Exa 6.6.3 red white and blue balls

```
#PAGE=129
r=6
w=4
bb=5
x=r+w+bb
a=r/x
a
b=w/x
b
c=bb/x
c
d=1-a
d
e=(r+w)/(x)
e
```

R code Exa 6.6.4 fair dice tossed twice

```
#PAGE=129
l1=(1:6)
l2=(1:6)
```

```
e1=c(4,5,6)
e2=c(1,2,3,4)
len=length(e1)
len2=length(e2)
m1=length(l1)
m2=length(l2)
m=m1*m2
len1=len*len2
p=len1/m
p
```

R code Exa 6.6.5 Deck of 52 cards

```
#PAGE=130
n=52
n1=4
n2=4
p=(n1/n)*(n2/n)
cat(p)

b=(n1)*(n2-1)/(n*(n-1))
cat(b)
```

R code Exa 6.6.6 three balls drawn from a box

```
#PAGE=130
r=6
w=4
b=5
x=r+w+b
y=(r-1)+w+b
z=(r-1)+(w-1)+b

```

```
x1=r/x
x2=w/y
x3=b/z


a=r/x
bb=w/x
c=b/x

a1=a*bb*c
a1

b1=x1*x2*x3
b1
```

R code Exa 6.6.7 Two tosses of a fair dice

```
#PAGE=130
n=4
e1=n+1
e2=n+1
e=e1+e2+1
n1=n2=6
a=e/(n1*n2)
a
```

R code Exa 6.6.8 white and black balls

```
#PAGE=131
w1=4
b1=2
w2=3
b2=5
```

```
x1=w1+b1
x2=w2+b2

a1=(w1/x1)*(w2/x2)
a1

bb2=(b1/x1)*(b2/x2)
bb2

c=(w1/x1)*(b2/x2)+(b1/x1)*(w2/x2)
c
```

R code Exa 6.6.9 games of chess

```
#PAGE=131
a=6
b=4
t=2
n=3
g=a+b+t
a1=a/g
b1=b/g
t1=t/g

p1=a1**n
p1

p2=t1*(1-t1)*t1+(1-t1)*t1*t1+t1*t1*(1-t1)
p2

p3=a1*b1*a1+b1*a1*b1
p3

p4=1-(1-b1)**n
p4
```

R code Exa 6.6.10 probability of girls and boys

```
#PAGE=132
x=c(0:3)
n1=3
p=1/2
q=1-p
p1=(p**n1)
p1
p2=(q**n1)
p2
c=p1*3
c
d=p2*3
d

p=c(p1,c,d,p2)
p
y<- matrix(c(x,p),ncol=4,byrow=TRUE)
colnames(y) <- c(" "," "," "," ")
rownames(y) <- c('Numbers of boys','Probability')
y <- as.table(y)
y
```

R code Exa 6.6.11 Graph of distribution

```
#PAGE=133
x=c(0:3)
n1=3
p=1/2
q=1-p
```

```
p1=(p**n1)
p1
p2=(q**n1)
p2
c=p1*3
c
d=p2*3
d

p=c(p1,c,d,p2)
p
y<- matrix(c(x,p),ncol=4,byrow=TRUE)
colnames(y) <- c(" "," "," "," ")
rownames(y) <- c('Numbers of boys','Probability')
y <- as.table(y)
y
barplot(p,xlab='Number of Boys',ylab='p(X)')
```

R code Exa 6.6.12 Continuous Random Variable

```
#PAGE=133
x=c(0:4)
x1=0
p1=1/2-x1
p1
h=2
h1=h**2
h1
x2=4
x=x2/h
x

a=(1-(1/x))/h1
a
a1=p1-h1*a
```

```
a1

x3=1
x4=2
p3=p1**3
p3

p4=p1-p3
p5=p1**2

b=p1*(p4+p5)
b
```

R code Exa 6.6.13 man purchases a raffle ticket

```
#PAGE=134
w1=5000
w2=2000
p1=0.001
p2=0.003
fair_price=w1*p1+w2*p2
cat('$',fair_price)
```

R code Exa 6.6.14 business venture

```
#PAGE=134
p1=300
p2=100
p11=0.6
p22=0.4
ex=p1*p11-p2*p22
cat('$',ex)
```

R code Exa 6.6.15 probability distribution

```
#page 134
x<-c(8,12,16,20,24)
p<-c(1/8,1/6,3/8,1/4,1/12)
E1=0
len<-length(x)
for( i in 1:len)
{
  E1=E1+x[i]*p[i]
}
cat(E1)

E2=0
for (i in 1:len)
{
  E2=E2+x[i]**2*p[i]
}
cat(E2)

E3=0
for (i in 1:len)
{
  E3=E3+(E1-x[i])**2*p[i]
}
cat(E3)
```

R code Exa 6.6.16 white and black balls

```
#PAGE=134
w=2
b=3
```

```
e=10
n=4
x=w+b
pa=w/x
pa

a=e*pa
a

pab=(b/x)*(w/(x-1))
pab

b=e*pab
b

pabc=(b/x)*(w/(x-1))*((n-2)/(x-2))
pabc

c=pabc*e
c

pd=(b/x)*(w/(x-1))*((n-2)/(x-2))*((n-3)/(x-3))
pd

d=e*pd
d
```

R code Exa 6.6.17 5 different marbles

```
#PAGE=135
a=5
factorial(a)
```

R code Exa 6.6.18 benches and seats

```
#PAGE=135
a=10
b=4
x=factorial(a)
z=factorial(a-b)
ans=x/z
ans
```

R code Exa 6.6.19 permutation

```
#PAGE=135
a1=8
a2=3
a=factorial(a1)/(factorial(a1-a2))
a

b1=6
b2=4
b=factorial(b1)/(factorial(b1-b2))
b

c1=15
c2=1
c=factorial(c1)/(factorial(c1-c2))
c

d1=3
d2=3
d=factorial(d1)/(factorial(d1-d2))
d
```

R code Exa 6.6.20 Men and women

```r
#PAGE=135
m=5
w=4
p1=factorial(m)
p2=factorial(w)
p=p1*p2
p
```

R code Exa 6.6.21 Allowed and not allowed repetitions

```r
#PAGE=136
x=(0:9)
t2=length(x)-1
h=length(x)
t1=length(x)
o=length(x)
a=t2*h*t1*o
a

t3=length(x)-1
h1=length(x)-1
t4=h1-1
o1=t4-1
b=t3*h1*t4*o1
b

t5=length(x)-1
h2=t5-1
t6=h2-1
o2=1
c=t5*h2*t6*o2
c
```

R code Exa 6.6.22 Mathematics physics and chemistry

```
#PAGE=136
m=4
p=6
c=2
n=3
p1=factorial(m)
p2=factorial(p)
p3=factorial(c)
p4=factorial(n)

a=p1*p2*p3*p4
a

m1=1
x=m1+p+c
p5=factorial(x)

b=p5*p1
b
```

R code Exa 6.6.23 red white and blue marbles

```
#PAGE=136
r=5
w=2
b=3
x=r+w+b

a1=factorial(r)
a2=factorial(w)
```

```
a3=factorial(b)
a4=factorial(x)

a=a4/(a2*a3*a1)
a
```

R code Exa 6.6.24 people and round table

```
#PAGE=137
x=7
a=factorial(x-1)
a

y=2
b=factorial(x-y)*factorial(y)
b=a-b
b
```

R code Exa 6.6.25 objects into groups

```
#PAGE=137
o=10
x=4
y=6

a=factorial(o)
b=factorial(x)
c=factorial(y)

m=a/(b*c)
m
```

R code Exa 6.6.26 Evaluation

```
#PAGE=137
x1=7
y1=4
a=factorial(x1)/(factorial(y1)*factorial(x1-y1))
a

x2=6
y2=5
b=factorial(x2)/(factorial(y2)*factorial(x2-y2))
b

x3=4
y3=4
c=factorial(x3)/(factorial(y3)*factorial(x3-y3))
c
```

R code Exa 6.6.27 committee of people

```
#PAGE=138
a=9
b=5
x=factorial(a)/(factorial(b)*factorial(a-b))
x
```

R code Exa 6.6.28 Mathematics and Physics

```
#PAGE=138
```

```
m=5
p=7
m1=2
p1=3

f1=factorial(m)/(factorial(m1)*factorial(m-m1))
f2=factorial(p)/(factorial(p1)*factorial(p-p1))
a=f1*f2
a

p2=p-1
p3=p1-1
f3=factorial(m)/(factorial(m1)*factorial(m-m1))
f4=factorial(p2)/(factorial(p3)*factorial(p2-p3))
b=f3*f4
b

m2=3
f5=factorial(m2)/(factorial(m1)*factorial(m2-m1))
f6=factorial(p)/(factorial(p1)*factorial(p-p1))
c=f5*f6
c
```

R code Exa 6.6.29 Girls and flowers

```
#PAGE=138
x=c(1:5)
y=5
sum=0
for (i in 1:5)
{
  a=factorial(y)/(factorial(i)*factorial(y-i))
  sum=sum+a
}
print(sum)
```

R code Exa 6.6.30 consonants and vowels

```
#PAGE=139
c=7
v=5
c1=4
v1=3
f1=factorial(c)/(factorial(c1)*factorial(c-c1))
f2=factorial(v)/(factorial(v1)*factorial(v-v1))
p=factorial(c)
a=f1*f2*p
a
```

R code Exa 6.6.31 Evaluate 50 factorial

```
#PAGE=139
n=50
e=2.718
pi=3.14
a2=n*(-1)
a1=sqrt(2*pi*n)
a1=a1*(n**n)*(e**a2)
a1

b=log(2*n,10)/2+log(pi,10)/2+n*log(n,10)-n*log(e,10)
b=round(b,0)
b
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 6.6.32 Box of red white and blue balls

```
#PAGE=139
r=8
w=3
b=9
x=r+w+b

a1=r/x
a2=(r-1)/(x-1)
a3=(r-2)/(x-2)
a=a1*a2*a3
a

b1=w/x
b2=(w-1)/(x-1)
b3=(w-2)/(x-2)
b=b1*b2*b3
b

r1=2
w1=1
x1=r1+w1
f1=factorial(r)/(factorial(r1)*factorial(r-r1))
f2=factorial(w)/(factorial(w1)*factorial(w-w1))
f3=factorial(x)/(factorial(x1)*factorial(x-x1))
c=(f1*f2)/f3
c

x2=x-w
f4=factorial(x2)/(factorial(w)*factorial(x2-w))
f5=factorial(x)/(factorial(w)*factorial(x-w))
p1=f4/f5
d=1-p1
d

o=1
b=9
```

```
f6=factorial(r)/(factorial(o)*factorial(r-o))
f7=factorial(w)/(factorial(o)*factorial(w-o))
f8=factorial(b)/(factorial(o)*factorial(b-o))
f9=factorial(x)/(factorial(w)*factorial(x-w))
e=(f6*f7*f8)/f9
e

f1=factorial(w)
f=e/f1
f
```

R code Exa 6.6.33 pack of cards

```
#PAGE=140
c=52
n=5
a1=4
x=c-a1
a2=n-a1
f1=factorial(x)/(factorial(a2)*factorial(x-a2))
f2=factorial(c)/(factorial(n)*factorial(c-n))
f3=factorial(a1)/(factorial(a1)*factorial(a1-a1))
a=(f3*f1)/f2
a

b1=1
f4=factorial(a1)/(factorial(b1)*factorial(a1-b1))
b=(f3*f4)/f2
b

a2=a1-1
a3=a1-2
f5=factorial(a1)/(factorial(a2)*factorial(a1-a2))
f6=factorial(a1)/(factorial(a3)*factorial(a1-a3))
c=(f5*f6)/f2
```

```
c

b1=1
f7=factorial(a1)/(factorial(b1)*factorial(a1-b1))
d=(f7**n)/f2
d

g=4
h=3
c=52
f8=factorial(c/4)/(factorial(a2)*factorial(c/4-a2))
f9=factorial(c/4)/(factorial(a3)*factorial(c/4-a3))
e=(g*f8*h*f9)/f2
e


f10=factorial(x)/(factorial(n)*factorial(x-n))
f=f10/f2
f=1-f
f
```

R code Exa 6.6.34 tossing a fair die

```
#PAGE=141
n=5
r=3
a=1/6
b=1-a
f1=factorial(n)/(factorial(r)*factorial(n-r))
x=a**r
y=b**(n-r)
p=x*y*f1
p
```

R code Exa 6.6.35 Machine and bolts

```r
#PAGE=141
t=10
x=0.2
y=0.8
a1=2
f1=factorial(t)/(factorial(a1)*factorial(t-a1))
a=f1*(x**a1)*(y**(t-a1))
a=round(a,digits=4)
a

m=0
n=1
f2=factorial(t)/(factorial(m)*factorial(t-m))
f3=factorial(t)/(factorial(n)*factorial(t-n))
p1=f2*(x**m)*(y**(t-m))
p2=f3*(x**n)*(y**(t-n))
b=1-p1-p2
b=round(b,digits=4)
b

s=0
for(i in 6:10)
{
  f4=factorial(t)/(factorial(i)*factorial(t-i))*(x**
     i)*(y**(t-i))
  s=s+f4
}
c=round(s,digits=5)
c
```

R code Exa 6.6.36 Defective bolts

```
#PAGE=141
t=10
x=0.2
y=0.8
a1=2
f1=factorial(t)/(factorial(a1)*factorial(t-a1))
a=f1*(x**a1)*(y**(t-a1))
a=round(a,digits=4)
a

m=0
n=1
f2=factorial(t)/(factorial(m)*factorial(t-m))
f3=factorial(t)/(factorial(n)*factorial(t-n))
p1=f2*(x**m)*(y**(t-m))
p2=f3*(x**n)*(y**(t-n))
b=1-p1-p2
b=round(b,digits=4)
b

s=0
for(i in 6:10)
{
  f4=factorial(t)/(factorial(i)*factorial(t-i))*(x**
     i)*(y**(t-i))
  s=s+f4
}
c=round(s,digits=5)
c


N=1000
a=a*N
a

b=b*N
```

```
b=round(b,digits=0)
b

c=c*N
c=round(c,digits = 0)
c
```

R code Exa 6.6.37 Sample space

```
#PAGE=142
x=0
y=0
for(i in 1:6)
{
  for(j in 1:6)
  {
    c=c(i,j);
    print(c);
    if(sum(c)==7) x<-x+1
    if(sum(c)==11) y<-y+1
  }
}
pa=x/(6*6)
pb=y/(6*6)
p=pa+pb
cat(p)
```

R code Exa 6.6.39 Algebra physics and statistics

```
#PAGE=144
t=500
a=329
p=186
```

```
s=295
a_p=83
a_s=217
p_s=63

a1=t-(a+p+s-a_p-a_s-p_s)
a1

t1=a_s-a1
t2=a-a_s
b=t2
b

c=p-a_p
c

d=s-p_s
d

m1=a-a_p-a_s+a1
s1=s-a_s-p_s+a1
n1=a_s-a1
e=m1+s1+n1
e

f=a-a_p-a_s+a1
f
```

R code Exa 6.7 Drawing an ace and a spade

```
#PAGE=124
e1=4
e2=13
e3=1
e4=52
```

```
p=e1/e4+e2/e4-e3/e4
cat(p)
```

R code Exa 6.8 Pair of fair dice

```
#PAGE=124
total_outcoms=36
list=list()
list[[1]]<-c(1,4)
list[[2]]<-c(4,1)
list[[3]]<-c(2,3)
list[[4]]<-c(3,2)
favourable_outcomes=length(list)
n=900
probability=favourable_outcomes/total_outcoms
ans=probability*n
ans
```

R code Exa 6.9 Probability of a man winning

```
#PAGE=125
p=10
p1=1/5
r=p*p1
cat('$',r)
```

R code Exa 6.10 3 Candidates

```
#PAGE=126
n=3
```

```
m=5
a=factorial(m)
cat(a)
b=factorial(m-1)
c=factorial(n)
d=b*c
cat(d)
```

R code Exa 6.12 Number of permutations of letters

```
#PAGE=127
n='statistics'
m=nchar(n)
library(stringr)
a=str_count(n, "s")
b=str_count(n, "t")
c=str_count(n, "a")
d=str_count(n, "i")
e=str_count(n, "c")

v1=factorial(m)
v2=factorial(a)
v3=factorial(b)
v4=factorial(c)
v5=factorial(d)
v6=factorial(e)

ans=v1/(v2*v3*v4*v5*v6)
cat(ans)
```

R code Exa 6.13 Number of combinations

```
#PAGE=127
```

```
library(combinat)
a=combn(letters[1:3],2)
len1=dim(a)[2]
len2=dim(a)[1]
ans=(len1*len2)/factorial(len2)
cat(ans)
```

Chapter 7

The Binomial Normal And Poisson Distributions

R code Exa 7.1 fair coin

```
#PAGE=150
x=6
y=2
f1=factorial(x)/(factorial(y)*factorial(x-y))
a=(1/2)**y
b=(1/2)**(x-y)
c=f1*a*b
c
```

R code Exa 7.2 tossing a fair coin

```
#PAGE=150
x=6
y=4
f1=factorial(x)/(factorial(y)*factorial(x-y))
a=(1/2)**y
```

```
b=(1/2)**(x-y)
c=f1*a*b

y=y+1
f1=factorial(x)/(factorial(y)*factorial(x-y))
a=(1/2)**y
b=(1/2)**(x-y)
d=f1*a*b

y=y+1
f1=factorial(x)/(factorial(y)*factorial(x-y))
a=(1/2)**y
b=(1/2)**(x-y)
e=f1*a*b

f=c+d+e
f
```

R code Exa 7.4 standard deviation

```
#PAGE=150
t=100
p=1/2
q=1-1/2
s=sqrt(t*p*q)
s
```

R code Exa 7.5 fair die toss

```
#PAGE=153
t=12
n=2
s=t/n
```

```
a=factorial(t)/(factorial(n)**s)
b=(1/s)**(2*6)
c=a*b
c=round(c,digits=5)
c
```

R code Exa 7.7.1 Evaluate

```
#PAGE=154
t=5
a=factorial(t)
a

t2=6
t3=2
t4=4
b=factorial(t2)/(factorial(t3)*factorial(t4))
b

t5=8
t6=3
c=factorial(t5)/(factorial(t6)*factorial(t5-t6))
c

t7=7
t8=5
d=factorial(t7)/(factorial(t8)*factorial(t7-t8))
d

t9=4
t10=4
e=factorial(t9)/(factorial(t10)*factorial(t9-t10))
e

t11=4
```

```
t12=0
f=factorial(t11)/(factorial(t12)*factorial(t11-t12))
f
```

R code Exa 7.7.2 tossing a coin three times

```
#PAGE=154
t1=3
t2=t1
a=factorial(t1)/(factorial(t2)*factorial(t1-t2))
a=a*(1/2)**t1*(1/2)**(t1-t2)
a

t1=3
t2=t1-1
b=factorial(t1)/(factorial(t2)*factorial(t1-t2))
b=b*(1/2)**t2*(1/2)**(t1-t2)
b

t1=3
t2=t1-2
c=factorial(t1)/(factorial(t2)*factorial(t1-t2))
c=c*(1/2)**t2*(1/2)**(t1-t2)
c

t1=3
t2=t1-3
d=factorial(t1)/(factorial(t2)*factorial(t1-t2))
d=d*(1/2)**t2*(1/2)**(t1-t2)
d
```

R code Exa 7.7.3 five tosses of a fair die

```
#PAGE=155
t=5
d=3
p=1/6
q=5/6

n1=0
a1=factorial(t)/(factorial(n1)*factorial(t-n1))
a2=(p)**(n1)
a3=q**t
a=a1*a2*a3
a

t1=t-1
n2=n1+1
b1=factorial(t)/(factorial(n2)*factorial(t-n2))
b2=(p)**(n2)
b3=q**t1
b=b1*b2*b3
b

t2=t1-1
n3=n2+1
c1=factorial(t)/(factorial(n3)*factorial(t-n3))
c2=(p)**(n3)
c3=q**t2
c=c1*c2*c3
c

t3=t2-1
n4=n3+1
d1=factorial(t)/(factorial(n4)*factorial(t-n4))
d2=(p)**(n4)
d3=q**t3
d=d1*d2*d3
d

t4=t3-1
```

```
n5=n4+1
e1=factorial(t)/(factorial(n5)*factorial(t-n5))
e2=(p)**(n5)
e3=q**t4
e=e1*e2*e3
e

t5=t4-1
n6=n5+1
f1=factorial(t)/(factorial(n6)*factorial(t-n6))
f2=(p)**(n6)
f3=q**t5
f=f1*f2*f3
f
```

R code Exa 7.7.5 family of 4 children

```
#PAGE=156
c=4
p=1/2
q=1-p
s=0
for(i in 1:4)
{
  f1=factorial(c)/(factorial(i)*factorial(c-i))
  a1=(p**i)*(q**(c-i))
  a=f1*a1
  s=s+a
}
print(s)

b=1-p**4-q**4
b
```

R code Exa 7.7.6 2000 families with 4 children

```
#PAGE=156
n=2000
c=4
a=n*15/c^2
cat(a)
b=n*3/8
cat(b)
nn=1/4+3/8
c=n*nn
cat(c)
c=4
d=n/c^2
cat(d)
```

R code Exa 7.7.7 bolts produced by a machine

```
#PAGE=156
p=0.2
q=1-p
c=4

a1=1
a2=c-a1
f1=factorial(c)/(factorial(a1)*factorial(c-a1))
p1=p**a1
q1=q**a2
a=f1*p1*q1
a

b1=0
```

```
b2=c-b1
f1=factorial(c)/(factorial(b1)*factorial(c-b1))
p1=p**b1
q1=q**b2
b=f1*p1*q1
b

c1=2
c2=c-c1
f1=factorial(c)/(factorial(c1)*factorial(c-c1))
p1=p**c1
q1=q**c2
c3=f1*p1*q1
c3
c=a+b++c3
c
```

R code Exa 7.7.8 college student graduation probability

```
#PAGE=157
m1=0.4
m2=1-m1
n=5
a1=m1^(n-5)*m2^n
cat(a1)
round(a1,2)


c=n-4
d=4
b1=m1^c*m2^d
b1=factorial(n)/(factorial(d)*factorial(c))*b1
cat(b1)
round(b1,2)

```

```

c1=1-a1
cat(c1)
round(c1,2)

c=n
d=n-5
b1=m1^c*m2^d
b1=factorial(n)/(factorial(d)*factorial(c))*b1
cat(b1)
round(b1,2)
```

R code Exa 7.7.9 pair of dice

```
#PAGE=157
c=6
p=1/9
q=8/9

a1=2
a2=c-a1
f1=factorial(c)/(factorial(a1)*factorial(c-a1))
p1=p**a1
q1=q**a2
a=f1*p1*q1
a

b1=0
b2=c-b1
f1=factorial(c)/(factorial(b1)*factorial(c-b1))
p1=p**b1
q1=q**b2
b=f1*p1*q1

c1=1
```

```
c2=c-c1
f1=factorial(c)/(factorial(c1)*factorial(c-c1))
p1=p**c1
q1=q**c2
c=f1*p1*q1

d=b+c
b=1-d
b
```

R code Exa 7.7.12 Defective bolts

```
#PAGE=158
d=0.1
q=1-d
t=400

a=d*t
a

b=q*d*t
b=sqrt(b)
b
```

R code Exa 7.7.13 skewness and kurtosis

```
#PAGE=158
p=0.1
q=1-p
t=400

a=(q-p)/sqrt(t*p*q)
a=round(a,digits=3)
```

```
a

b=3+(1-6*p*q)/(t*p*q)
b=round(b,digits = 2)
b
```

R code Exa 7.7.14 final examination in mathematics

```
#PAGE=159
m=72
s=15

a1=60
a=(a1-m)/s
a

b1=93
b=(b1-m)/s
b

c1=72
c=(c1-m)/s
c
```

R code Exa 7.7.15 grades corresponding to standard scores

```
#PAGE=159
m=72
s=15

a1=-1
a=m+a1*s
a
```

```
b1=1.6
b=m+b1*s
b
```

R code Exa 7.7.16 Examination in English

```
#PAGE=159
s1=0.8
s2=-0.4
g1=88
g2=64

a <- matrix(c(1,1,s2,s1),nrow=2,ncol=2)
b <- matrix(c(64,88),nrow=2,ncol=1)

solve(a,b)
```

R code Exa 7.7.17 Area under normal curve

```
#PAGE=159
z1=0
z2=1.2
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a=a1-a2
a=round(a,4)
cat(a)

z1=-0.68
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
```

```
a=a1-a2
b=round(a,4)
cat(b)

z1=-0.46
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
z3=2.21
a4=pnorm(z3,0,1)
a5=a4-a2
a5=round(a5,4)
cat(a5)

z1=0.81
z2=1.94
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
a3=round(a3,4)
cat(a3)

z1=-0.6
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
e=a1-a3
e=round(e,4)
cat(e)


z1=-1.28
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
```

```
a3=a3+a1
a3=round(a3,4)
cat(a3)

z1=-1.44
z2=0
z3=2.05
a1=pnorm(z1,0,1)
a2=pnorm(z2,0,1)
a3=pnorm(z3,0,1)
a4=a3-a2
a5=a2-a1
a4=round(a4,4)
a5=round(a5,4)
g=1-a4-a5
cat(g)


#"The answer may slightly vary due to rounding off values."
```

R code Exa 7.7.18 Determining z value

```
#PAGE=160
z1=0
b=pnorm(z1)
c=0.377
a=b+c
a=qnorm(a)
a=round(a,2)
cat('+-',a)


z2=0
a1=pnorm(z2,0,1)
```

```
e=0.8621
a2=e
e=qnorm(e)
e=round(e,2)
cat(e)



z1=-1.5
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
a5=0.0217
a4=a5+a2
a6=qnorm(a4)
a6=round(a6,2)
cat(a6)
a7=a5-a2
a7=(a7*(-1))
a8=qnorm(a7)
a8=round(a8,2)
cat(a8)
```

R code Exa 7.7.19 Ordinate of the normal curve

```
#PAGE=161
z1=0.84
z1=dnorm(z1)
z1=round(z1,4)
cat(z1)

z2=-1.27
z2=dnorm(z2)
z2=round(z2,4)
```

```
cat(z2)

z3=-0.05
z3=dnorm(z3)
z3=round(z3,4)
cat(z3)
```

R code Exa 7.7.20 500 male students and problem solving

```
#PAGE=161
n=500
t=151
s=15
a1=120
a2=155
a3=0.5
a1=a1-a3
a2=a2+a3
a3=(a1-t)/s
a4=(a2-t)/s

z1=a3
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
z3=a4
a4=pnorm(z3,0,1)
a5=a4-a2
a5=round(a5,4)
a5=a5*n
cat(a5)


b1=185
```

```
b2=0.5
b3=b1+b2
b3=(b3-t)/s
z1=b3
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
a3=a1+a3
a3=a3=a3*n
a3=round(a3,0)
cat(a3)
```

R code Exa 7.7.21 500 students

```
#PAGE=162
n=128
m=0.5
a1=n-m
a1
t=500
t1=151
v=15
a2=(a1-t1)/v
a2=round(a2,2)
a2


z1=a2
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
e=a1-a3
e=round(e,4)
```

```
e
e=t*e
e=round(e,0)
cat(e)


b1=n+m
b1=(b1-t1)/v
b2=n-m
b2=(b2-t1)/v
b2=round(b2,2)

z1=b2
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
z3=b1
a4=pnorm(z3,0,1)
a5=a4-a2
a5=round(a5,4)
a5
a5=a5*t
a5=round(a5,0)
cat(a5)


c1=n+m
c1=(c1-t1)/v
c1=round(c1,2)
z1=c1
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
e=a1-a3
e=round(e,4)
e
```

```
e=e*t
e=round(e,0)
cat(e)
```

R code Exa 7.7.22 Quiz in Biology

```
#PAGE=163
g=c(0:10)
n=10
m=6.7
sd=1.2
d=0.5

a=6
a1=a-d
a2=a+d
a3=(a1-m)/sd
a4=(a2-m)/sd
a4=round(a4,2)
z1=a3
z2=a4
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=a1-a2
a3=round(a3,4)
a3=a3*100
a3=round(a3,0)
cat(a3,'%')


z1=10/100
e=qnorm(z1)
x=(e*sd)+m
x=round(x,0)
cat(x)
```

```
e=e*(-1)
x=(e*sd)+m
x=round(x,0)
cat(x)
```

R code Exa 7.7.23 Sample of 200 washers

```
#PAGE=164
s=200
m=5.02
sd=0.05
d1=4.96
d2=5.08
s1=(d1-m)/sd
s2=(d2-m)/sd

z1=s2
z2=0
a1=pnorm(z2,0,1)
a2=pnorm(z1,0,1)
a3=-a1+a2
e=round(a3,4)
e=e*2
e=e*100
e=round(e,0)
cat(e,'%')
f=100-e
cat(f,'%')
```

R code Exa 7.7.24 10 tosses of fair coin

```
#PAGE=164
```

```
a=3
b=6
n=10
p1=factorial(n)/(factorial(a)*factorial(n-a))
p1=p1*((1/2)**a)*((1/2)**(n-a))

a=a+1
p2=factorial(n)/(factorial(a)*factorial(n-a))
p2=p2*((1/2)**a)*((1/2)**(n-a))

a=a+1
p3=factorial(n)/(factorial(a)*factorial(n-a))
p3=p3*((1/2)**a)*((1/2)**(n-a))

a=a+1
p4=factorial(n)/(factorial(a)*factorial(n-a))
p4=p4*((1/2)**a)*((1/2)**(n-a))

p=p1+p2+p3+p4
p=round(p,4)
p

p=1/2
q=1-p
s=sqrt(n*p*q)
s=round(s,2)

u=n/2
a=3
b=6
d=0.5
a=a-d
b=b+d
c1=(a-u)/s
c2=(b-u)/s
c1=round(c1,2)
c2=round(c2,2)

```

```
z1=c1
z2=0
z3=c2
a1=pnorm(z1,0,1)
a2=pnorm(z2,0,1)
a3=pnorm(z3,0,1)
a4=a3-a2
a5=a2-a1
g=a4+a5
g=round(g,4)
cat(g)

#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 7.7.25 fair coin

```
#PAGE=165
n=500
p=1/2
q=1-p
d=250
u=sqrt(n*p*q)
u=round(u,digits=2)


x=10
a1=d+x+p
a2=d-x-p

s1=(d-a2)/u
s1=round(s1,digits = 2)
s1=pnorm(s1,mean=0)
```

```
s2=(d-a1)/u
s2=round(s2,digits = 2)
s2=pnorm(s2,mean=0)

s=s1-s2
s=round(s,digits=4)
s

x=30
b1=d+x+p
b2=d-x-p

s1=(d-b2)/u
s1=round(s1,digits = 2)
s1=pnorm(s1,mean=0)

s2=(d-b1)/u
s2=round(s2,digits = 2)
s2=pnorm(s2,mean=0)

s=s1-s2
s=round(s,digits=4)
s
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 7.7.26 Die tossed 120 times

```
#PAGE=166
n=120
m=4
d=0.5
d1=0
d2=18
```

```
d1=d1-d
d2=d2+d

p=1/6
q=1-p
u=n*p
s=sqrt(n*p*q)
s=round(s,2)
a1=(d1-u)/s
b1=(d2-u)/s
b1=round(b1,2)


z1=a1
z2=0
z3=b1
a1=pnorm(z1,0,1)
a2=pnorm(z2,0,1)
a3=pnorm(z3,0,1)
a4=a3-a2
a5=a2-a1
g=a4+a5
cat(g)


n=120
m=4
d=0.5
d1=0
d2=14
d1=d1-d
d2=d2+d

p=1/6
q=1-p
u=n*p
s=sqrt(n*p*q)
s=round(s,2)
```

```
a1=(d1-u)/s
b1=(d2-u)/s
b1=round(b1,2)


z1=a1
z2=0
z3=b1
a1=pnorm(z1,0,1)
a2=pnorm(z2,0,1)
a3=pnorm(z3,0,1)
a4=a3-a2
a5=a2-a1
g=a4+a5
g=round(g,4)
cat(g)
```

R code Exa 7.7.27 tools from a manufacturing process

```
#PAGE=166
p=0.1
t=10
n=2
f1=factorial(t)/(factorial(n)*factorial(t-n))
a1=(p)**n
b1=(1-p)**(t-n)
a=f1*a1*b1
a=round(a,digits=4)
a
a=round(a,digits=2)
a

e=2.718
l=t*p
p1=(l**n*e**(-l))/factorial(n)
```

```
p1=round(p1,digits=2)
p1
```

R code Exa 7.7.28 bad reaction from injection

```
#PAGE=167
n=2000
p=0.001
x1=3
e=2.718

l=n*p
a=(l**x1*e**(-l))/factorial(x1)
a=round(a,digits = 3)
a

b=0
for(i in 0:2)
{
  s=(l**i*e**(-l))/factorial(i)
  b=b+s
}

b=1-b
b=round(b,digits=3)
b
```

R code Exa 7.7.29 poisson distribution

```
#PAGE=167
l=0.72
e=2.718
x1=0
```

```
b=(l**x1*e**(-l))/factorial(x1)
b=round(b,digits=4)
b

x2=1
c=(l**x2*e**(-l))/factorial(x2)
c=round(c,digits=4)
c

x3=2
d=(l**x3*e**(-l))/factorial(x3)
d=round(d,digits=4)
d

x4=3
f=(l**x4*e**(-l))/factorial(x4)
f=round(f,digits=4)
f
```

R code Exa 7.7.30 red white and blue balls

```
#PAGE=168
r=5
w=4
b=3
x=r+w+b
r1=3
w1=2
b1=1
x2=r1+w1+b1
p=(factorial(x2))/(factorial(r1)*factorial(w1)*
    factorial(b1))*((r/x)**r1)*((w/x)**w1)*((b/x)**b1
    )
p
```

R code Exa 7.7.31 Binomial Distribution

```r
#PAGE=168
n=c(0:5)
t=c(38,144,342,287,164,25)
s=sum(t)
s1=n*t
s1=sum(s1)
a=s1/s
cat(a)
b=5
b1=a/b
cat(b1)

c=n[1]
p1=(factorial(b)/(factorial(c)*factorial(b-c)))*(b1**c)*((1-b1)**(b-c))
p1=round(p1,4)

c=n[2]
p2=(factorial(b)/(factorial(c)*factorial(b-c)))*(b1**c)*((1-b1)**(b-c))
p2=round(p2,4)

c=n[3]
p3=(factorial(b)/(factorial(c)*factorial(b-c)))*(b1**c)*((1-b1)**(b-c))
p3=round(p3,4)

c=n[4]
p4=(factorial(b)/(factorial(c)*factorial(b-c)))*(b1**c)*((1-b1)**(b-c))
p4=round(p4,4)

```

```
c=n[5]
p5=(factorial(b)/(factorial(c)*factorial(b-c)))*(b1**c)*((1-b1)**(b-c))
p5=round(p5,4)

c=n[6]
p6=(factorial(b)/(factorial(c)*factorial(b-c)))*(b1**c)*((1-b1)**(b-c))
p6=round(p6,4)

p=c(p1,p2,p3,p4,p5,p6)
pf=p*1000
pf1=round(pf,0)
t=c(38,144,342,287,164,25)

y <- matrix(c(n,p,pf,t),nrow=6,byrow=FALSE)
colnames(y) <- c("Number of heads","Pr(X heads)","Expected Frequency","Observed Frequency")
rownames(y) <- c(" "," "," "," "," "," ")
y <- as.table(y)
y
```

R code Exa 7.7.32 Probability graph

```
#PAGE=169
w2=c(62,65,68,71,74)
d=0.5
w2=w2+d
f=c(5,18,42,27,8)
f0=f[1]
f1=f0+f[2]
f2=f1+f[3]
f3=f2+f[4]
f4=f3+f[5]
f=c(f0,f1,f2,f3,f4)
```

```
plot(w2,f,xlab = 'Weight(kg)',ylab = 'Relative
    cumulative frequency')
```

R code Exa 7.7.33 Normal curve of data

```
#PAGE=169
w1=c(60,63,66,69,72)
w2=c(62,65,68,71,74)
d=0.5
w3=w1-d
w3[6]=w3[5]+d*6
w3
f=c(5,18,42,27,8)
x=67.45
s=2.92
z=(w3-x)/s
zz=round(z,digits = 2)
zz
z1=0
a1=pnorm(z1)
a2=pnorm(zz)
z=-a2+a1
z=round(z,4)
z=abs(z)
z

l1=z[1]-z[2]
l2=z[2]-z[3]
l3=z[3]+z[4]
l4=z[4]-z[5]
l5=z[5]-z[6]
l=c(l1,l2,l3,l4,l5)
l=abs(l)
exp=l*100
```

```r

l=round(l,4)
exp=round(exp,2)
w11=c(w1[1],'-',w2[1])
w12=c(w1[2],'-',w2[2])
w13=c(w1[3],'-',w2[3])
w14=c(w1[4],'-',w2[4])
w15=c(w1[5],'-',w2[5])

wid=c(w11,w12,w13,w14,w15,'-')
w1=c(w1,'-')
w2=c(w2,'-')
exp=c(exp,'-')
l=c(l,'-')
f=c(f,'-')
y <- matrix(c(w1,w2,w3,zz,z,l,exp,f),ncol=8,byrow=FALSE)
colnames(y) <- c(" Weight1","Weight2","X","z"," Area under normal curve"," Area for each class"," Expected Frequency","Observed Frequency")
rownames(y) <- c(" "," "," "," "," "," ")
y <- as.table(y)
y
```

R code Exa 7.7.34 Automobile Accidents

```r
#PAGE=170
x=c(0,1,2,3,4)
f=c(21,18,7,3,1)
s=sum(f)
a=sum(f*x)/s
cat(a)

c=x[1]
p1=(a^c)*(2.718)**(-0.9)/factorial(c)
```

```
p1=round(p1,4)
c=x[2]
p2=((a^c)*(2.718)**(-0.9))/factorial(c)
p2=round(p2,4)
c=x[3]
p3=((a^c)*(2.718)**(-0.9))/factorial(c)
p3=round(p3,4)
c=x[4]
p4=((a^c)*(2.718)**(-0.9))/factorial(c)
p4=round(p4,4)
c=x[5]
p5=((a^c)*(2.718)**(-0.9))/factorial(c)
p5=round(p5,4)
pr=c(p1,p2,p3,p4,p5)

t=50
exp=t*pr
exp=round(exp,0)


y <- matrix(c(x,pr,exp,f),ncol=4,byrow=FALSE)
colnames(y) <- c("Number of Accidents","Pr(X)","
   Expected number of days","Actual number of days")
rownames(y) <- c(" "," "," "," "," ")
y <- as.table(y)
y
```

Chapter 8

Elementary Sampling Theory

R code Exa 8.8.1 population of sample

```
#PAGE=179
f=c(2,3,6,8,11)
a=mean(f)
cat(a)

b1=sum((f-a)**2)/5
b=sqrt(b1)
b=round(b,2)
cat(b)

a1=c(2,2)
a1=mean(a1)
a2=c(2,3)
a2=mean(a2)
a3=c(2,6)
a3=mean(a3)
a4=c(2,8)
a4=mean(a4)
a5=c(2,11)
a5=mean(a5)

```

```
b1=c(3,2)
b1=mean(b1)
b2=c(3,3)
b2=mean(b2)
b3=c(3,6)
b3=mean(b3)
b4=c(3,8)
b4=mean(b4)
b5=c(3,11)
b5=mean(b5)

c1=c(6,2)
c1=mean(c1)
c2=c(6,3)
c2=mean(c2)
c3=c(6,6)
c3=mean(c3)
c4=c(6,8)
c4=mean(c4)
c5=c(6,11)
c5=mean(c5)

d1=c(8,2)
d1=mean(d1)
d2=c(8,3)
d2=mean(d2)
d3=c(8,6)
d3=mean(d3)
d4=c(8,8)
d4=mean(d4)
d5=c(8,11)
d5=mean(d5)

e1=c(11,2)
e1=mean(e1)
e2=c(11,3)
e2=mean(e2)
e3=c(11,6)
```

```
e3=mean(e3)
e4=c(11,8)
e4=mean(e4)
e5=c(11,11)
e5=mean(e5)

c=c(a1,a2,a3,a4,a5,b1,b2,b3,b4,b5,c1,c2,c3,c4,c5,d1,
   d2,d3,d4,d5,e1,e2,e3,e4,e5)
c1=sum(c)
c2=sum(c)/length(c)
cat(c2)

m1=sum((c-c2)**2)
m1=m1/25
d=sqrt(m1)
d=round(d,2)
cat(d)
```

R code Exa 8.8.2 sampling without replacement

```
#PAGE=180
f=c(2,3,6,8,11)
a=mean(f)
cat(a)

b1=sum((f-a)**2)/5
b=sqrt(b1)
b=round(b,2)
cat(b)

a2=c(2,3)
a2=mean(a2)
a3=c(2,6)
a3=mean(a3)
a4=c(2,8)
```

```
a4=mean(a4)
a5=c(2,11)
a5=mean(a5)
b3=c(3,6)
b3=mean(b3)
b4=c(3,8)
b4=mean(b4)
b5=c(3,11)
b5=mean(b5)
c4=c(6,8)
c4=mean(c4)
c5=c(6,11)
c5=mean(c5)
d5=c(8,11)
d5=mean(d5)
cc=c(a2,a3,a4,a5,b3,b4,b5,c4,c5,d5)

cc1=sum(cc)/length(cc)
cat(cc1)

d1=sum((cc-cc1)**2)/length(cc)
d=sqrt(d1)
d=round(d,2)
cat(d)
```

R code Exa 8.8.3 weights of 3000 male students

```
#PAGE=180
n=3000
m=66
sd=3
s=25
a1=m
a1
a2=sd/sqrt(s)
```

```
a2

b1=m
b1
b2=(sd/sqrt(s))*(sqrt((n-s)/(n-1)))
b2=round(b2,digits=1)
b2
```

R code Exa 8.8.4 mean of samples

```
#PAGE=181
n=3000
m=66
sd=3
s=25
s=25
a1=m
a1
a2=sd/sqrt(s)
a2
x=64.8
y=66.3
a3=(x-a1)/a2
a3
a4=(y-a1)/a2
a4
z1=pnorm(a3,lower.tail = F)
z2=pnorm(a4,lower.tail = F)
z=z1-z2
z=round(z,digits = 4)
z

x=seq(-4,4,length=200)
y=1/sqrt(2*pi)*exp(-x^2/2)
plot(x,y,type="l",lwd=2,col="black")
```

```
x=seq(a3,a4,length=200)
y=dnorm(x)
polygon(c(a3,x,a4),c(0,y,0),col="gray")

c=64.4
a5=(c-a1)/a2
a5=round(a5,digits = 2)
a5
z3=pnorm(a5,lower.tail = T)
z3=round(z3,digits = 4)
z3

x=seq(-4,4,length=200)
y=1/sqrt(2*pi)*exp(-x^2/2)
plot(x,y,type="l",lwd=2,col="black")
x=seq(-4,a5,length=200)
y=dnorm(x)
polygon(c(-4,x,a5),c(0,y,0),col="gray")
```

R code Exa 8.8.5 500 ball bearings

```
#PAGE=181
w=5.02
sd=0.3
n=100
a1=496
a2=500
a3=510

s=(sd/sqrt(n))*(sqrt((a2-n)/(a2-1)))
s=round(s,digits = 3)


x1=((a1/n-w)/s)
x1=round(x1,digits = 2)
```

```
x1

x2=((a2/n-w)/s)
x2=round(x2,digits = 2)
x2

c1=pnorm(x1,lower.tail = F)
c2=pnorm(x2,lower.tail = F)
c=c1-c2
c=round(c,digits = 4)
c
x=seq(-4,4,length=200)
y=1/sqrt(2*pi)*exp(-x^2/2)
plot(x,y,type="l",lwd=2,col="black")
x=seq(x1,x2,length=200)
y=dnorm(x)
polygon(c(x1,x,x2),c(0,y,0),col="gray")

x3=((a3/n-w)/s)
x3=round(x3,digits = 2)
x3
c3=pnorm(x3,lower.tail = F)
c3=round(c3,digits = 4)
c3

x=seq(-4,4,length=200)
y=1/sqrt(2*pi)*exp(-x^2/2)
plot(x,y,type="l",lwd=2,col="black")
x=seq(x3,4,length=200)
y=dnorm(x)
polygon(c(x3,x,4),c(0,y,0),col="gray")
```

R code Exa 8.8.6 Random samples of students

```
#PAGE=182
```

```
w1=c(60,63,66,69,72)
w2=c(62,65,68,71,74)
f=c(5,18,42,27,8)
m=(w1+w2)/2
a=mean(m)


s1=sample(0:100,4)
s1=toString(s1)
s2=sample(0:100,4)
s2=toString(s2)
s3=sample(0:100,4)
s3=toString(s3)
s4=sample(0:100,4)
s4=toString(s4)
s5=sample(0:100,4)
s5=toString(s5)
s6=sample(0:100,4)
s6=toString(s6)
s7=sample(0:100,4)
s7=toString(s7)
s8=sample(0:100,4)
s8=toString(s8)
s9=sample(0:100,4)
s9=toString(s9)
s10=sample(0:100,4)
s10=toString(s10)
s11=sample(0:100,4)
s11=toString(s11)
s12=sample(0:100,4)
s12=toString(s12)
s13=sample(0:100,4)
s13=toString(s13)
s14=sample(0:100,4)
s14=toString(s14)
s15=sample(0:100,4)
s15=toString(s15)
s16=sample(0:100,4)
```

```
s16=toString(s16)
s17=sample(0:100,4)
s17=toString(s17)
s18=sample(0:100,4)
s18=toString(s18)
s19=sample(0:100,4)
s19=toString(s19)
s20=sample(0:100,4)
s20=toString(s20)
s21=sample(0:100,4)
s21=toString(s21)
s22=sample(0:100,4)
s22=toString(s22)
s23=sample(0:100,4)
s23=toString(s23)
s24=sample(0:100,4)
s24=toString(s24)
s25=sample(0:100,4)
s25=toString(s25)
s26=sample(0:100,4)
s26=toString(s26)
s27=sample(0:100,4)
s27=toString(s27)
s28=sample(0:100,4)
s28=toString(s28)
s29=sample(0:100,4)
s29=toString(s29)
s30=sample(0:100,4)
s30=toString(s30)
s=c(s1,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12,s13,s14,
   s15,s16,s17,s18,s19,s20,s21,s22,s23,s24,s25,s26,
   s27,s28,s29,s30)

c1=sample(m,4)
c2=sample(m,4)
c3=sample(m,4)
c4=sample(m,4)
c5=sample(m,4)
```

```
c6=sample(m,4)
c7=sample(m,4)
c8=sample(m,4)
c9=sample(m,4)
c10=sample(m,4)
c11=sample(m,4)
c12=sample(m,4)
c13=sample(m,4)
c14=sample(m,4)
c15=sample(m,4)
c16=sample(m,4)
c17=sample(m,4)
c18=sample(m,4)
c19=sample(m,4)
c20=sample(m,4)
c21=sample(m,4)
c22=sample(m,4)
c23=sample(m,4)
c24=sample(m,4)
c25=sample(m,4)
c26=sample(m,4)
c27=sample(m,4)
c28=sample(m,4)
c29=sample(m,4)
c30=sample(m,4)

c=c(c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12,c13,c14,
    c15,c16,c17,c18,c19,c20,c21,c22,c23,c24,c25,c26,
    c27,c28,c29,c30)

h1=mean(c1)
h2=mean(c2)
h3=mean(c3)
h4=mean(c4)
h5=mean(c5)
h6=mean(c6)
h7=mean(c7)
h8=mean(c8)
```

```
h9=mean(c9)
h10=mean(c10)
h11=mean(c11)
h12=mean(c12)
h13=mean(c13)
h14=mean(c14)
h15=mean(c15)
h16=mean(c16)
h17=mean(c17)
h18=mean(c18)
h19=mean(c19)
h20=mean(c20)
h21=mean(c21)
h22=mean(c22)
h23=mean(c23)
h24=mean(c24)
h25=mean(c25)
h26=mean(c26)
h27=mean(c27)
h28=mean(c28)
h29=mean(c29)
h30=mean(c30)

h=c(h1,h2,h3,h4,h5,h6,h7,h8,h9,h10,h11,h12,h13,h14,
   h15,h16,h17,h18,h19,h20,h21,h22,h23,h24,h25,h26,
   h27,h28,h29,h30)


c1=toString(c1)
c2=toString(c2)
c3=toString(c3)
c4=toString(c4)
c5=toString(c5)
c6=toString(c6)
c7=toString(c7)
c8=toString(c8)
c9=toString(c9)
c10=toString(c10)
```

```r
c11=toString(c11)
c12=toString(c12)
c13=toString(c13)
c14=toString(c14)
c15=toString(c15)
c16=toString(c16)
c17=toString(c17)
c18=toString(c18)
c19=toString(c19)
c20=toString(c20)
c21=toString(c21)
c22=toString(c22)
c23=toString(c23)
c24=toString(c24)
c25=toString(c25)
c26=toString(c26)
c27=toString(c27)
c28=toString(c28)
c29=toString(c29)
c30=toString(c20)

c=c(c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12,c13,c14,c15,c16,c17,c18,c19,c20,c21,c22,c23,c24,c25,c26,c27,c28,c29,c30)


y <- matrix(c(s,c,h),nrow=30,ncol=3,byrow=FALSE)
colnames(y) <- c("Sample Number drawn","Corresponding Weight","Mean Weight")
rownames(y) <- c("1. ","2. ","3. ","4. ","5. ","6. ","7. ","8. ","9. ","10. ","11. ","12. ","13. ","14. ","15. ","16. ","17. ","18. ","19. ","20. ","21. ","22. ","23. ","24. ","25. ","26. ","27. ","28. ","29. ","30. ")
y <- as.table(y)
y
```

```
c=0.75
fu=23
n=30
fu2=123

m1=a+(c*fu)/n
m1=round(m1,2)
cat(m1,'kg')

sd=c*sqrt(fu2/n-(fu/n)**2)
sd=round(sd,2)
cat(sd,'kg')

s1=2.92
n=4
c=s1/sqrt(n)
cat(c,'kg')
```

R code Exa 8.8.7 120 tosses of a fair coin

```
#PAGE=184
t=120
a1=40/100
a2=60/100
p=1/2
q=1-p
d=0.5
t1=t*a1
t2=t*a2

t1=t1-d
t2=t2+d
u=t*p
s=sqrt(t*p*q)
```

```
z1=(t1-t/2)/s
z2=(t2-t/2)/s

z1=pnorm(z1)
z2=pnorm(0)
z=2*(z2-z1)
z=round(z,4)
cat(z)


n1=5/8
u1=p
sp=sqrt((p*q)/t)
n2=1/(2*t)
b=(n1-n2-u1)/sp
b=round(b,2)
cat(b)

z1=pnorm(b)
z1=round(z1,4)
z1=1-z1
cat(z1)
```

R code Exa 8.8.8 Group of 500 people

```
#PAGE=185
t=120
a1=40/100
a2=60/100
p=1/2
q=1-p
d=0.5
t1=t*a1
t2=t*a2
N=500
```

```
t1=t1-d
t2=t2+d
u=t*p
s=sqrt(t*p*q)
z1=(t1-t/2)/s
z2=(t2-t/2)/s

z1=pnorm(z1)
z2=pnorm(0)
z=2*(z2-z1)
z=round(z,4)
z=z*N
z=round(z,0)
z4=N-z
cat(z)
cat(z4)


n1=5/8
u1=p
sp=sqrt((p*q)/t)
n2=1/(2*t)
b=(n1-n2-u1)/sp
b=round(b,2)
cat(b)

z1=pnorm(b)
z1=round(z1,4)
z1=1-z1
z1=N*z1
cat(z1)
```

R code Exa 8.8.9 Machine and tools

```
#page 185
u=p=2/100
no_of_tools=n=400
v1<-sqrt((p*(1-p))/n)
v1
x<-1/(2*n)
x
a<-3/100
a
z_value=(a-x-u)/v1
z_value
p1<-pnorm(-abs(z_value))
p<-round(p1,digits=4)
p

u=p=2/100
no_of_tools=n=400
v1<-sqrt((p*(1-p))/n)
v1
x<-1/(2*n)
x
b<-2/100
z_value_2<-(b+x-u)/v1
z_value_2<-round(z_value_2,digits=2)
z_value_2
p2<-pnorm(abs(z_value_2))
p<-round(p2,digits=4)
p
```

R code Exa 8.8.10 Election returns

```
#PAGE=186
p=0.46
q=1-p

```

```
a1=200
s=sqrt(p*q/a1)
s=round(s,digits = 4)

m=1/(2*a1)
n=0.5

s1=m+n

s2=(s1-p)/s
s2=round(s2,digits = 2)
a=pnorm(s2,mean=0,sd=1,lower.tail=F)
a=round(a,digits=4)
a

b1=1000
c=sqrt(p*q/b1)
c=round(c,digits = 4)

c1=(s1-p)/c
c1=round(c1,digits=2)
b=pnorm(c1,mean=0,sd=1,lower.tail=F)
b=round(b,digits=4)
b
```

R code Exa 8.8.11 Elements of the population

```
#PAGE=186
u1=c(3,7,8)
u2=c(2,4)
m1=mean(u1)
m1
m2=mean(u2)
m2

```

```
u4=u1-u2[2]
u4
u3=u1-u2[1]
u3
u=c(u3,u4)
u
x=matrix(u,ncol=2,nrow=3)
v=t(x)
v
c=mean(v)
c

d1=(u1[1]-m1)**2
d2=(u1[2]-m1)**2
d3=(u1[3]-m1)**2
d=(d1+d2+d3)/3
d=sqrt(d)
d

e1=(u2[1]-m2)**2
e2=(u2[2]-m2)**2
e=(e1+e2)/2
e

f1=(u[1]-c)**2
f2=(u[2]-c)**2
f3=(u[3]-c)**2
f4=(u[4]-c)**2
f5=(u[5]-c)**2
f6=(u[6]-c)**2
f=(f1+f2+f3+f4+f5+f6)/length(u)
f=sqrt(f)
f
```

R code Exa 8.8.12 Electric light bulbs

```
#PAGE=187
l1=1400
s1=200
l2=1200
s2=100
n=125
l=l1-l2
s=sqrt((s1**2+s2**2)/n)


a1=160
a2=(a1-s1)/s
a=pnorm(a2,mean=0,sd=1,lower.tail=F)
a=round(a,digits=4)
a

b1=250
b2=(b1-s1)/s
b=pnorm(b2,mean=0,sd=1,lower.tail=F)
b=round(b,digits=4)
b
```

R code Exa 8.8.13 Ball bearing

```
#PAGE=188
m1=0.5
m2=0.5
s1=0.02
s2=s1
n1=1000
n2=n1
m=m1-m2
s=(s1**2)/n1+(s2**2)/n2
s=sqrt(s)
s=round(s,6)
```

```
cat(s)
a=2
a1=a/n1
a2=-a1
a3=(a1-0)/s
a4=(a2-0)/s
a3=round(a3,2)
a4=round(a4,2)
cat(a3)
cat(a4)
ans=2*(m1-0.4871)
cat(ans)
```

R code Exa 8.8.14 heads and tails

```
#PAGE=188
p=1/2
q=1/2
a=50
b=50
t=5
m=a-b
s=sqrt((2*p*q)/a)
t1=t-p
p=t1/a

p1=(p-m)/s
x=pnorm(p1,lower.tail = F)
x=round(x,digits = 4)
x
y=1-x
y
```

R code Exa 8.8.15 Two distances with different standard deviation

```
#PAGE=188
u1=273
u2=156
s1=1.6
s2=0.8
a1=u1+u2
cat(a1, 'mm')
a2=sqrt(s1**2+s2**2)
a2=round(a2,digits = 1)
cat(a2, 'mm')

b1=u1-u2
cat(b1, 'mm')
b2=sqrt(s1**2+s2**2)
b2=round(b2,digits = 1)
cat(b2, 'mm')
```

R code Exa 8.8.16 Electric light bulb

```
#PAGE=189
u1=u2=u3=1500
u=u1+u2+u3
s1=s2=s3=150
s=sqrt(s1**2*3)
s=round(s,digits = 0)
s
a1=5000
a2=(a1-u)/s
a2=round(a2,digits = 2)
a2
a=pnorm(a2,lower.tail=F)
a=round(a,digits=4)
a
```

```
b1=4200
b2=(b1-u)/s
b2=round(b2,digits = 2)
b2
b=pnorm(b2,lower.tail = T)
b=round(b,digits = 4)
b
```

R code Exa 8.8.17 Mean and Standard deviation

```
#PAGE=189
c=c
  (0,0.25,4,9,20.25,0.25,0,2.25,6.25,16,4,2.25,0,1,6.25,9,6.25,1,0,

u=sum(c)/length(c)
cat(u)

c1=(c-u)**2
c1=sum(c1)
c2=c1/length(c)
c2=sqrt(c2)
c2=round(c2,2)
cat(c2)
#"The answer provided in the textbook is wrong."
```

R code Exa 8.8.18 Sampling without replacement

```
#PAGE=190
c=c
  (0,0.25,4,9,20.25,0.25,0,2.25,6.25,16,4,2.25,0,1,6.25,9,6.25,1,0,

```

```
m2 <- matrix(c, 5, 5)
  lower.tri(m2)
  m2[lower.tri(m2)] <- NA

c1=m2[upper.tri(m2)]

u=sum(c1)/length(c1)
cat(u)


c11=(c1-u)**2
c11=sum(c11)
c2=c11/length(c1)
c2=sqrt(c2)
c2=round(c2,2)
cat(c2)
```

R code Exa 8.8.19 Sampling distribution of standard deviation

```
#PAGE=190
s=200
n=5
u=n
cat(u,'kg')

s1=n/sqrt(2*s)
cat(s1,'kg')
```

R code Exa 8.8.20 Percentage of the samples

```
#PAGE=190
s=200
n=5
```

```
s1=0.25
a1=5.5
z=(a1-n)/s1
z1=pnorm(z)
z2=pnorm(0)
z3=z2-z1
z3=z2+z3
z3=round(z3,4)
cat(z3)
z3=z3*100
z3=round(z3,1)
cat(z3,'%')


b1=4.4
z4=(b1-n)/s1
z1=pnorm(z4)
z2=pnorm(0)
z3=z2-z1
z3=round(z3,4)
z3=0.5-z3
cat(z3)
z3=z3*100
z3=round(z3,1)
cat(z3,'%')
```

Chapter 9

Statistical Estimation Theory

R code Exa 9.9.2 sample of five measurements

```
#PAGE=197
x=c(63.3,63.7,63.6,63.2,63.7)
a=mean(x)
cat(a,'mm')
len=length(x)

b=(x-a)**2
b=sum(b)
b=b/(len-1)
cat(b,'mm^2')
s=sqrt(b)
s=round(s,digits=2)
cat(s,'mm')
```

R code Exa 9.9.3 random sample of weights of students

```
#PAGE=198
w1=c(60,62)
```

```
w1=mean(w1)
w2=c(63,65)
w2=mean(w2)
w3=c(66,68)
w3=mean(w3)
w4=c(69,71)
w4=mean(w4)
w5=c(72,74)
w5=mean(w5)
w=c(w1,w2,w3,w4,w5)
f=c(5,18,42,27,8)
p=sum(f)
a=median(w)
b=w-a
c=3
b=b/c
d=f*b
e=sum(d)
x=a+(c*e)/p
cat(x,'kg')

w=c(w1,w2,w3,w4,w5)
a=median(w)
f=c(5,18,42,27,8)
s=sum(f)
d=w-a
fd=d*f
e=sum(fd)
d=d**2
fd2=f*d
h=sum(fd2)
h=h/s
e=(e/s)**2
s=(h-e)

n=100
s2=(n*s)/(n-1)
s2
```

```
s3=sqrt(s2)
s3=round(s3,digits = 2)
cat(s3,'kg')
```

R code Exa 9.9.4 unbiased and efficient estimate

```
#PAGE=198
x=c(63.3,63.7,63.6,63.2,63.7)
a=sort(x)
a=median(x)
cat(a,'mm')
```

R code Exa 9.9.5 XYZ university students

```
#PAGE=198
a=1-0.95
a1=qnorm(a/2,lower.tail=FALSE)
a1=round(a1,2)
x=67.45
s=2.93
n=100
s1=x+a1*s/sqrt(n)
s2=x-a1*s/sqrt(n)
s1=round(s1,2)
s2=round(s2,2)
cat(s2,'kg -',s1,'kg')

b=1-0.99
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
x=67.45
s=2.93
n=100
```

```
s1=x+a1*s/sqrt(n)
s2=x-a1*s/sqrt(n)
s1=round(s1,2)
s2=round(s2,2)
cat(s2,'kg -',s1,'kg')

m=1546
np=sqrt((m-n)/(m-1))
np=round(np,3)
b=1-np
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
x=67.45
s=2.93
n=100
s1=x+a1*s/sqrt(n)
s2=x-a1*s/sqrt(n)
s1=round(s1,2)
s2=round(s2,2)
cat(s2,'kg -',s1,'kg')
```

R code Exa 9.9.6 Measurements of the diameter of a a random sample

```
#PAGE=199
n=200
m=8.24
s=0.42
a1=95
a1=1-(100-a1)/200
a1=qnorm(a1)
a1=round(a1,digits = 2)

b1=99
b1=1-(100-b1)/200
b1=qnorm(b1)
```

```r
b1=round(b1,digits = 2)

l1=m-a1*(s/sqrt(n))
l1=round(l1,digits = 2)
u1=m+a1*(s/sqrt(n))
u1=round(u1,digits = 2)
cat(l1,'-',u1,'kg')

l2=m-b1*(s/sqrt(n))
l2=round(l2,digits = 2)
u2=m+b1*(s/sqrt(n))
u2=round(u2,digits = 2)
cat(l2,'-',u2,'kg')
```

R code Exa 9.9.7 confidence limits for the mean diameters

```r
#PAGE=199
n=200
m=8.24
s=0.42
a1=98
a1=1-(100-a1)/200
a1=qnorm(a1)
a1=round(a1,digits = 2)
a1
b1=90
b1=1-(100-b1)/200
b1=qnorm(b1)
b1=round(b1,digits = 2)
b1
c1=99.73
c1=1-(100-c1)/200
c1=qnorm(c1)
c1=round(c1,digits = 2)
c1
```

```
l1=m-a1*(s/sqrt(n))
l1=round(l1,digits = 2)
u1=m+a1*(s/sqrt(n))
u1=round(u1,digits = 2)
cat(l1,'-',u1,'mm')

l2=m-b1*(s/sqrt(n))
l2=round(l2,digits = 2)
u2=m+b1*(s/sqrt(n))
u2=round(u2,digits = 2)
cat(l2,'-',u2,'mm')

l2=m-c1*(s/sqrt(n))
l2=round(l2,digits = 2)
u2=m+c1*(s/sqrt(n))
u2=round(u2,digits = 2)
cat(l2,'-',u2,'mm')
```

R code Exa 9.9.8 measuring reaction time

```
#PAGE=200
s=0.05
e=0.01

a1=95
a1=1-(100-a1)/200
a1=qnorm(a1)
a1=round(a1,digits = 2)
n1=(a1*s/e)**2
n1

b1=99
b1=1-(100-b1)/200
b1=qnorm(b1)
b1=round(b1,digits = 2)
```

```
n2=(b1*s/e)**2
n2=round(n2,digits = 1)
n2
```

R code Exa 9.9.9 Random sample of 50 mathematics grades

```
#PAGE=200
m=50
t=200
n=75
s=10

a1=95
a1=1-(100-a1)/200
a1=qnorm(a1)
a1=round(a1,digits = 2)

a2=n+a1*(s/sqrt(m))*sqrt((t-m)/(t-1))
a3=n-a1*(s/sqrt(m))*sqrt((t-m)/(t-1))

cat(a3,'-',a2)


b1=(s/sqrt(m))*sqrt((t-m)/(t-1))
b1=round(b1,digits = 2)
b1

c=1
z=c/b1
z=round(z,digits = 2)
z=pnorm(1-z/2,lower.tail = FALSE)
z=round(z,digits = 2)
d1=z*2
d1=d1*100
d1
```

```
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 9.9.10 sample poll of 100 voters

```
#PAGE=200
n=100
p=55/100
q=1-p
a=95/100
a1=(1-a)/2
a2=qnorm(a1,lower.tail=FALSE)
a2=round(a2,digits = 2)
c1=a2*sqrt((p*q)/n)
c1=round(c1,digits = 1)
c2=p+c1
c3=p-c1
cat(c2,'-',c3)

b=99/100
a1=(1-b)/2
a2=qnorm(a1,lower.tail=FALSE)
a2=round(a2,digits = 2)
c1=a2*sqrt((p*q)/n)
c1=round(c1,digits = 2)
c2=p+c1
c3=p-c1
cat(c2,'-',c3)

c=99.73/100
a1=(1-c)/2
a2=qnorm(a1,lower.tail=FALSE)
a2=round(a2,digits = 2)
c1=a2*sqrt((p*q)/n)
c1=round(c1,digits = 2)
```

```
c2=p+c1
c3=p-c1
cat(c2,'-',c3)
```

R code Exa 9.9.11 sample of voters

```
#PAGE=201
n=100
p=55/100
q=1-p
a=95/100
a1=(1-a)/2
a2=qnorm(a1,lower.tail=FALSE)
a2=round(a2,digits = 2)
n=(0.5*a2/0.05)**2
n=round(n,1)
n
ans=round(n,0)
cat(ans+1)


b=99.73/100
b1=(1-b)/2
b2=qnorm(b1,lower.tail=FALSE)
b2=round(b2,digits = 2)
n=(0.5*b2/0.05)**2
n=round(n,1)
n
ans=round(n,0)
cat(ans+1)
```

R code Exa 9.9.12 Confidence limits

```
#PAGE=201
b=1-0.9973
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
p=0.55
n=100
z=a1**2

p1=p+(z/(2*n))+a1*sqrt((p*(1-p)/n)+(z/(4*n**2)))
p2=1+(z/n)
p3=p1/p2
p3=round(p3,2)
cat(p3)


p1=p+(z/(2*n))-a1*sqrt((p*(1-p)/n)+(z/(4*n**2)))
p2=1+(z/n)
p3=p1/p2
p3=round(p3,1)
cat(p3)
```

R code Exa 9.9.13 40 tosses of coin

```
#PAGE=202
t=40
aa=24
p1=aa/t

b=1-0.95
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
p=p1
n=t
```

```
z=a1**2

p1=p+(z/(2*n))+a1*sqrt((p*(1-p)/n)+(z/(4*n**2)))
p2=1+(z/n)
p3=p1/p2
p3=round(p3,2)

p1=p+(z/(2*n))-a1*sqrt((p*(1-p)/n)+(z/(4*n**2)))
p2=1+(z/n)
p4=p1/p2
p4=round(p4,2)

cat(p4,p3)


t=40
aa=24
p1=aa/t

b=1-0.9973
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
p=p1
n=t
z=a1**2

p1=p+(z/(2*n))+a1*sqrt((p*(1-p)/n)+(z/(4*n**2)))
p2=1+(z/n)
p3=p1/p2
p3=round(p3,2)

p1=p+(z/(2*n))-a1*sqrt((p*(1-p)/n)+(z/(4*n**2)))
p2=1+(z/n)
p4=p1/p2
p4=round(p4,2)

cat(p4,p3)
```

R code Exa 9.9.14 sample of 150 and 200 light bulbs

```
#PAGE=202
xa=1400
xb=1200
s1=120
s2=80
n1=150
n2=100
b=1-0.95
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
an1=xa-xb+a1*sqrt((s1**2/n1)+(s2**2/n2))
an1=round(an1,0)
an2=xa-xb-a1*sqrt((s1**2/n1)+(s2**2/n2))
an2=round(an2,0)

cat(an2,an1,'h')

b=1-0.99
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
an1=xa-xb+a1*sqrt((s1**2/n1)+(s2**2/n2))
an1=round(an1,0)
an2=xa-xb-a1*sqrt((s1**2/n1)+(s2**2/n2))
an2=round(an2,0)

cat(an2,an1,'h')
```

R code Exa 9.9.15 random sample of adults and teenagers

```
#PAGE=202
a=400
t=600
a1=100
t1=300
p1=a1/a
q1=1-p1
p2=t1/t
q2=1-p2
z=95/100
z1=(1-z)/2
z2=qnorm(z1,lower.tail=FALSE)
z2=round(z2,digits = 2)
k=z2*sqrt((p1*q1)/t+(p2*q2)/a)
k=round(k,digits = 2)
m1=p2-p1-k
m1
m2=p2-p1+k
m2

z3=99/100
z1=(1-z3)/2
z2=qnorm(z1,lower.tail=FALSE)
z2=round(z2,digits = 2)
k=z2*sqrt((p1*q1)/t+(p2*q2)/a)
k=round(k,digits = 2)
n1=p2-p1-k
n1
n2=p2-p1+k
n2
```

R code Exa 9.9.16 Electromotive force of batteries

```
#PAGE=203
m1=m2=m3=m4=45.1
```

```
s1=s2=s3=s4=0.04
m=m1*4
s=sqrt(4*s1**2)
s
b=1-0.95
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
a2=m+a1*s
a2=round(a2,2)
a3=m-a1*s
a3=round(a3,2)
cat(a3,a2,'V')

b=1-0.99
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
a2=m+a1*s
a2=round(a2,2)
a3=m-a1*s
a3=round(a3,2)
cat(a3,a2,'V')

b=1-0.9973
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
a2=m+a1*s
a2=round(a2,2)
a3=m-a1*s
a3=round(a3,2)
cat(a3,a2,'V')

b=1-0.5
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
```

```
a2=m+a1*s
a2=round(a2,2)
a3=m-a1*s
a3=round(a3,2)
cat(a3,a2,'V')
```

R code Exa 9.9.17 standard deviation of light bulbs

```
#PAGE=203
s=200
sd=100
z=95/100
z1=(1-z)/2
z1=qnorm(z1,lower.tail=FALSE)
z1=round(z1,digits = 2)

a2=sd-(z1*sd)/(sqrt(2*s))
a1=sd+(z1*sd)/(sqrt(2*s))
cat(a2,a1,'h')

z=99/100
z1=(1-z)/2
z1=qnorm(z1,lower.tail=FALSE)
z1=round(z1,digits = 2)

a4=sd-(z1*sd)/(sqrt(2*s))
a3=sd+(z1*sd)/(sqrt(2*s))
cat(a4,a3,'h')
```

R code Exa 9.9.18 Sample of light bulbs

```
#PAGE=203
s=200
```

```
sd=100
z=99.73/100
z1=(1-z)/2
z1=qnorm(z1,lower.tail=FALSE)
z1=round(z1,digits = 2)
k=z1*sd
k
a1=5
n1=(k/a1)**2/2
n1

a2=10
n2=(k/a2)**2/2
n2
```

R code Exa 9.9.19 Probable error and confidence limits

```
#PAGE=204
v=50
m=18.2
sd=0.5

z=50/100
z4=(1-z)/2
z4=qnorm(z4,lower.tail=FALSE)
z4=round(z4,digits = 4)

a=(0.6745*sd)/sqrt(v-1)
a=round(a,digits = 3)
cat(a,'V')

m=round(m,digits = 0)
m2=m+a
m1=m-a
cat(m1,m2)
```

```
#"The answer may vary due to difference in
    representation."
```

R code Exa 9.9.20 Probable error and confidence limits for a measurement

```
#PAGE=204
m=216.480
e=0.272
z=95/100
z1=(1-z)/2
z1=qnorm(z1,lower.tail=FALSE)
z1=round(z1,digits = 2)
k=e/0.6745
x1=m+z1*k
x2=m-z1*k
cat(x2,x1,'kg')
#"The answer may vary due to difference in
    representation."
```

Chapter 10

Statistical Decision Theory

R code Exa 10.10.1 Probability of getting heads and tails

```
#PAGE=210
h1=40
h2=60
m=(h1+h2)/2
n=100
p=1/2
q=1-p
u=n*p
s=sqrt(n*p*q)
h1=h1-0.5
h2=h2+0.5
c1=(h1-m)/s
c2=(h2-m)/s
a1=pnorm(c1,lower.tail = F)
a2=pnorm(c2,lower.tail = F)
a=a1-a2

a=round(a,digits = 4)
a=abs(a)
a
#"The answer may slightly vary due to rounding off
```

```
values."
```

R code Exa 10.10.2 Hypothesis testing

```
#PAGE=211
n=100
a=40
b=60


m=1.9642
m1=1-m
cat(m1)

d=0.5
a1=a-d
b1=b+d

z1=(a1-n/2)/5
z2=z1*(-1)


z.rg <- c(z1, z2)


cuts <- sort(sort(c(z.rg, -3.5, 3.5)))  # c(-3.5, 3.5) will be the xlim of the plot
x.sq <- seq(cuts[1], cuts[4], len=200)
alpha <- c(.001, .01, .05)
z <- c(qnorm(alpha/2), 0, abs(qnorm(alpha/2)))


plot(x.sq, dnorm(x.sq), type="l", xlab="z-score", ylab=" ", xaxt="n")
z <- c(qnorm(alpha/2), 0, abs(qnorm(alpha/2)))
```

```
axis(1, z, round(z, 2))
abline(h=0)

polygon(c(cuts[2], cuts[2], x.sq[x.sq > cuts[2] & x.sq < cuts[3]], cuts[3], cuts[3]),
        c(0, dnorm(cuts[2]), dnorm(x.sq[x.sq > cuts[2] & x.sq < cuts[3]]), dnorm(cuts[3]), 0),
        col="lightgrey", border=1)

polygon(c(cuts[3], cuts[3], x.sq[x.sq > cuts[3]], cuts[4], cuts[4]),
        c(0, dnorm(cuts[3]), dnorm(x.sq[x.sq > cuts[3]]), dnorm(cuts[4]), 0),
        col="#4da6ff", border=1)
polygon(c(cuts[1], cuts[1], x.sq[x.sq < cuts[2]], cuts[2], cuts[2]),
        c(0, dnorm(cuts[1]), dnorm(x.sq[x.sq < cuts[2]]), dnorm(cuts[2]), 0),
        col="#4da6ff", border=4)

arrows(z.rg, rep(dnorm(z.rg), length(z.rg)), z.rg, rep(dnorm(0)*.666, length(z.rg)),
       length=0, lty=2, col=4)
sapply(z.rg, function(x) text(x, dnorm(0)*.666 + .02, bquote(italic("z=")~.(x)), col=4))
```

R code Exa 10.10.3 Hypothesis test of a fair coin

```
#PAGE=211
n=64
a=0.05
a1=a/2
z1=qnorm(a1,lower.tail=FALSE)
z1=round(z1,digits = 2)
```

```
z2=qnorm(a1,lower.tail=TRUE)
z2=round(z2,digits = 2)

x=pnorm(0)
z=x-a/2

p=1/2
q=1-p

u=n*p
s=sqrt(n*p*q)

x1=z1*s+u
x2=z2*s+u

cat(x2,x1)

b=0.01
b1=b/2
z3=qnorm(b1,lower.tail=FALSE)
z3=round(z3,digits = 2)

z4=qnorm(b1,lower.tail=TRUE)
z4=round(z4,digits = 2)

x=pnorm(0)
z=x-b/2

p=1/2
q=1-p

u=n*p
s=sqrt(n*p*q)

x3=z3*s+u
x3=round(x3,digits = 0)
x4=z4*s+u
```

```
x4=round(x4,digits = 0)

cat(x4,x3)
```

R code Exa 10.10.5 An experiment on extrasensory perception

```
#PAGE=213
n=50
p=1/2
q=1-p
c=32
u=p*n
s=sqrt(n*p*q)
a=0.05
a1=p-a
z=1.645
x=n/2
y=(c-x)/s
y=round(y,digits = 2)
y
c1=c-p
y=(c1-x)/s
y=round(y,digits = 2)
y

b=0.01
b1=p-b
z2=qnorm(b,lower.tail = FALSE)
z2=round(z2,digits = 2)
z2

if(z2>y) x <- TRUE
x
#"The answer may vary due to difference in
    representation."
```

R code Exa 10.10.6 Manufacturer of a patent medicine

```
#PAGE=214
p=90/100
q=1-p
t=8
n=200
r=160
b=0.01
b1=p-b
z2=qnorm(b,lower.tail = FALSE)
z2=round(z2,digits = 2)
z2
z3=qnorm(b,lower.tail = TRUE)
z3=round(z3,digits = 2)
z3
u=n*p
s=sqrt(n*p*q)
x=(r-u)/s
x=round(x,digits = 2)
x
if(z3>x) y <- TRUE
y
#"The answer may vary due to difference in
   representation."
```

R code Exa 10.10.7 Fluorescent light bulbs

```
#PAGE=214
u=1600
a=0.05
```

```r
a=a/2
z1=qnorm(a,lower.tail = FALSE)
z1=round(z1,digits = 3)
z1
z2=qnorm(a,lower.tail = TRUE)
z2=round(z2,digits = 3)
z2
l=100
c=1570
s=120
s1=s/(sqrt(l))
x=(c-u)/s1
x
if (x>z1||x<z2) k<-FALSE
k

b1=0.01
b1=b1/2
z3=qnorm(b1,lower.tail=FALSE)
z3=round(z3,digits = 2)
z3
z4=qnorm(b1,lower.tail=TRUE)
z4=round(z4,digits = 2)
z4
if (x<z3||x>z4) l<-TRUE
l
```

R code Exa 10.10.8 hypothesis and alternative hypothesis

```r
#PAGE=215
u=1600
a=0.05
z1=qnorm(a,lower.tail = FALSE)
z1=round(z1,digits = 3)
z1
```

```r
z2=qnorm(a,lower.tail = TRUE)
z2=round(z2,digits = 3)
z2
l=100
c=1570
s=120
s1=s/(sqrt(l))
x=(c-u)/s1
x
if (x>z1||x<z2) k<-FALSE
k

b1=0.01
z3=qnorm(b1,lower.tail=FALSE)
z3=round(z3,digits = 2)
z3
z4=qnorm(b1,lower.tail=TRUE)
z4=round(z4,digits = 2)
z4
if (x>z1||x<z2) l<-FALSE
l
```

R code Exa 10.10.9 Breaking strengths of cables

```r
#PAGE=215
u=1800
a=0.05
l=50
c=1850
s=100
s1=s/(sqrt(l))
x=(c-u)/s1
x

b1=0.01
```

```
z3=qnorm(b1,lower.tail=FALSE)
z3=round(z3,digits = 2)
z3
z4=qnorm(b1,lower.tail=TRUE)
z4=round(z4,digits = 2)
z4
if (x>z3||x<z4) l<-TRUE
l
```

R code Exa 10.10.10 Accepting hypothesis

```
#PAGE=216
p=0.7
q=1-p
n=100
h1=40
h2=60
h1=h1-0.5
h2=h2+0.5
u=n*p
s=sqrt(n*p*q)
s1=(h2-p*n)/s
s2=(h1-p*n)/s
s1=round(s1,digits = 2)
s2=round(s2,digits = 2)
a=pnorm(s1)
b=pnorm(s2)
c=a-b
c=round(c,digits = 4)
c
```

R code Exa 10.10.11 Work problem

```
#PAGE=216
p=0.6
q=1-p
n=100
h1=40
h2=60
h1=h1-0.5
h2=h2+0.5
u=n*p
s=sqrt(n*p*q)
s1=(h2-p*n)/s
s2=(h1-p*n)/s
s1=round(s1,digits = 2)
s2=round(s2,digits = 2)
a=pnorm(s1)
b=pnorm(s2)
c=a-b
c=round(c,digits = 2)
c

p=0.8
q=1-p
n=100
h1=40
h2=60
h1=h1-0.5
h2=h2+0.5
u=n*p
s=sqrt(n*p*q)
s1=(h2-p*n)/s
s2=(h1-p*n)/s
s1=round(s1,digits = 2)
s2=round(s2,digits = 2)
a=pnorm(s1)
b=pnorm(s2)
c=a-b
c=round(c,digits = 4)
c
```

```
p=0.4
q=1-p
n=100
h1=40
h2=60
h1=h1-0.5
h2=h2+0.5
u=n*p
s=sqrt(n*p*q)
s1=(h2-p*n)/s
s2=(h1-p*n)/s
s1=round(s1,digits = 2)
s2=round(s2,digits = 2)
a=pnorm(s1)
b=pnorm(s2)
c=a-b
c=round(c,digits = 2)
c
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 10.10.12 Graph of results

```
#PAGE=217
p=c(0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9)
b=c(0,0,0.0192,0.504,0.9642,0.504,0.0192,0,0)

plot(p,b,type = 'l')

c=1-b
plot(p,c,type = 'l')
```

R code Exa 10.10.13 Rope manufacturing company

```
#PAGE=217
u=300
s=24
a=0.01
n=600
z=2.33
t=64
b=s/sqrt(t)
c=b*z+u
c=round(c,0)
cat(c,'N')

u2=310
u1=(c-u2)/3
z1=pnorm(u1)
z1=round(z1,4)
cat(z1)
```

R code Exa 10.10.14 OC and power curve

```
#PAGE=219
a=307
a1=290
u1=(a-a1)/3
z1=pnorm(u1)
z1=round(z1,4)
cat(z1)


a2=295
u2=(a-a2)/3
z2=pnorm(u2)
z2=round(z2,4)
```

```
cat(z2)


a3=300
u3=(a-a3)/3
z3=pnorm(u3)
z3=round(z3,2)
cat(z3)

a7=305
u7=(a-a7)/3
z7=pnorm(u7)
z7=round(z7,3)
cat(z7)


a4=310
u4=(a-a4)/3
z4=pnorm(u4)
z4=round(z4,4)
cat(z4)

a5=315
u5=(a-a5)/3
z5=pnorm(u5)
z5=round(z5,4)
cat(z5)

a6=320
u6=(a-a6)/3
z6=pnorm(u6)
z6=round(z6,4)
cat(z6)



u=c(a1,a2,a3,a7,a4,a5,a6)
b=c(z1,z2,z3,z7,z4,z5,z6)
```

```
plot(u,b,type = 'l')

c=1-b
plot(u,c,type = 'l')
```

R code Exa 10.10.15 To test hypothesis that a coin is fair

```
#PAGE=219
p=0.5
a1=0.05
q=1-p
a2=0.6
a3=1-a2

b1=sqrt(a2*a3)
b1=round(b1,2)
b2=sqrt(p*q)

z1=1.96
z2=-1.645
c1=b2*z1
c2=b1*z2

n=((c1-c2)/(a2-p))**2
n=round(n,0)
cat(n)

x=a2*n+c2*sqrt(n)
x=round(x,0)
cat(x)

np=n*p
x1=x-np
cat(x1)
```

```
m1=np+x1
m2=np-x1
cat(m2,m1)
```

R code Exa 10.10.16 Ball bearing machine is constructed

```
#PAGE=220
u=5.74
s=0.08
n=6
z=99.73

a1=u-(3*s)/sqrt(n)
a1=round(a1,2)

a2=u+(3*s)/sqrt(n)
a2=round(a2,2)

cat(a1,'mm',a2,'mm')

a=runif(14,min=a1,max=a2)

library(ggplot2)

a=runif(20,min=a1,max=a2)


set.seed(2017)
date <- seq(from = as.Date("2017-12-04"), to = as.
   Date("2017-12-08"),
            by = "days")
date=rep(date,4)

dat <- data.frame(date, a)
```

```
ggplot(dat, aes(x = date, y = a)) +
  geom_point() +
  scale_x_date(date_breaks = "day", date_labels = "%a") +
  theme_bw()+ labs(x=' ',y='Sample Mean(mm)')

#- The answer may vary due to difference in representation.
```

R code Exa 10.10.17 Examination of two classes

```
#PAGE=221
c1=40
c2=50
m1=74
s1=8
m2=78
s2=7
s=sqrt((s1**2/c1)+(s2**2/c2))
s=round(s,digits = 3)
z=(m1-m2)/s
z=round(z,digits = 2)
z
a=0.05
a=a/2
z1=qnorm(a,lower.tail = FALSE)
z1=round(z1,digits = 3)
z1

z2=qnorm(a,lower.tail = TRUE)
z2=round(z2,digits = 3)
z2
if (z1<z||z2>z) k<-FALSE
k
```

```
b=0.01
b=b/2
z1=qnorm(b,lower.tail = FALSE)
z1=round(z1,digits = 2)
z1

z2=qnorm(b,lower.tail = TRUE)
z2=round(z2,digits = 2)
z2
if (z1<z||z2>z) k<-TRUE
k
#"The answer may vary due to difference in
   representation."
```

R code Exa 10.10.18 Male students and college athletics

```
#PAGE=222
n1=50
m1=68.2
s1=2.5
n2=50
m2=67.5
s2=2.8
s=sqrt((s1**2/n1)+(s2**2/n2))
s=round(s,digits = 2)
z=(m1-m2)/s
z=round(z,digits = 2)
a=0.05
x=qnorm(a,lower.tail = FALSE)
x=round(x,digits = 3)
x
if (x>z) k<-TRUE
k
b=0.1
```

```
y=qnorm(b,lower.tail = FALSE)
y=round(y,digits = 2)
y
if (y<z) k<-FALSE
k
#"The answer may vary due to difference in representation."
```

R code Exa 10.10.19 sample of two groups

```
#PAGE=222
n1=50
m1=68.2
s1=2.5
n2=50
m2=67.5
s2=2.8

s3=sqrt(s1**2+s2**2)
s3=round(s3,digits = 2)
k=0.7
a=0.05
x=qnorm(a,lower.tail = FALSE)
x=round(x,digits = 3)

n=(x*s3)/k
n=n**2
n=round(n,digits = 0)
d=n-n1
d

b=0.01
y=qnorm(b,lower.tail = FALSE)
y=round(y,digits = 3)
n=(y*s3)/k
```

```
n=n**2
n=n+1
d=n-n1
d=round(d,digits = 0)
d
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 10.10.20 two groups A and B

```
#PAGE=223
n1=75
n2=65
n=100
p=(n1+n2)/(2*n)
q=1-p
s=sqrt(p*q*(1/n+1/n))
s=round(s,digits = 4)
p1=n1/n
p2=n2/n
z=(p1-p2)/s
z=round(z,digits = 2)
a=0.01
x=qnorm(a,lower.tail = FALSE)
x=round(x,digits = 2)

if (x>z) k<-FALSE
k

b=0.05
y=qnorm(b,lower.tail = FALSE)
y=round(y,digits = 2)
if (y>z) l<-FALSE
l

```

```
c=0.1
y1=qnorm(c,lower.tail = FALSE)
y1=round(y1,digits = 2)
if (x>z) L<-TRUE
L

#"The answer may vary due to difference in
    representation."
```

R code Exa 10.10.21 Groups of people cured

```
#PAGE=224
n=300
a=225
b=195
p=(a+b)/(2*n)
q=1-p
s=sqrt(p*q*(1/n+1/n))
s=round(s,digits = 4)
z=a/100-b/100
z=z/s
a=0.01
x=qnorm(a,lower.tail = FALSE)
x=round(x,digits = 2)
if (x<z) k<-FALSE
k
#"The answer may vary due to difference in
    representation."
```

R code Exa 10.10.22 A sample poll from district A and B

```
#PAGE=224
n1=300
```

```
n2=200
p1=0.56
q1=0.48
p=(p1*n1+q1*n2)/(n1+n2)
q=1-p
s=sqrt((p*q*(1/n1+1/n2)))
s=round(s,digits = 4)
z=(p1-q1)/s
z=round(z,digits = 2)
z
a=0.05
a1=a/2
z1=qnorm(a1,lower.tail = FALSE)
z1=round(z1,digits = 2)
z1
z2=qnorm(a1,lower.tail = TRUE)
z2=round(z2,digits = 2)
z2

if (z2<z||z1>z) k<-TRUE
k

a=0.05
z3=qnorm(a,lower.tail = FALSE)
z3=round(z3,digits = 2)
z3
z4=qnorm(a,lower.tail = TRUE)
z4=round(z4,digits = 2)
z4


if (z4>z||z3<z) k<-FALSE
k
#"The answer may vary due to difference in
   representation."
```

R code Exa 10.10.23 An instructor and short quiz

```
#PAGE=224
n=10
p=1/2
q=1-p
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p**i*q**(n-i)
  s=s+y
}
s=round(s,digits = 4)
s
```

R code Exa 10.10.24 Probability of accepting the hypothesis

```
#PAGE=225
n=10
p=0.7
q=1-p
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p**i*q**(n-i)
  s=s+y
}
s=round(s,digits = 4)
```

```
s=1-s
s
```

R code Exa 10.10.25 Probability of accepting the hypothesis

```
#PAGE=225
n=10
p1=0.6
q1=1-p1
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p1**i*q1**(n-i)
  s=s+y
}
s1=round(s,digits = 3)
s1=1-s1
s1

n=10
p2=0.8
q2=1-p2
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p2**i*q2**(n-i)
  s=s+y
}
s2=round(s,digits = 3)
s2=1-s2
s2
```

```
n=10
p3=0.9
q3=1-p3
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p3**i*q3**(n-i)
  s=s+y
}
s3=round(s,digits = 3)
s3=1-s3
s3

n=10
p4=0.4
q4=1-p4
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p4**i*q4**(n-i)
  s=s+y
}
s4=round(s,digits = 3)
s4=1-s4
s4

n=10
p5=0.3
q5=1-p5
a=7
s=0
for (i in a:n)
{
```

```
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p5**i*q5**(n-i)
  s=s+y
}
s5=round(s,digits = 3)
s5=1-s5
s5

n=10
p6=0.2
q6=1-p6
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p6**i*q6**(n-i)
  s=s+y
}
s6=round(s,digits = 3)
s6=1-s6
s6

n=10
p7=0.1
q7=1-p7
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p7**i*q7**(n-i)
  s=s+y
}
s7=round(s,digits = 4)
s7=1-s7
s7
```

```
n=10
p8=0.7
q8=1-p8
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p8**i*q8**(n-i)
  s=s+y
}
s8=round(s,digits = 3)
s8=1-s8
s8


n=10
p9=0.5
q9=1-p9
a=7
s=0
for (i in a:n)
{
  x=factorial(n)/(factorial(i)*factorial(n-i))
  y=x*p9**i*q9**(n-i)
  s=s+y
}
s9=round(s,digits = 3)
s9=1-s9
s9


s=c(s7,s6,s5,s4,s9,s1,s8,s2,s3)
p=c(p7,p6,p5,p4,p9,p1,p8,p2,p3)

y <- matrix(c(p,s),ncol=9,byrow=TRUE)
colnames(y) <- c(” ”,” ”,” ”,” ”,” ”,” ”,” ”,” ”,” ”
```

```
    )
rownames(y) <- c("p","B")
y <- as.table(y)
y
```

R code Exa 10.10.26 Graph of B and P

```
#PAGE=225
p=c(0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9)
b=c
    (1,0.999,0.989,0.945,0.828,0.618,0.35,0.121,0.013)

plot(p,b,type='l')
```

R code Exa 10.10.27 Coin tossed 6 times

```
#PAGE=225
n1=6
a=0.05
b=0.01
p=1/2
q=1-p

m=(p**n1)
n=c(0:6)


a1=factorial(n1)/(factorial(n1-n[1])*factorial(n[1])
    )
a2=factorial(n1)/(factorial(n1-n[2])*factorial(n[2])
    )
```

```
a3=factorial(n1)/(factorial(n1-n[3])*factorial(n[3]))
a4=factorial(n1)/(factorial(n1-n[4])*factorial(n[4]))
a5=factorial(n1)/(factorial(n1-n[5])*factorial(n[5]))
a6=factorial(n1)/(factorial(n1-n[6])*factorial(n[6]))
a7=factorial(n1)/(factorial(n1-n[7])*factorial(n[7]))

a1=a1*m
a2=a2*m
a3=a3*m
a4=a4*m
a5=a5*m
a6=a6*m
a7=a7*m

b1=a1
b1=round(b1,5)
b2=a1+a2
b2=round(b2,4)
cat(b1)
cat(b2)
if (b1<a) print(FALSE)
if (b2>a) print(FALSE)
if (b2>b) print(TRUE)


c1=a1+a7
cat(c1)

if (c1<a) print(FALSE)
if (c1<a) print(TRUE)
#"The answer may vary due to difference in representation."
```

R code Exa 10.10.28 coin comes up heads five times

```
#PAGE=226
n=6
p=1/64
a=0.05
x0=1*p
x1=(factorial(n)/(factorial(1)*factorial(n-1)))*p
x2=(factorial(n)/(factorial(2)*factorial(n-2)))*p
x3=(factorial(n)/(factorial(3)*factorial(n-3)))*p
x4=(factorial(n)/(factorial(4)*factorial(n-4)))*p
x5=(factorial(n)/(factorial(5)*factorial(n-5)))*p
x6=(factorial(n)/(factorial(6)*factorial(n-6)))*p
x=c(x0,x1,x2,x3,x4,x5,x6)

n1=c(0,1,2,3,4,5,6)

p1=x5+x6
p1=round(p1,digits = 4)
p1

p2=x0+x1+x5+x6
p2=round(p2,digits = 4)
p2
```

Chapter 11

Small Sampling Theory

R code Exa 11.11.1 t distribution

```
#PAGE=234
f=9
a11=0.05
a1=1-a11
a=qt(a1,df=f)
a=round(a,digits = 2)
a

b11=0.05
b1=b11/2
a1=1-b1
b=qt(a1,df=f)
b=round(b,digits = 2)
b

c11=0.99
a1=1-c11
a1=a1/2
a=qt(a1,df=f)
c=round(a,digits = 2)
c=abs(c)
```

```
c

d11=0.99
a1=1-d11
a=qt(a1,df=f)
d=round(a,digits = 2)
d
d=abs(d)
d

e11=0.9
a1=1-e11
a=qt(a1,df=f)
e=round(a,digits = 2)
e=abs(e)
e
```

R code Exa 11.11.2 sample of 10 measurements

```
#PAGE=235
a=16
x1=0.05
x1=1-x1
x=qt(x1,df=a)
x=round(x,digits = 2)
x

b=27
x1=0.05
x1=1-x1
x=qt(x1,df=b)
x=round(x,digits = 2)
x

c=200
```

```
x1=0.05
x1=1-x1
x=qt(x1,df=c)
x=round(x,digits = 2)
x
##"The answer may slightly vary due to rounding off values."
```

R code Exa 11.11.3 two tailed test

```
#PAGE=235
n=95/100
n=1-n
n=n/2

a=9
x1=n
x1=1-x1
x=qt(x1,df=a)
x=round(x,digits = 2)
cat('-',x,'+',x)

b=20
x1=n
x1=1-x1
x=qt(x1,df=b)
x=round(x,digits = 2)
cat('-',x,'+',x)

c=30
x1=n
x1=1-x1
x=qt(x1,df=c)
x=round(x,digits = 2)
cat('-',x,'+',x)
```

```
d=60
x1=n
x1=1-x1
x=qt(x1,df=d)
x=round(x,digits = 2)
cat('-',x,'+',x)
#"The answer may vary due to difference in representation."
```

R code Exa 11.11.4 sample of 10 diameter measurements

```
#PAGE=235
n=10
m=43.8
s=0.6
f=n-1

a11=0.95
a1=1-a11
a1=a1/2
a=qt(a1,df=f)
a=round(a,digits = 2)
a=abs(a)

x1=m+a*s/sqrt(n-1)
x1=round(x1,digits = 2)
x2=m-a*s/sqrt(n-1)
x2=round(x2,digits = 2)
cat(x2,'mm',x1,'mm')

b11=0.99
b1=1-b11
b1=b1/2
b=qt(b1,df=f)
```

```
b=round(b,digits = 2)
b=abs(b)

x1=m+b*s/sqrt(n-1)
x1=round(x1,digits = 2)
x2=m-b*s/sqrt(n-1)
x2=round(x2,digits = 2)
cat(x2,'mm',x1,'mm')
```

R code Exa 11.11.5 Large sampling theory

```
#PAGE=235
a=95/100
a=1-a
a=a/2
a=qnorm(a,lower.tail = FALSE)
a=round(a,digits = 2)


m=43.8
n=10
s=0.6
x1=m+a*s/sqrt(n)
x1=round(x1,digits = 2)
x2=m-a*s/sqrt(n)
x2=round(x2,digits = 2)
cat(x2,'mm',x1,'mm')

b=99/100
b=1-b
b=b/2
b=qnorm(b,lower.tail = FALSE)
b=round(b,digits = 2)

m=43.8
```

```r
n=10
s=0.6
x3=m+b*s/sqrt(n)
x3=round(x3,digits = 2)
x4=m-b*s/sqrt(n)
x4=round(x4,digits = 2)
cat(x4,'mm',x3,'mm')
```

R code Exa 11.11.6 machine and washers

```r
#PAGE=236
x=0.53
u=0.5
s=0.03
n=10
t=(x-u)*sqrt(n-1)/s
t

n=0.05
n=n/2

a=9
x1=n
x1=1-x1
x=qt(x1,df=a)
x=round(x,digits = 2)
x2=-x
cat('-',x,'+',x)

if (x<t||x2>t) l<-FALSE
l

n=0.01
n=n/2

```

```
a=9
x1=n
x1=1-x1
x=qt(x1,df=a)
x=round(x,digits = 2)
x2=-x
cat('−',x,'+',x)
if (x>t||x2<t) l<-TRUE
l
```

R code Exa 11.11.7 Test of the breaking strengths

```
#PAGE=236
x=7750
u=8000
s=145
N=6
t=(x-u)*sqrt(N-1)/s
t=round(t,2)
t

n=0.05
a=N-1
x1=n
x1=1-x1
x=qt(x1,df=a)
x=round(x,digits = 2)
x2=-x
cat('−',x,'+',x)

if (x<t||x2>t) l<-FALSE
l

n=0.01
a=N-1
```

```
x1=n
x1=1-x1
x=qt(x1,df=a)
x=round(x,digits = 2)
x2=-x
cat('-',x,'+',x)
if (x>t||x2<t) l<-TRUE
l
```

R code Exa 11.11.8 intelligence quotients

```
#PAGE=237
n1=16
m1=107
s1=10
n2=14
m2=112
s2=8
n=2
s=sqrt((n1*s1**2+n2*s2**2)/(n1+n2-n))
s=round(s,digits = 2)
t=(m2-m1)/(s*sqrt(1/n1+1/n2))
t=round(t,digits = 2)

a=0.01
a=a/2
f=n1+n2-n
a=qt(a,df=f)
a=round(a,digits = 2)
a
a1=a*(-1)
a1

if(t>a||t<a1) k<-TRUE
k
```

```
b=0.05
b=b/2
f=n1+n2-n
b=qt(b,df=f)
b=round(b,digits = 2)
b
b1=b*(-1)
b1

if(t>b||t<b1) l<-TRUE
l
#"The answer may vary due to difference in
    representation."
```

R code Exa 11.11.9 Agricultural station

```
#PAGE=237
n=24
n1=n/2
n2=n-n1
m1=4.8
s1=0.4
m2=5.1
s2=0.36
a=1/100
n3=2
s=sqrt((n1*s1**2+n2*s2**2)/(n1+n2-n3))
s=round(s,digits = 3)

t=(m2-m1)/(s*sqrt(1/n1+1/n2))
t=round(t,digits = 2)
t

```

```
a=1/100
f=n1+n2-n3
a=qt(a,df=f)
a=round(a,digits = 2)
a
a1=a*(-1)
a1

if(t<a1||t>a) k<-TRUE
k

b=5/100
f=n1+n2-n3
b=qt(b,df=f)
b=round(b,digits = 2)
b
b1=b*(-1)
b1

if(t<b1||t>b) l<-FALSE
l
#"The answer may vary due to difference in representation."
```

R code Exa 11.11.10 chi square test

```
#PAGE=238
f=5
a=0.05
a=1-a
a=qchisq(a,df=f)
a=round(a,digits = 1)
a

b1=0.05
```

```
b1=b1/2
b1=1-b1
b1=qchisq(b1,df=f)
b1=round(b1,digits = 1)

b2=0.05
b2=b2/2
b2=qchisq(b2,df=f)
b2=round(b2,digits = 3)
cat(b2,b1)

c=0.1
c=qchisq(c,df=f)
c=round(c,digits = 2)
c

d=0.01
d=1-d
d=qchisq(d,df=f)
d=round(d,digits = 1)
d
```

R code Exa 11.11.11 critical values

```
#PAGE=239
a11=0.05
a1=15

a=1-a11
a=qchisq(a,df=a1)
a=round(a,digits = 1)
a

b1=21
a=1-a11
```

```
a=qchisq(a,df=b1)
b=round(a,digits = 1)
b

c1=50
a=1-a11
a=qchisq(a,df=c1)
c=round(a,digits = 1)
c
```

R code Exa 11.11.12 median values and degree of freedom

```
#PAGE=239
a11=0.5

a1=9
a=1-a11
a=qchisq(a,df=a1)
a=round(a,digits = 2)
a

b1=28
a=1-a11
a=qchisq(a,df=b1)
b=round(a,digits = 1)
b

c1=40
a=1-a11
a=qchisq(a,df=c1)
c=round(a,digits = 1)
c
```

R code Exa 11.11.13 standard deviation of weights

```
#PAGE=239
n=16
n1=1000
s=2.4
f=n-1

a1=95/100
a2=1-a1
a2=a2/2

a=a1+a2
a=qchisq(a,df=f)
a3=round(a,digits = 1)
a=qchisq(a2,df=f)
a4=round(a,digits = 2)

a5=sqrt(a3)
a5=round(a5,digits = 2)
a6=sqrt(a4)
a6=round(a6,digits = 2)

x1=s*sqrt(n)/a5
x1=round(x1,digits = 2)
x2=s*sqrt(n)/a6
cat(x1,'kg',x2,'kg')


b1=99/100
b2=1-b1
b2=b2/2

b=b1+b2
b=qchisq(b,df=f)
b3=round(b,digits = 1)
b=qchisq(b2,df=f)
b4=round(b,digits = 2)
```

```r

b5=sqrt(b3)
b5=round(b5,digits = 2)
b6=sqrt(b4)
b6=round(b6,digits = 2)

x1=s*sqrt(n)/b5
x1=round(x1,digits = 2)
x2=s*sqrt(n)/b6
x2=round(x2,digits = 2)
cat(x1,'kg',x2,'kg')
```

R code Exa 11.11.14 degree of freedom

```r
#PAGE=239
f=50
a1=95/100
a1=1-a1
a=qnorm(a1,lower.tail = FALSE)
a=round(a,digits = 2)


x1=a+sqrt(2*f-1)
x1=x1**2
x1=x1/2
x1=round(x1,digits = 1)
x1

b=100
x2=a+sqrt(2*b-1)
x2=x2**2
x2=x2/2
x2=round(x2,digits = 1)
x2
```

R code Exa 11.11.15 standard deviation of the lifetimes of sample of electric bulbs

```
#PAGE=240
v=200
x1=0.025
x1=1-x1
x=qt(x1,df=199)
x=round(x,digits = 2)
x2=-x
x2
xx1=((sqrt(2*(v-1)-1)+x)^2)/2
xx1=round(xx1,0)
xx1

xx2=((sqrt(2*(v-1)-1)+x2)^2)/2
xx2=round(xx2,0)
xx2
xx1=sqrt(xx1)
xx2=sqrt(xx2)
c1=100*sqrt(v)/xx1
c2=100*sqrt(v)/xx2
c1=round(c1,1)
c2=round(c2,1)
cat(c1,'h',c2,'h')

v=200
x1=0.005
x1=1-x1
x=qt(x1,df=199)
x=round(x,digits = 2)
x2=-x
x2
xx1=((sqrt(2*(v-1)-1)+x)^2)/2
```

```
xx1=round(xx1,0)
xx1

xx2=((sqrt(2*(v-1)-1)+x2)^2)/2
xx2=round(xx2,0)
xx2
xx1=sqrt(xx1)
xx2=sqrt(xx2)
c1=100*sqrt(v)/xx1
c2=100*sqrt(v)/xx2
c1=round(c1,1)
c2=round(c2,1)
cat(c1,'h',c2,'h')

#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 11.11.17 standard deviation of weights

```
#PAGE=240
w=2
s1=12.5
n=20
f=n-1
s2=16
x=(n*s2**2)/(s1**2)
x=round(x,digits = 1)
x

a=0.05
a=1-a
a=qchisq(a,df=f)
a=round(a,digits = 1)
a
if(a<x) k<-FALSE
```

```
k

b=0.01
b=1-b
b=qchisq(b,df=f)
b=round(b,digits = 1)
b
if(b>x) l<-TRUE
l
#"The answer may vary due to difference in
   representation."
```

R code Exa 11.11.18 two sample of sizes 9 and 12

```
#PAGE=241
n1=9
n2=12
v1=16
v2=25
sv1=20
sv2=8

k1=(n1*sv1)/((n1-1)*v1)
k2=(n2*sv2)/((n2-1)*v2)
k=k1/k2
k=round(k,digits = 2)
k
f1=n1-1
f2=n2-1
a=0.05
a1=qchisq(a,df=f1)

if(a<k) l<-TRUE
l
b=0.01
```

```
b1=qchisq(b,df=f2)
b2=qchisq(b,df=f1)
b=b1+b2
b=round(b,digits = 2)
b
if(b>k) l<-FALSE
l
#"The answer may vary due to difference in
   representation."
```

R code Exa 11.11.19 two sample of sizes 8 and 10

```
#PAGE=241
n1=8
n2=10
v1=20
v2=36
k1=n1/((n1-1)*v1)
k2=n2/((n2-1)*v2)
k=k1/k2
k=round(k,digits = 2)
k
f1=n1-1
f2=n2-1
f=k*2
f
```

Chapter 12

The Chi Square Test

R code Exa 12.12.1 200 tosses of a coin

```
#PAGE=249
n=200
n1=115
n2=85
e1=n/2
e2=n-e1
x=((n1-e1)**2)/e1+((n2-e2)**2)/e2
x
k=2
f=k-1
a=0.05
a=1-a
a=qchisq(a,df=f)
a=round(a,digits = 2)
a

if(a<x) l<-FALSE
l

b=0.01
b=1-b
```

```
b=qchisq(b,df=f)
b=round(b,digits = 2)
b

if(b>x) L<-TRUE
L
#"The answer may vary due to difference in representation."
```

R code Exa 12.12.2 Yates correction

```
#PAGE=249
n=200
n1=115
n2=85
e1=n/2
e2=n-e1
x=(abs(n1-e1)-0.5)**2/e1+(abs(n2-e2)-0.5)**2/e2
x
k=2
f=k-1

a=0.05
a=1-a
a=qchisq(a,df=f)
a=round(a,digits = 2)
a

if(a<x) l<-FALSE
l

b=0.01
b=1-b
b=qchisq(b,df=f)
b=round(b,digits = 2)
```

```
b

if(b>x) L<-TRUE
L
```

R code Exa 12.12.3 Normal approximation

```
#PAGE=249
n=200
p=0.5
q=1-p
u=n*p
s=sqrt(n*p*q)
s=round(s,2)
h=115
su=(h-100)/s
su=round(su,2)
su

b=1-0.95
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
a2=-a1
if (a2>su||a1<su) l<-FALSE
l

b=1-0.99
a1=qnorm(b/2,lower.tail=FALSE)
a1=round(a1,2)
a1
a2=-a1
if (a2<su||a1>su) l<-TRUE
l
#"The answer may vary due to difference in
```

representation."

R code Exa 12.12.4 Observed and Expected frequency

```
#PAGE=250
k=6
o=c(25,17,15,23,24,16)
f=20
s=sum((o-f)**2)/f
s

x=0.95
x=qchisq(x,df=k-1)
x=round(x,digits = 1)
x
if (s<x) l<-TRUE
l

x=0.05
x=qchisq(x,df=k-1)
x=round(x,digits = 2)
x
if (s>x) l<-FALSE
l
```

R code Exa 12.12.5 Random numbers

```
#PAGE=250
d=c(0,1,2,3,4,5,6,7,8,9)
o=c(17,31,29,18,14,20,35,30,20,36)
e=25
s=0
l=length(d)
```

```
for (i in 1:l)
{
  x=((o[i]-e)**2)/e
  s=s+x
}
s=round(s,digits = 1)
s
f=l-1
x=0.99
x=qchisq(x,df=f)
x=round(x,digits = 1)
x
if(x<s) k<-TRUE
k
#"The answer may vary due to difference in
    representation."
```

R code Exa 12.12.6 Experiments with peas

```
#PAGE=251
n1=315
n2=108
n3=101
n4=32
n=n1+n2+n3+n4
k1=9
k2=3
k3=3
k4=1
x=k1+k2+k3+k4
x1=(k1*n)/x
x2=(k2*n)/x
x3=(k3*n)/x
x4=(k4*n)/x
y=c(x1,x2,x3,x4)
```

```
z=c(n1,n2,n3,n4)
s=0
l=length(y)
for(i in 1:l)
{
  v=(((z[i]-y[i])**2)/y[i])
  s=s+v
}
s=round(s,digits = 2)
s
f=l-1
a=0.01
a=1-a
a=qchisq(a,df=f)
a=round(a,digits = 1)
a
if(s<a) k<-TRUE
k

b=0.05
b=1-b
b=qchisq(b,df=f)
b=round(b,digits = 2)
b
if(s<b) k<-TRUE
k
#"The answer may vary due to difference in
   representation."
```

R code Exa 12.12.7 Large number of marbles

```
#PAGE=251
n=12
r=2
o=5
```

```
y=4
g=1
c2=r+g
c1=o+y
n1=n/2
n2=n-n1
x=((c2-n1)**2)/n1+((c1-n2)**2)/n2
x
t=2
f=t-1
a=0.95
a=qchisq(a,df=f)
a=round(a,digits = 2)
a
if(a>x) k<-TRUE
k
#"The answer may vary due to difference in
    representation."
```

R code Exa 12.12.8 360 tosses of a pair of dice

```
#PAGE=252
t=360
n1=74
n2=24
m1=t/6
m2=t/(6*3)
x1=((n1-m1)^2)/m1+((n2-m2)^2)/m2
x1=round(x1,2)
x1

v=2-1
x=0.95
x=qchisq(x,df=v)
x=round(x,digits = 2)
```

```
x=sqrt(x)
x=x^2
x
if (x<x1) l<-FALSE
l

x2=((n1-m1-0.5)^2)/m1+((n2-m2-0.5)^2)/m2
x2
```

R code Exa 12.12.9 survey of 320 families

```
#PAGE=252
x=320
f=c(18,56,110,88,40,8)
p=1/2
q=1-p
l=length(f)
t=l-1
p1=p**t
p2=5*(p**(t-1))*q**1
p3=10*(p**(t-2))*q**2
p4=10*(p**(t-3))*q**3
p5=5*(p**(t-4))*q**4
p6=(p**(t-5))*q**5

k=c(p1,p2,p3,p4,p5,p6)
k=k*x
s=0
for(i in 1:l)
{
  m=((f[i]-k[i])**2)/k[i]
  s=s+m
}
s=round(s,digits = 0)
s
```

```
a=0.95
a=qchisq(a,df=t)
a=round(a,digits = 1)
a
if(a<s) k1<-FALSE
k1

a1=0.99
a1=qchisq(a1,df=t)
a1=round(a1,digits = 1)
a1
if(a1>s) k2<-TRUE
k2
#"The answer may vary due to difference in representation."
```

R code Exa 12.12.11 verification

```
#PAGE=253
n1=315
n2=108
n3=101
n4=32
n=n1+n2+n3+n4
k1=9
k2=3
k3=3
k4=1
x=k1+k2+k3+k4
x1=(k1*n)/x
x2=(k2*n)/x
x3=(k3*n)/x
x4=(k4*n)/x
y=c(x1,x2,x3,x4)
z=c(n1,n2,n3,n4)
```

```
z=z^2
l=z/y
l=sum(l)
l=l-n
l=round(l,digits = 2)
l
```

R code Exa 12.12.12 goodness of fit

```
#PAGE=253
f=c(38,144,342,287,164,25)
e=c(33.2,161.9,316.2,308.7,150.7,29.4)
x=(f-e)**2
x=x/e
x=sum(x)
l=length(f)
m=1
f=l-1-m

a=0.95
a=qchisq(a,df=f)
a=round(a,digits = 2)
a

if(x<a) k2<-TRUE
k2


b=0.05
b=qchisq(b,df=f)
b=round(b,digits = 3)
b

if(x>b) k<-FALSE
k
```

```
#"The answer may vary due to difference in
    representation."
```

R code Exa 12.12.13 Goodness of fit

```
#PAGE=254
f=c(5,18,42,27,8)
e=c(4.13,20.68,38.92,27.71,7.43)
x=(f-e)
x=x^2
x=x/e
x=sum(x)

l=length(f)
m=2
f=l-1-m
a=0.95
a=qchisq(a,df=f)
a=round(a,digits =2 )
a

if(a>x) k<-TRUE
k

a1=0.05
a1=qchisq(a1,df=f)
a1=round(a1,digits =3 )
a1

if(a1<x) k1<-FALSE
k1
#"The answer may vary due to difference in
    representation."
```

R code Exa 12.12.14 chi square test

```
#PAGE=254
n1=100
n2=100
a1=75
b1=65
a2=n1-a1
b2=n2-b1

x1=70
x2=n1-x1
y1=70
y2=n2-y1

x=((a1-x1)**2)/x1+((b1-y1)**2)/y1+((a2-x2)**2)/x2+((
    b2-y2)**2)/y2
x=round(x,digits = 2)
x

a=0.05
a=1-a
a=qchisq(a,df=1)
a
if(a>x) k<-FALSE
k

a1=0.01
a1=1-a1
a1=qchisq(a1,df=1)
a1
if(a1>x) k<-FALSE
k
#"The answer may vary due to difference in
```

```
representation."
```

R code Exa 12.12.15 Yates correction

```
#PAGE=255
n=c(75,65,25,35)
a=70
b=30
c=0.5
x=((abs(n[1]-a)-c)^2)/a+((abs(n[2]-a)-c)^2)/a+((abs(
    n[3]-b)-c)^2)/b+((abs(n[4]-b)-c)^2)/b
x=round(x,2)
x
```

R code Exa 12.12.16 Students passed and failed

```
#PAGE=255
x1=50
x2=5
y1=47
y2=14
z1=56
z2=8
t1=27*100/180
t2=100-t1
t11=55
t22=61
t33=64
x11=(t11*t1)/100
x12=(t22*t1)/100
x13=(t33*t1)/100
x21=(t11*t2)/100
x22=(t22*t2)/100
```

```
x23=(t33*t2)/100
a1=((x1-x21)**2)/x21
a2=((y1-x22)**2)/x22
a3=((z1-x23)**2)/x23
a4=((x2-x11)**2)/x11
a5=((y2-x12)**2)/x12
a6=((z2-x13)**2)/x13
a=c(a1,a2,a3,a4,a5,a6)
a=sum(a)
a
h=2
k=3
f=(h-1)*(k-1)
m1=0.95
m1=qchisq(m1,df=f)
m1=round(m1,digits = 2)
m1

if(a<m1)k1<-TRUE
k1

m2=0.9
m2=qchisq(m2,df=f)
m2=round(m2,digits = 2)
m2

if(a>m2)k2<-FALSE
k2
#"The answer may vary due to difference in
    representation."
```

R code Exa 12.12.17 Computing the value

```
#PAGE=256
a1=50
```

```
a2=47
a3=56
b1=5
b2=14
b3=8
n11=a1+a2+a3
n22=b1+b2+b3
n1=a1+b1
n2=a2+b2
n3=a3+b3
n=n11+n22
x1=((a1**2)/n1+(a2**2)/n2+(a3**2)/n3)*n/n11
x2=((b1**2)/n1+(b2**2)/n2+(b3**2)/n3)*n/n22
x=x1+x2-n
x=round(x,digits = 2)
x
```

R code Exa 12.12.19 Contingency table

```
#PAGE=257
a1=75
a2=25
b1=65
b2=35
n1=140
n2=60
n11=100
n22=100
n=n1+n2
x=(n*(a1*b2-a2*b1)**2)/(n1*n2*n11*n22)
x=round(x,digits = 2)
x

x1=n*(((a1*b2-a2*b1)-n/2)**2)/(n1*n2*n11*n22)
x1=round(x1,digits = 2)
```

```
x1
```

R code Exa 12.12.21 coefficient of contingency

```
#PAGE=258
n1=100
n2=100
a1=75
b1=65
a2=n1-a1
b2=n2-b1

x1=70
x2=n1-x1
y1=70
y2=n2-y1

x=((a1-x1)**2)/x1+((b1-y1)**2)/y1+((a2-x2)**2)/x2+((
   b2-y2)**2)/y2
x=round(x,digits = 2)
x

c=sqrt(x/(x+n1+n2))
c=round(c,digits = 4)
c
```

R code Exa 12.12.22 Maximum Value of coefficient

```
#PAGE=258
a=100
b=100
t1=100
t2=100
```

```
t3=100
t4=100
t=200
n=t/4

x=((a-n)**2)/n+((0-n)**2)/n+((0-n)**2)/n+((b-n)**2)/
   n
x

c=sqrt(x/(x+t))
c=round(c,digits = 4)
c
```

R code Exa 12.12.23 Correlation coefficient

```
#PAGE=259
n1=100
n2=100
a1=75
b1=65
a2=n1-a1
b2=n2-b1

x1=70
x2=n1-x1
y1=70
y2=n2-y1

x=((a1-x1)**2)/x1+((b1-y1)**2)/y1+((a2-x2)**2)/x2+((
   b2-y2)**2)/y2
x=round(x,digits = 2)

k=2
r=sqrt(x/((n1+n2)*(k-1)))
r=round(r,digits = 4)
```

```
r

x4=((abs(a1-x1)-0.5)**2)/x1+((abs(b1-y1)-0.5)**2)/y1
   +((abs(a2-x2)-0.5)**2)/x2+((abs(b2-y2)-0.5)**2)/
   y2
x4=round(x4,digits = 2)

a=sqrt(x4/(n1+n2))
a=round(a,digits = 4)
a
```

R code Exa 12.12.25 Hypothesis test

```
#PAGE=259
x=c(2.37,2.86,3.54)
f=c(1,1,1)
x=sum(x)
x
f=sum(f)

a=0.95
a=qchisq(a,df=f)
a=round(a,digits = 2)
a

if(x>a) k<-TRUE
k

#"The answer may vary due to difference in
   representation."
```

Chapter 13

Curve Fitting And The Method Of Least Squares

R code Exa 13.13.1 Straight line

```
#PAGE=269
x=c(2,3,5,7,9,10)
y=c(1,3,7,11,15,17)
plot(x,y,ylim =c(0,16))
lines(x,y,col="grey")
```

R code Exa 13.13.2 The increase in Y corresponding to a unit increase in X

```
#PAGE=269
a=4
y=2*a-3
y

b=15
x=(b*2)-3
```

```
x

c=0
y=2*c-3
y

d=7.5
x=(d+3)/2
x

e=0
x=(e+3)/2
x
```

R code Exa 13.13.3 Equation of a straight line

```
#PAGE=270
x1=2
x2=4
y1=-3
y2=5
m=(y2-y1)/(x2-x1)
c=m*x1-y1
cat('Y +',-y1,'=',m,'( X -',x1,')')
```

R code Exa 13.13.5 Slope equation and intercepts

```
#PAGE=272
x1=1
y1=5
x2=4
y2=-1
m=(y2-y1)/(x2-x1)
```

```
cat(m)

b1=y1-m
b2=-y2*m
cat('Y =',b1,'-',-b2,'X')

c1=0
y=b1+m*c1
cat(y)

c2=0
x=(b1+c2)/(-m)
cat(x)
```

R code Exa 13.13.7 Equation of line slope

```
#PAGE=272
m=-4
y=16
cat('Y =',y,'-',-m,'X')
```

R code Exa 13.13.8 Straight line

```
#PAGE=273
x=c(1,3,4,6,8,9,11,14)
y=c(1,2,4,4,5,7,8,9)
plot(x,y)

a=7.5
b=12
c=(a-1)/(b-0)
c
abline(1,c)
```

R code Exa 13.13.9 Comparing and Estimation

```
#PAGE=273
a=0.542
x1=1
y1=1+a*x1
y1=round(y1,digits = 1)

x2=3
y2=1+a*x2
y2=round(y2,digits = 1)

x3=4
y3=1+a*x3
y3=round(y3,digits = 1)

x4=6
y4=1+a*x4
y4=round(y4,digits = 1)

x5=8
y5=1+a*x5
y5=round(y5,digits = 1)

x6=9
y6=1+a*x6
y6=round(y6,digits = 1)

x7=11
y7=1+a*x7
y7=round(y7,digits = 1)

x8=14
y8=1+a*x8
```

```
y8=round(y8,digits = 1)

x=c(x1,x2,x3,x4,x5,x6,x7,x8)
y=c(1,2,4,4,5,7,8,9)
y1=c(y1,y2,y3,y4,y5,y6,y7,y8)

y<- matrix(c(x,y,y1),ncol=8,byrow=TRUE)
colnames(y) <- c(" "," "," "," "," "," "," "," ")
rownames(y) <- c("X","Y","Yest")
y<- as.table(y)
y
```

R code Exa 13.13.10 Length and Breadth

```
#PAGE=274
x=c(70,63,72,60,66,70,74,65,62,67,65,68)
y=c(155,150,180,135,156,168,178,160,132,145,139,152)

plot(x,y)
lm(y~x)
abline(lm(y~x),col='green',lwd=2)


x1=60
y1=130
x2=72
y2=170
c1=(y2-y1)/(x2-x1)
c2=y1-c1*x1
cat('Y =',c1,'X - ',(-1)*c2)

x1=63
y1=c1*x1+c2
cat(y1,'mm')

```

```
y2=168
x2=(y2-c2)/c1
cat(x2,'mm')
```

R code Exa 13.13.11 dependent and independent variables

```
#PAGE=275
x1=c(1,3,4,6,8,9,11,14)
y1=c(1,2,4,4,5,7,8,9)
x2=x1^2
xy=x1*y1
y2=y1^2
l=length(x1)

x1=sum(x1)
x2=sum(x2)
y1=sum(y1)
y2=sum(y2)
xy=sum(xy)


a0=((y1*x2)-(x1*xy))/(l*x2-x1**2)
a0=round(a0,digits = 3)

a1=((l*xy)-(x1*y1))/(l*x2-x1**2)
a1=round(a1,digits = 3)
cat('Y =',a0,'+',a1,'X')

b0=((x1*y2)-(y1*xy))/(l*y2-y1**2)
b0=round(b0,digits = 3)

b1=((l*xy)-(x1*y1))/(l*y2-y1**2)
b1=round(b1,digits = 3)
cat('X =',b0,'+',b1,'Y')
```

R code Exa 13.13.12 Graph of two lines

```
#PAGE=276
t=0:16
z=0.667*t+0.333
w=0.545+0.636*t

plot(t,z, type="l", col="green", lwd=5, xlab="Breadth", ylab="Length")
lines(t, w, col="red", lwd=2)
```

R code Exa 13.13.13 least squares lines

```
#PAGE=276
a=-7
b=11
c=2
d=-3
e=6
f=-1

A <- matrix(data=c(a,b,c,d), nrow=2, ncol=2, byrow=TRUE)
b <- matrix(data=c(e,f), nrow=2, ncol=1, byrow=FALSE)
round(solve(A, b), 2)

x=12
y=0.545+0.636*x
y=round(y,1)
cat(y)

```

```
y1=3
x1=-0.5+1.5*y1
cat(x1)
```

R code Exa 13.13.17 Fit a least squares lines

```
#PAGE=279
x=c(70,63,72,60,66,70,74,65,62,67,65,68)
y=c(155,150,180,135,156,168,178,160,132,145,139,152)
x1=mean(x)
y1=mean(y)
s1=sum(x)
s2=sum(y)
x2=x-x1
x2=round(x2,1)
y2=y-y1
y2=round(y2,1)
xy=x2*y2
x3=x2**2
y3=y2**2
sxy=sum(xy)
sx3=sum(x3)
sy3=sum(y3)


a1=sxy/sx3
a1=round(a1,2)
a2=a1*x1-y1
a2=round(a2,0)
cat('Y =',a1,'X - ',a2)

a1=sxy/sy3
a1=round(a1,2)
a2=-a1*y1+x1
a2=round(a2,0)
```

```
cat('X =',a1,'Y +',a2)
```

R code Exa 13.13.18 Graphs of two lines

```
#PAGE=281

t=60:76
z=3.22*t-60.9
w=(t-31)/0.232

plot(t,z, type="l", col="green", lwd=5, xlab="
   Breadth", ylab="Length")
lines(t, w, col="red", lwd=2)

x1=63
y1=x1*3.22-60.9
y1=round(y1,digits = 0)
cat(y1,'mm')

y2=168
x2=31+0.232*y2
x2=round(x2,digits = 0)
cat(x2,'mm')
```

R code Exa 13.13.19 Medical care in United States

```
#PAGE=281
y1=c(1976:1984)
y=c
   (184.7,202.4,219.4,239.7,265.9,294.5,328.7,357.3,378)

plot(y1,y,type='b')
```

```

x=(0:8)
s1=sum(x)
m1=mean(x)
s2=sum(y)
m2=mean(y)

x1=x-m1
y1=y-m2
x2=x1^2
xy=x1*y1
s3=sum(x2)
s4=sum(xy)

a=s4/s3
a=round(a,2)
m1
b=-m1*a+m2
b=round(b,1)
cat('Y =',b,'+',a,'X')

x=9
ans1=b+a*x
cat(ans1)

x=-1
ans2=b+a*x
cat(ans2)
```

R code Exa 13.13.20 Farm Employment of the United States

```
#PAGE=284

yr=c
  (1935,1940,1945,1950,1955,1960,1965,1970,1975,1980)
```

```
y=c(12.7,11,10,9.9,8.4,7.1,5.6,4.5,4.3,3.7)
x=c(0,1,2,3,4,5,6,7,8,9)
y1=mean(y)
x1=mean(x)
x2=x-x1
y2=y-y1
y2=round(y2,digits = 1)
x3=x2**2
x3=sum(x3)
xy=x2*y2
xy=sum(xy)
xy=round(xy,digits = 1)

c1=xy/x3
c1=round(c1,digits = 2)
c2=c1*(-1*x1)+y1
c2=round(c2,digits = 1)

t=1935:1980
z=c1*t-c2

plot(yr,y, type="l", col="green", lwd=5, xlab="index", ylab="year",xlim = c(1935,1980))
lines(t, z, col="red", lwd=2)

c1=c1*(-1)
cat('Y =',c2,'-',c1,'X')

a=which(x==0)
a=yr[a]
b=1990
c=b-a
c=c/5
c
c2=c2-0.1
yc1=c2-(c1*c)
cat(yc1,'million')
```

```
d=2000
e=d-a
e=e/5
e
yc=c2-c1*e
cat(yc,'million')
```

R code Exa 13.13.21 Thermodynamic principles

```
#PAGE=286
v=c(54.3,61.8,72.4,88.7,118.6,194)
p=c(61.2,49.5,37.6,28.4,19.2,10.1)

x=log10(v)
x=round(x,4)

y=log10(p)
y=round(y,4)

sx=sum(x)
sy=sum(y)

x2=x^2
x2=round(x2,4)

xy=x*y
xy=round(xy,4)

sx2=sum(x2)
sxy=sum(xy)

n=length(v)
a=(sy*sx2-sx*sxy)/(n*sx2-sx**2)
a=round(a,2)

```

```
a1=(n*sxy-sx*sy)/(n*sx2-sx**2)
a1=round(a1,2)


c=10^a
y=-1*a1
c=round(c,-3)
am=formatC(c,format="e")
cat(am)
cat(y)

cat('PV^1.4 =',c)

v1=100
v2=log10(v1)

p1=a+a1*v2
p2=10^p1
p2=round(p2,1)
cat(p2)
```

R code Exa 13.13.22 Plotting the data

```
#PAGE=287
v=c(54.3,61.8,72.4,88.7,118.6,194)
p=c(61.2,49.5,37.6,28.4,19.2,10.1)
v1=log10(v)
p1=log10(p)

plot(v,p,xlim = c(10,300),ylim = c(10,100),xlab = '
   Volume V',ylab='Pressure P')
a=lm(p~v)
abline(a)

b=lm(v~p)
```

```
c=coef(b)[2]
c1=c+1
c1=round(c1,1)

v=100
p=25
p=log10(25)
q=log10(100)
a3=p-q*c1
a3=round(a3,2)

ans=10**a3
ans=round(ans,-3)
cat(ans)
```

R code Exa 13.13.23 Population of United States

```
#PAGE=288
y1=c(1880:1980)
y=c
   (50.2,62.9,76,92,105.7,122.8,131.7,151.1,179.3,203.3,226.5)

x=c(-5:5)
s1=sum(x)
s2=sum(y)
x2=sum(x^2)
x3=sum(x^3)
x4=sum(x^4)
xy=sum(x*y)
x2y=sum(x^2*y)

a1=xy/x2
a1=round(a1,2)
a1

```

```r
A <- matrix(data=c(11,x2,x2,x4), nrow=2, ncol=2, byrow=TRUE)
b <- matrix(data=c(s2,x2y), nrow=2, ncol=1, byrow=FALSE)
c=round(solve(A, b), 2)

c
a=c[1,1]
b=c[2,1]
cat('Y =',a,'+',a1,'X +',b,'X^2')

yy=c(1880,1890,1900,1910,1920,1930,1940,1950,1960,1970,1980)
y=c(50.2,62.9,76,92,105.7,122.8,131.7,151.1,179.3,203.3,226.5)
x=c(-5:5)

p=a+a1*x+b*x^2
p=round(p,1)
p

y1 <- matrix(c(yy,p,y),ncol=11,byrow=TRUE)
colnames(y1) <- c(1880,1890,1900,1910,1920,1930,1940,1950,1960,1970,1980)
rownames(y1) <- c("Year","Trend Value","Actual Value")
y1 <- as.table(y1)
y1
```

Chapter 14

Correlation Theory

R code Exa 14.14.1 Least Squares Regression

```
#PAGE=301
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)

plot(x,y,ylim=c(62,72),xlim=c(62,72))

x2=x**2
y2=y**2
xy=x*y

n1=sum(x)
n2=sum(y)
n3=sum(x2)
n4=sum(y2)
n5=sum(xy)

l=length(x)

c=matrix(c(l,n1,n1,n3),nrow=2,ncol=2)

d=matrix(c(n2,n5),nrow=2,ncol=1)
```

```
e=solve(c,d)
a0=e[2]
a0=round(a0,digits = 3)
a1=e[1]
a1=round(a1,digits = 2)
cat('Y =',a1,'+',a0,'X')


f=matrix(c(l,n2,n2,n4),nrow=2,ncol=2)

g=matrix(c(n1,n5),nrow=2,ncol=1)

h=solve(f,g)
a3=h[2]
a3=round(a3,digits = 3)
a2=h[1]
a2=round(a2,digits = 2)
cat('X =',a2,'+',a3,'Y')





t=62:72
z=a0*t+a1
w=(t-a2)/a3

plot(t,z, type="l", col="green", lwd=5, xlab="
    Breadth", ylab="Length")
lines(t, w, col="red", lwd=2)
```

R code Exa 14.14.2 Regression lines

```
#PAGE=303
```

```
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
s1=sum(x)
m1=mean(x)
s2=sum(y)
m2=mean(y)
m1=round(m1,1)
m2=round(m2,1)

x1=x-m1
y1=y-m2
x2=x1^2
xy=x1*y1
y2=y1^2
s3=sum(x2)
s4=sum(xy)
s5=sum(y2)

a1=s4/s3
a1=round(a1,3)
a=s4/s5
a=round(a,1)
cat('Y -',m2,'=',a1,'( X -',m1,')')

cat('X -',m1,'=',a,'( Y -',m2,')')
```

R code Exa 14.14.5 Computing Standard error

```
#PAGE=305
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
yest=35.82+0.476*x
yest=round(yest,2)
a=y-yest
a1=a^2
```

```
s1=sum(a1)/12
s1=round(s1,3)
cat(s1)
ans=sqrt(s1)
ans=round(ans,2)
cat(ans,'kg')

y2=38.92
a=0.476
xy=40.34
ans2=y2-a*xy
ans2=ans2/length(x)
ans2=round(ans2,3)
ans2
ans2=sqrt(ans2)
ans2=round(ans2,2)
cat(ans2,'kg')
```

R code Exa 14.14.6 Regression line

```
#PAGE=305
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
a1=35.82
a2=0.476


a3=a1+1.28
a4=a1-1.28

plot(x,y)
abline(a1,a2)
abline(a3,a2)
abline(a4,a2)

```

```
n=3
b1=(length(x)-n)
b=b1/length(x)
cat(b*100,'%')
```

R code Exa 14.14.8 Total variation explained variation and unexplained variation

```
#PAGE=306

x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)

l=length(x)
a1=mean(x)
a2=mean(y)
s1=sum(x)
s2=sum(y)
x1=x-a1
y1=y-a2
x2=x1**2
xy=x1*y1
y2=y1**2

s3=sum(x2)
s4=sum(xy)
s5=sum(y2)

s3=round(s3,digits = 2)
s4=round(s4,digits = 2)
s5=round(s5,digits = 2)

a=sum(y2)
a=round(a,digits = 2)
a
```

```
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
yest=35.82+0.476*x
yest=round(yest,digits = 2)
y1=y-yest
y1=y1**2
y1=sum(y1)
y1=round(y1,digits = 2)
y1

m=mean(y)
y2=(yest-m)**2
y2=sum(y2)
y2=round(y2,digits = 2)
y2
```

R code Exa 14.14.9 Coefficient of determination and correlation

```
#PAGE=307

x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)

l=length(x)
a1=mean(x)
a2=mean(y)
s1=sum(x)
s2=sum(y)
x1=x-a1
y1=y-a2
x2=x1**2
xy=x1*y1
y2=y1**2

```

```
s3=sum(x2)
s4=sum(xy)
s5=sum(y2)

s3=round(s3,digits = 2)
s4=round(s4,digits = 2)
s5=round(s5,digits = 2)

a=sum(y2)
a=round(a,digits = 2)

x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
yest=35.82+0.476*x
yest=round(yest,digits = 2)
y1=y-yest
y1=y1**2
y1=sum(y1)
y1=round(y1,digits = 2)

m=mean(y)
y2=(yest-m)**2
y2=sum(y2)
y2=round(y2,digits = 2)

a1=y2/a
a1=round(a1,digits = 4)
a1

b1=sqrt(a1)
b1=round(b1,digits = 4)
b1
```

R code Exa 14.14.11 Coefficient of linear correlation

```
#PAGE=308
x=c(1,3,4,6,8,9,11,14)
y=c(1,2,4,4,5,7,8,9)
m1=mean(x)
m1=ceiling(m1)
m2=mean(y)
x1=x-m1
y1=y-m2
xy=x1*y1
x2=x1**2
y2=y1**2

s1=sum(x1)
s2=sum(y2)
s3=sum(x2)
s4=sum(y2)
s5=sum(xy)

r=s5/(sqrt(s3*s2))
r=round(r,digits = 3)
r
```

R code Exa 14.14.12 standard variation variance and covariance

```
#PAGE=308
x=c(1,3,4,6,8,9,11,14)
y=c(1,2,4,4,5,7,8,9)
m1=mean(x)
m1=ceiling(m1)
m2=mean(y)
x1=x-m1
y1=y-m2
xy=x1*y1
x2=x1**2
y2=y1**2
```

```
s1=sum(x1)
s2=sum(y2)
s3=sum(x2)
s4=sum(y2)
s5=sum(xy)

r=s5/(sqrt(s3*s2))
r=round(r,digits = 3)

l=length(x)

a=sqrt(s3/l)
a=round(a,digits = 2)
a

b=sqrt(s4/l)
b=round(b,digits = 2)
b

c=a**2
c=round(c,digits = 1)
c

d=b**2
d=round(d,digits = 0)
d

e=s5/l
e
```

R code Exa 14.14.13 verification

```
#PAGE=309

```

```
x=c(1,3,4,6,8,9,11,14)
y=c(1,2,4,4,5,7,8,9)
m1=mean(x)
m1=ceiling(m1)
m2=mean(y)
x1=x-m1
y1=y-m2
xy=x1*y1
x2=x1**2
y2=y1**2

s1=sum(x1)
s2=sum(y2)
s3=sum(x2)
s4=sum(y2)
s5=sum(xy)

r=s5/(sqrt(s3*s2))
r=round(r,digits = 3)

l=length(x)

a=sqrt(s3/l)
a=round(a,digits = 2)

b=sqrt(s4/l)
b=round(b,digits = 2)

c=a**2
c=round(c,digits = 1)

d=b**2
d=round(d,digits = 0)

e=s5/l

a1=e/(a*b)
a1=round(a1,digits = 3)
```

```
a1
```

R code Exa 14.14.14 Product moment formula

```
#PAGE=309
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)

m1=mean(x)
m2=mean(y)

x1=x-m1
y1=y-m2

x2=x1**2
y2=y1**2
xy=x1*y1

n1=sum(x)
n1=round(n1,digits = 2)
n2=sum(y)
n2=round(n2,digits = 2)
n3=sum(x2)
n3=round(n3,digits = 2)
n4=sum(y2)
n4=round(n4,digits = 2)
n5=sum(xy)
n5=round(n5,digits = 2)

r=n5/(sqrt(n3*n4))
r=round(r,digits = 4)
r
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 14.14.16 Linear correlation coefficient

```
#PAGE=309
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)

plot(x,y,ylim=c(62,72),xlim=c(62,72))

x2=x**2
y2=y**2
xy=x*y

n1=sum(x)
n2=sum(y)
n3=sum(x2)
n4=sum(y2)
n5=sum(xy)

l=length(x)

a=(l*n5-n1*n2)
b=(sqrt((l*n3-n1**2)*(l*n4-n2**2)))
a=a/b
a=round(a,digits = 4)
a
```

R code Exa 14.14.17 Frequency distributions

```
#PAGE=310
t=100
a=c
   (0,0,0,2,4,4,10,0,0,1,4,6,5,16,0,0,5,10,8,1,24,1,4,9,5,2,0,21,3,6
```

```
y<- matrix(c(a),ncol=7,byrow=TRUE)
colnames(y) <- c("40-49","50-59","60-69","70-79","80-89","90-99","total")
rownames(y) <- c("90-99","80-89","70-79","60-69","50-59","40-49","total")
y <- as.table(y)
y

a=y[2,4]
a

b=y[7,c(1,2,3)]
b=sum(b)
b=b/t*100
cat(b,'%')

c=y[c(1,2,3),c(1,2,3,4)]
c=sum(c)
c

d=y[c(5,6),c(1,2)]
d=sum(d)
d=t-d
d=d/t*100
cat(d,'%')
```

R code Exa 14.14.19 Coefficient of linear correlation

```
#PAGE=311
x=c(44.5,54.5,64.5,74.5,84.5,94.5)
y1=c(94.5,84.5,74.5,64.5,54.5,44.5)
ux=c(-2,-1,0,1,2,3)
uy=c(2,1,0,-1,-2,-3)
```

```
a=c
  (0,0,0,2,4,4,0,0,1,4,6,5,0,0,5,10,8,1,1,4,9,5,2,0,3,6,6,2,0,0,3,5

y<- matrix(c(a),ncol=6,byrow=TRUE)
colnames(y) <- c(x)
rownames(y) <- c(y1)
y <- as.table(y)
y

a1=y[1,c(4,5,6)]
fy1=sum(a1)

a2=y[2,c(3,4,5,6)]
fy2=sum(a2)

a3=y[3,c(3,4,5,6)]
fy3=sum(a3)

a4=y[4,c(1,2,3,4,5)]
fy4=sum(a4)

a5=y[5,c(1,2,3,4)]
fy5=sum(a5)

a6=y[6,c(1,2,3)]
fy6=sum(a6)

fy=c(fy1,fy2,fy3,fy4,fy5,fy6)
fuy=uy*fy
fuy2=(uy**2)*fy


b1=y[c(4,5,6),1]
b1=sum(b1)

b2=y[c(4,5,6),2]
b2=sum(b2)
```

```
b3=y[c(2,3,4,5,6),3]
b3=sum(b3)

b4=y[c(1,2,3,4,5),4]
b4=sum(b4)

b5=y[c(1,2,3,4),5]
b5=sum(b5)

b6=y[c(1,2,3),6]
b6=sum(b6)

fx=c(b1,b2,b3,b4,b5,b6)
fux=ux*fx
fux2=(ux**2)*fx

n1=sum(fy)
n2=sum(fx)
n3=sum(fux)
n4=sum(fuy)
n5=sum(fux2)
n6=sum(fuy2)

c1=4+16+24
c2=4+12+15
c3=0
c4=2+4-5-4
c5=12+12-4
c6=18+15
r=c(c1,c2,c3,c4,c5,c6)

r1=2+12+18
r2=4+12+15
r3=0
r4=4+4-5-4
r5=16+12-4
r6=24+15
```

```
c=c(r1,r2,r3,r4,r5,r6)

c1=sum(c)
c3=c2=10

r1=(n1*c1-n3*n4)
r2=sqrt((n1*n5-n3^2)*(n1*n6-n4^2))
r=r1/r2
r=round(r,digits = 4)
r
```

R code Exa 14.14.20 Computing and Verify

```
#PAGE=312
x=c(44.5,54.5,64.5,74.5,84.5,94.5)
y1=c(94.5,84.5,74.5,64.5,54.5,44.5)
ux=c(-2,-1,0,1,2,3)
uy=c(2,1,0,-1,-2,-3)

a=c
  (0,0,0,2,4,4,0,0,1,4,6,5,0,0,5,10,8,1,1,4,9,5,2,0,3,6,6,2,0,0,3,5

y<- matrix(c(a),ncol=6,byrow=TRUE)
colnames(y) <- c(x)
rownames(y) <- c(y1)
y <- as.table(y)
y

a1=y[1,c(4,5,6)]
fy1=sum(a1)

a2=y[2,c(3,4,5,6)]
fy2=sum(a2)

a3=y[3,c(3,4,5,6)]
```

```
fy3=sum(a3)

a4=y[4,c(1,2,3,4,5)]
fy4=sum(a4)

a5=y[5,c(1,2,3,4)]
fy5=sum(a5)

a6=y[6,c(1,2,3)]
fy6=sum(a6)

fy=c(fy1,fy2,fy3,fy4,fy5,fy6)
fuy=uy*fy
fuy2=(uy**2)*fy


b1=y[c(4,5,6),1]
b1=sum(b1)

b2=y[c(4,5,6),2]
b2=sum(b2)

b3=y[c(2,3,4,5,6),3]
b3=sum(b3)

b4=y[c(1,2,3,4,5),4]
b4=sum(b4)

b5=y[c(1,2,3,4),5]
b5=sum(b5)

b6=y[c(1,2,3),6]
b6=sum(b6)

fx=c(b1,b2,b3,b4,b5,b6)
fux=ux*fx
fux2=(ux**2)*fx
```

```
n1=sum(fy)
n2=sum(fx)
n3=sum(fux)
n4=sum(fuy)
n5=sum(fux2)
n6=sum(fuy2)

c1=4+16+24
c2=4+12+15
c3=0
c4=2+4-5-4
c5=12+12-4
c6=18+15
r=c(c1,c2,c3,c4,c5,c6)

r1=2+12+18
r2=4+12+15
r3=0
r4=4+4-5-4
r5=16+12-4
r6=24+15
c=c(r1,r2,r3,r4,r5,r6)

c1=sum(c)
c3=c2=10

a=c2*(sqrt(n5/n1-(n3/n1)**2))
a=round(a,digits = 3)
a

b=c3*(sqrt(n6/n1-(n4/n1)**2))
b=round(b,digits = 3)
b

c=c2*c3*(c1/n1-(n3/n1)*(n4/n1))
c

r=c/(a*b)
```

```
r=round(r,digits = 4)
r
```

R code Exa 14.14.23 Linear correlation coefficient

```
#PAGE=313
x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)

x2=x**2
y2=y**2
xy=x*y

n1=sum(x)
n2=sum(y)
n3=sum(x2)
n4=sum(y2)
n5=sum(xy)

l=length(x)

c=matrix(c(l,n1,n1,n3),nrow=2,ncol=2)

d=matrix(c(n2,n5),nrow=2,ncol=1)

e=solve(c,d)
a0=e[2]
a0=round(a0,digits = 3)
a1=e[1]
a1=round(a1,digits = 2)

f=matrix(c(l,n2,n2,n4),nrow=2,ncol=2)

g=matrix(c(n1,n5),nrow=2,ncol=1)

```

```
h=solve(f,g)
a3=h[2]
a3=round(a3,digits = 3)
a2=h[1]
a2=round(a2,digits = 2)

a1=a0
b1=a3
r=a1*b1
r=sqrt(r)
r=round(r,digits = 4)
r
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 14.14.24 Equation of regression lines

```
#PAGE=314
a=64.5
b=74.5
c=10
n=100
ux=64
uy=-55

x=a+c*ux/n
y=b+c*uy/n
sx=13.966
sy=14.925
r=0.7686

a1=r*sy/sx
a1=round(a1,3)
a2=r*sx/sy
a2=round(a2,3)
```

```
cat('Y -',x,'=',a1,'( x -',x,')')
cat('Y -',y,'=',a2,'( x -',y,')')
```

R code Exa 14.14.25 Standard errors

```
#PAGE=314

x=c(44.5,54.5,64.5,74.5,84.5,94.5)
y1=c(94.5,84.5,74.5,64.5,54.5,44.5)
ux=c(-2,-1,0,1,2,3)
uy=c(2,1,0,-1,-2,-3)

a=c
   (0,0,0,2,4,4,0,0,1,4,6,5,0,0,5,10,8,1,1,4,9,5,2,0,3,6,6,2,0,0,3,5
y<- matrix(c(a),ncol=6,byrow=TRUE)
colnames(y) <- c(x)
rownames(y) <- c(y1)
y <- as.table(y)
y

a1=y[1,c(4,5,6)]
fy1=sum(a1)

a2=y[2,c(3,4,5,6)]
fy2=sum(a2)

a3=y[3,c(3,4,5,6)]
fy3=sum(a3)

a4=y[4,c(1,2,3,4,5)]
fy4=sum(a4)

a5=y[5,c(1,2,3,4)]
fy5=sum(a5)
```

```
a6=y[6,c(1,2,3)]
fy6=sum(a6)

fy=c(fy1,fy2,fy3,fy4,fy5,fy6)
fuy=uy*fy
fuy2=(uy**2)*fy


b1=y[c(4,5,6),1]
b1=sum(b1)

b2=y[c(4,5,6),2]
b2=sum(b2)

b3=y[c(2,3,4,5,6),3]
b3=sum(b3)

b4=y[c(1,2,3,4,5),4]
b4=sum(b4)

b5=y[c(1,2,3,4),5]
b5=sum(b5)

b6=y[c(1,2,3),6]
b6=sum(b6)

fx=c(b1,b2,b3,b4,b5,b6)
fux=ux*fx
fux2=(ux**2)*fx

n1=sum(fy)
n2=sum(fx)
n3=sum(fux)
n4=sum(fuy)
n5=sum(fux2)
n6=sum(fuy2)
```

```
c1=4+16+24
c2=4+12+15
c3=0
c4=2+4-5-4
c5=12+12-4
c6=18+15
r=c(c1,c2,c3,c4,c5,c6)

r1=2+12+18
r2=4+12+15
r3=0
r4=4+4-5-4
r5=16+12-4
r6=24+15
c=c(r1,r2,r3,r4,r5,r6)

c1=sum(c)
c3=c2=10

a=c2*(sqrt(n5/n1-(n3/n1)**2))
a=round(a,digits = 3)
b=c3*(sqrt(n6/n1-(n4/n1)**2))
b=round(b,digits = 3)
c=c2*c3*(c1/n1-(n3/n1)*(n4/n1))
r=c/(a*b)
r=round(r,digits = 4)

a1=b*sqrt(1-r^2)
a1=round(a1,digits = 3)
a1

b1=a*sqrt(1-r^2)
b1=round(b1,digits = 3)
b1
```

R code Exa 14.14.26 US consumer price

```
#PAGE=314
yr=c(1975,1976,1977,1978,1979,1980,1981,1982,1983)
x=c(175,181,192,211,235,255,275,286,292)
y=c(169,185,202,219,240,266,295,329,357)
x1=mean(x)
x1=round(x1,digits = 0)
y1=mean(y)
y1=round(y1,digits = 0)

x=x-x1
y=y-y1
x2=x**2
y2=y**2
xy=x*y

s1=sum(x2)
s2=sum(y2)
s3=sum(xy)

a=s3/(sqrt(s1*s2))
a=round(a,digits = 2)
a
```

R code Exa 14.14.27 least squares parabola

```
#PAGE=315
x=c(1.2,1.8,3.1,4.9,5.7,7.1,8.6,9.8)
y=c(4.5,5.9,7,7.8,7.2,6.8,4.5,2.7)
s2=sum(y)
s1=sum(x)
xy=x*y
x2=x**2
x3=x**3
```

```
x4=x**4
xy2=x**2*y
l=length(x)
s3=sum(xy)
s4=sum(x2)
s5=sum(x3)
s6=sum(x4)
s7=sum(xy2)
s7=round(s7,digits = 0)
a <- matrix(c(l,s1,s4,s1,s4,s5,s4,s5,s6),nrow=3,ncol
   =3)
b <- matrix(c(s2,s3,s7),nrow=3,ncol=1)

y=solve(a,b)

a=y[1]
a=round(a,digits = 3)
b=y[2]
b=round(b,digits = 3)
c=y[3]
c=round(c,digits = 3)
cat('Y =',a,'+ ',b,'X - ',(-1)*c,'X^2')
```

R code Exa 14.14.28 least squares parabola

```
#PAGE=315
x=c(1.2,1.8,3.1,4.9,5.7,7.1,8.6,9.8)
y=c(4.5,5.9,7,7.8,7.2,6.8,4.5,2.7)
yest=2.588+2.065*x-0.211*x^2
yest=round(yest,3)
yest

y1 <- matrix(c(yest,y),ncol=8,byrow=TRUE)
colnames(y1) <- c(" "," "," "," "," "," "," "," ")
rownames(y1) <- c("Yest","Y")
```

```
y1 <- as.table(y1)
y1
```

R code Exa 14.14.29 Linear correlation coefficient

```
#PAGE=316
x=c(1.2,1.8,3.1,4.9,5.7,7.1,8.6,9.8)
y=c(4.5,5.9,7,7.8,7.2,6.8,4.5,2.7)
s2=sum(y)
s1=sum(x)
y8=y**2
s8=sum(y8)
xy=x*y
x2=x**2
x3=x**3
x4=x**4
xy2=x**2*y
l=length(x)
s3=sum(xy)
s4=sum(x2)
s5=sum(x3)
s6=sum(x4)
s7=sum(xy2)
s7=round(s7,digits = 0)
a <- matrix(c(l,s1,s4,s1,s4,s5,s4,s5,s6),nrow=3,ncol
   =3)
b <- matrix(c(s2,s3,s7),nrow=3,ncol=1)

y=solve(a,b)

a=y[1]
a=round(a,digits = 3)
b=y[2]
b=round(b,digits = 3)
c=y[3]
```

```
c=round(c,digits = 3)

l=length(x)

r=(l*s3-s1*s2)
r2=sqrt((l*s4-s1^2)*(l*s8-s2^2))
r=r/r2
r=round(r,digits = 4)
r


x=c(1.2,1.8,3.1,4.9,5.7,7.1,8.6,9.8)
y=c(4.5,5.9,7,7.8,7.2,6.8,4.5,2.7)

y1=mean(y)
y=(y-y1)**2
b1=sum(y)
b1=round(b1,digits = 2)

y2=a+b*x+c*x**2
y2=(y2-y1)**2
b2=sum(y2)
b2=round(b2,digits = 2)

r=b2/b1
r1=round(r,digits = 4)
r1
r1=sqrt(r)
r1=round(r1,digits = 2)
r1

d=1-r
d=round(d,digits = 4)
d
```

R code Exa 14.14.30 standard deviation

```
#PAGE=317
x=c(1.2,1.8,3.1,4.9,5.7,7.1,8.6,9.8)
y=c(4.5,5.9,7,7.8,7.2,6.8,4.5,2.7)
s2=sum(y)
s1=sum(x)
y8=y**2
s8=sum(y8)
xy=x*y
x2=x**2
x3=x**3
x4=x**4
xy2=x**2*y
l=length(x)
s3=sum(xy)
s4=sum(x2)
s5=sum(x3)
s6=sum(x4)
s7=sum(xy2)
s7=round(s7,digits = 0)
a <- matrix(c(l,s1,s4,s1,s4,s5,s4,s5,s6),nrow=3,ncol
    =3)
b <- matrix(c(s2,s3,s7),nrow=3,ncol=1)

y=solve(a,b)

a=y[1]
a=round(a,digits = 3)
b=y[2]
b=round(b,digits = 3)
c=y[3]
c=round(c,digits = 3)

l=length(x)

r=(l*s3-s1*s2)
r2=sqrt((l*s4-s1^2)*(l*s8-s2^2))
```

```
r=r/r2
r=round(r,digits = 4)


x=c(1.2,1.8,3.1,4.9,5.7,7.1,8.6,9.8)
y=c(4.5,5.9,7,7.8,7.2,6.8,4.5,2.7)

y1=mean(y)
y=(y-y1)**2
b1=sum(y)
b1=round(b1,digits = 2)

y2=a+b*x+c*x**2
y2=(y2-y1)**2
b2=sum(y2)
b2=round(b2,digits = 2)

a=sqrt(b1/l)
a=round(a,digits = 3)
a

r=b2/b1
r1=round(r,digits = 4)
r1=sqrt(r)
r1=round(r1,digits = 4)

b=a*sqrt(1-r1^2)
b=round(b,digits = 2)
b
```

R code Exa 14.14.31 Correlation coefficient

```
#PAGE=317
r=0.32
n=18
```

```
t=r*sqrt(n-2)/(sqrt(1-r^2))
t=round(t,2)

t1=1.75

if (t<t1) l<-TRUE
l
#"The answer may vary due to difference in
   representation."
```

R code Exa 14.14.32 Minimum sample size

```
#PAGE=317

c=0.32
a=0.05

x1=1-a
x=qt(x1,df=1/0)
x=round(x,digits = 2)
x

m=(x*sqrt(1-c^2))/c
m=m**2
m=m+2
m=round(m,digits = 1)
m

m1=ceiling(m)
m1
f1=m1-2
t=c*sqrt(f1)/(sqrt(1-c^2))
t=round(t,digits = 2)
t

```

```
m2=m1+1
f2=m2-2
t1=c*sqrt(f2)/(sqrt(1-c^2))
t1=round(t1,digits = 2)
t1

m3=m2+1
f3=m3-2
t2=c*sqrt(f3)/(sqrt(1-c^2))
t2=round(t2,digits = 2)
t2

if(t2>x)k<-TRUE
k
#"The answer may vary due to difference in representation."
```

R code Exa 14.14.33 Correlation coefficient

```
#PAGE=318
n=24
r=0.75
m=0.05
a=0.6
z1=1.1513*log((1+r)/(1-r),10)
z1=round(z1,digits = 3)

u=1.1513*log((1+a)/(1-a),10)
u=round(u,digits = 4)

s=1/sqrt(n-3)
s=round(s,digits = 4)

z=(z1-u)/s
z=round(z,digits = 2)
```

```
z

a=0.05
x1=1-a
x=qt(x1,df=1/0)
x=round(x,digits = 2)
x

if(x>z) k<-TRUE
k

b=0.5
y=1.1513*log((1+b)/(1-b),10)
y=round(y,digits = 4)

z2=(z1-y)/s
z2=round(z2,digits = 2)
z2

if(x>y) k<-FALSE
k
#"The answer may vary due to difference in
   representation."
```

R code Exa 14.14.34 Correlation coefficient between final grades

```
#PAGE=318
n=21
r=0.8
m=0.95

z1=1.1513*log((1+r)/(1-r),10)
z1=round(z1,digits =4)

a=95/100
```

```
a=1-a
a=a/2
a=qnorm(a,lower.tail = FALSE)
a=round(a,digits = 2)

s=a/sqrt(n-3)
s=round(s,digits = 4)

n1=s+z1
n2=z1-s

m1=n1/1.1513
m2=(10^m1-1)
m3=(10^m1+1)
u=m2/m3
u=round(u,digits = 2)

m4=n2/1.1513
m5=(10^m4-1)
m6=(10^m4+1)
u2=m5/m6
u2=round(u2,digits = 2)

cat(u2,'-',u)
#"The answer may vary due to difference in
  representation."
#"The answer provided in the textbook is wrong."
```

R code Exa 14.14.35 two correlation coefficients

```
#PAGE=318
n1=28
n2=35
r1=0.5
r2=0.3
```

```
z1=1.1513*log10((1+r1)/(1-r1))
z2=1.513*log10((1+r2)/(1-r2))
s=sqrt((1/(n1-3)+1/(n2-3)))
s=round(s,4)
s
u1=u2=0
z=(z1-z2-(u1-u2))/s
z1=1.96
z2=-z1
if (z<z1||z>z2) l<-TRUE
l
#"The answer may vary due to difference in
   representation."
```

R code Exa 14.14.36 Regression equation

```
#PAGE=319
a1=0.476
a0=35.82
r=0.18

x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
yest=35.82+0.476*x
yest=round(yest,digits = 2)
y1=y-yest
y1=y1**2
l=length(x)
s=sum(y1)/l
s=round(s,digits = 3)

x3=mean(x)
x1=x-x3
x1=x1**2
x1=sum(x1)
```

```
x1=x1/l
x1=sqrt(x1)
x1=round(x1,digits = 2)
x1

x=sqrt(s)
x=round(x,digits = 2)

y6=x/x1
t=((a1-r)*sqrt(l-2))/y6
t=round(t,digits = 2)
t


a=95/100
a=1-a
a=qnorm(a,lower.tail = FALSE)
a=round(a,digits = 2)

if(a<t) k<-TRUE
k
#"The answer may vary due to difference in
    representation."
```

R code Exa 14.14.37 regression coefficient

```
#PAGE=319
a1=0.476
a0=35.82
r=0.18

x=c(65,63,67,64,68,62,70,66,68,67,69,71)
y=c(68,66,68,65,69,66,68,65,71,67,68,70)
yest=35.82+0.476*x
yest=round(yest,digits = 2)
```

```
y1=y-yest
y1=y1**2
l=length(x)
s=sum(y1)/l
s=round(s,digits = 3)

x3=mean(x)
x1=x-x3
x1=x1**2
x1=sum(x1)
x1=x1/l
x1=sqrt(x1)
x1=round(x1,digits = 2)

x=sqrt(s)
x=round(x,digits = 2)

y6=x/x1
t=((a1-r)*sqrt(l-2))/y6
t=round(t,digits = 2)

g=qt(0.975,df=l-2)
g=round(g,digits = 2)

f=l-2
g1=(g*x)/(x1*sqrt(f))
g1=round(g1,digits = 3)
g1=a1+g1

g2=(g*x)/(x1*sqrt(f))
g2=round(g2,digits = 3)
g2=a1-g2

cat(g2,'-',g1)
#"The answer may vary due to difference in
    representation."
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 14.14.38 difference between two coefficients

```
#PAGE=319
l=12
g=qt(0.975,df=l-2)
g=round(g,digits = 2)
a1=65
y1=35.82+0.476*a1
y1
x0=65
m=800/l
a=((x0-m)/l)**2
ans1=y1+(g*1.28/sqrt(l-2))*sqrt(l+1+a/(2.66^2))
ans1=round(ans1,1)
ans2=y1-(g*1.28/sqrt(l-2))*sqrt(l+1+a/(2.66^2))
ans2=round(ans2,1)
cat(ans2,'-',ans1,'kg')
y2=69.14
x0=70
m=800/l
a=(x0-m)**2
ans1=y2+(g*1.28/sqrt(l-2))*sqrt(l+1+a/(2.66^2))
ans1=round(ans1,1)
ans2=y2-(g*1.28/sqrt(l-2))*sqrt(l+1+a/(2.66^2))
ans2=round(ans2,1)
cat(ans2,'-',ans1,'kg')
```

R code Exa 14.14.39 sons and fathers

```
#PAGE=320
l=12
```

```
g=qt(0.975,df=l-2)
g=round(g,digits = 2)
a1=65
y1=35.82+0.476*a1
y1
x0=65
m=800/l
a=(x0-m)**2
ans1=y1+(g*1.28/sqrt(l-2))*sqrt(1+a/(2.66^2))
ans1=round(ans1,1)
ans2=y1-(g*1.28/sqrt(l-2))*sqrt(1+a/(2.66^2))
ans2=round(ans2,1)
cat(ans2,'-',ans1,'kg')
y2=69.14
x0=70
m=800/l
a=(x0-m)**2
ans1=y2+(g*1.28/sqrt(l-2))*sqrt(+1+a/(2.66^2))
ans1=round(ans1,1)
ans2=y2-(g*1.28/sqrt(l-2))*sqrt(+1+a/(2.66^2))
ans2=round(ans2,1)
cat(ans2,'-',ans1,'kg')
```

Chapter 15

Multiple And Partial Correlation

R code Exa 15.15.3 variable and linear function

```
#PAGE=328
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
```

```
x9=sum(x9)
a <- matrix(c(1,x2,x3,x2,x5,x9,x3,x9,x6),nrow=3,ncol
    =3)

b <- matrix(c(x1,x7,x8),nrow=3,ncol=1)

c<-solve(a,b)
c=round(c,digits = 4)

b1=c[1]
b2=c[2]
b3=c[3]

cat('X1 =',b1,'+',b2,'X2 +',b3,'X3')


x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)


xest=b1+b2*x2+b3*x3
xest=round(xest,digits = 3)
xest

y <- matrix(c(xest,x1),ncol=1,byrow=TRUE)
colnames(y) <- c(" "," "," "," "," "," "," "," "," "
    ," "," "," ")
rownames(y) <- c("Xest","X")
y <- as.table(y)
y

x2=54
x3=9
xest=b1+b2*x2+b3*x3
xest=round(xest,digits = 3)
xest
```

R code Exa 15.15.4 standard deviation

```
#PAGE=330
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s1
s1=round(s1,digits = 2)
s1
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2
s2=round(s2,digits = 1)
s2
s3=sqrt((x6/l)-(x3/l)**2)
```

```
s3=round(s3,digits = 4)
s3
s3=round(s3,digits = 1)
s3
```

R code Exa 15.15.5 Computing the data

```
#PAGE=330
n=12
x1=753
x2=643
x3=106
x1x2=40830
x2x3=5779
x1x3=6796
x12=48139
x22=34843
x33=976
r12=(n*x1x2-x1*x2)/sqrt((n*x12-x1^2)*(n*x22-x2**2))
r12
r12=round(r12,2)
cat(r12)

r13=(n*x1x3-x1*x3)/sqrt((n*x12-x1^2)*(n*x33-x3**2))
r13
r13=round(r13,2)
cat(r13)

r23=(n*x2x3-x2*x3)/sqrt((n*x22-x2^2)*(n*x33-x3**2))
r23
r23=round(r23,2)
cat(r23)
```

R code Exa 15.15.6 Work problem

```
#PAGE=330
n=12
x1=753
x2=643
x3=106
x1x2=40830
x2x3=5779
x1x3=6796
x12=48139
x22=34843
x33=976
r12=0.82
r13=0.77
r23=0.8
s1=8.6
s2=5.7
s3=1.8
a=(r12-r13*r23)/(1-r23^2)*(s1/s2)
a=round(a,4)

b=(r13-r12*r23)/(1-r23^2)*(s1/s3)
b=round(b,3)

x1=x1/n
x1
x2=x2/n
x2=round(x2,3)
x3=x3/n
x3=round(x3,3)

cat('X1 - ',x1,'=',a,'( X2 - ',x2,') +',b,'X3 - ',x3,')
   ')
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 15.15.7 average increase per unit

```
#PAGE=330
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s1=round(s1,digits = 2)
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2=round(s2,digits = 1)
s3=sqrt((x6/l)-(x3/l)**2)
s3=round(s3,digits = 4)
s3=round(s3,digits = 1)


```

```
r2=(l*x7-x1*x2)/(sqrt((l*x4-x1^2)*(l*x5-x2^2)))
r2=round(r2,digits = 4)
r2=round(r2,digits = 2)

r1=(l*x8-x1*x3)/(sqrt((l*x4-x1^2)*(l*x6-x3^2)))
r1=round(r1,digits = 4)
r1=round(r1,digits = 2)

r3=(l*x9-x2*x3)/(sqrt((l*x5-x2^2)*(l*x6-x3^2)))
r3=round(r3,digits = 4)
r3=round(r3,digits = 2)

b0=((r2-r1*r3)/(1-r3^2))*(s1/s2)
b0=round(b0,digits = 4)
b0
b0=round(b0,digits = 1)
b0
b1=((r1-r2*r3)/(1-r3^2))*(s1/s3)
b1=round(b1,digits = 4)
b1
b1=round(b1,digits = 1)
b1
```

R code Exa 15.15.10 Standard error

```
#PAGE=332
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
```

```
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)
a <- matrix(c(l,x2,x3,x2,x5,x9,x3,x9,x6),nrow=3,ncol=3)

b <- matrix(c(x1,x7,x8),nrow=3,ncol=1)

c<-solve(a,b)
c=round(c,digits = 4)

b1=c[1]
b2=c[2]
b3=c[3]

x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)


xest=b1+b2*x2+b3*x3
xest=round(xest,digits = 3)

y=(x1-xest)
y=y^2
y=sum(y)
y=sqrt(y/l)
y1=round(y,digits = 4)
y1
y2=round(y,digits = 1)
y2
```

```
e=l/(l-3)
e=sqrt(e)*y2
e=round(e,digits = 1)
e
```

R code Exa 15.15.11 Obtaining the result

```
#PAGE=332
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2=round(s2,digits = 1)
s3=sqrt((x6/l)-(x3/l)**2)
```

```
s3=round(s3,digits = 4)
s3=round(s3,digits = 1)

r2=(l*x7-x1*x2)/(sqrt((l*x4-x1^2)*(l*x5-x2^2)))
r2=round(r2,digits = 4)

r1=(l*x8-x1*x3)/(sqrt((l*x4-x1^2)*(l*x6-x3^2)))
r1=round(r1,digits = 4)

r3=(l*x9-x2*x3)/(sqrt((l*x5-x2^2)*(l*x6-x3^2)))
r3=round(r3,digits = 4)

a=1-(r2^2)-(r3^2)-(r1^2)+2*r1*r2*r3
a=a/(1-r3^2)
s=s1*sqrt(a)
s=round(s,digits = 1)
s
```

R code Exa 15.15.12 coefficient linear multiple correlation

```
#PAGE=332
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
```

```
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2=round(s2,digits = 1)
s3=sqrt((x6/l)-(x3/l)**2)
s3=round(s3,digits = 4)
s3=round(s3,digits = 1)

r2=(l*x7-x1*x2)/(sqrt((l*x4-x1^2)*(l*x5-x2^2)))
r2=round(r2,digits = 4)

r1=(l*x8-x1*x3)/(sqrt((l*x4-x1^2)*(l*x6-x3^2)))
r1=round(r1,digits = 4)

r3=(l*x9-x2*x3)/(sqrt((l*x5-x2^2)*(l*x6-x3^2)))
r3=round(r3,digits = 4)

a=1-(r2^2)-(r3^2)-(r1^2)+2*r1*r2*r3
a=a/(1-r3^2)
s=s1*sqrt(a)
s=round(s,digits = 3)

e=sqrt(1-((s^2)/(s1^2)))
e=round(e,digits = 4)
e
#"The answer may slightly vary due to rounding off values."
```

R code Exa 15.15.13 coefficient of multiple determination

```
#PAGE=332
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2=round(s2,digits = 1)
s3=sqrt((x6/l)-(x3/l)**2)
s3=round(s3,digits = 4)
s3=round(s3,digits = 1)

r2=(l*x7-x1*x2)/(sqrt((l*x4-x1^2)*(l*x5-x2^2)))
r2=round(r2,digits = 4)

r1=(l*x8-x1*x3)/(sqrt((l*x4-x1^2)*(l*x6-x3^2)))
r1=round(r1,digits = 4)

```

```
r3=(l*x9-x2*x3)/(sqrt((l*x5-x2^2)*(l*x6-x3^2)))
r3=round(r3,digits = 4)

a=1-(r2^2)-(r3^2)-(r1^2)+2*r1*r2*r3
a=a/(1-r3^2)
s=s1*sqrt(a)
s=round(s,digits = 3)

e=sqrt(1-((s^2)/(s1^2)))
e=round(e,digits = 4)
e=e^2
e=round(e,digits = 4)
e
#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 15.15.14 Comparing the values

```
#PAGE=333
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
```

```
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2=round(s2,digits = 1)
s3=sqrt((x6/l)-(x3/l)**2)
s3=round(s3,digits = 4)
s3=round(s3,digits = 1)

r2=(l*x7-x1*x2)/(sqrt((l*x4-x1^2)*(l*x5-x2^2)))
r2=round(r2,digits = 4)
r1=(l*x8-x1*x3)/(sqrt((l*x4-x1^2)*(l*x6-x3^2)))
r1=round(r1,digits = 4)
r3=(l*x9-x2*x3)/(sqrt((l*x5-x2^2)*(l*x6-x3^2)))
r3=round(r3,digits = 4)
a=1-(r2^2)-(r3^2)-(r1^2)+2*r1*r2*r3
a=a/(1-r3^2)
s=s1*sqrt(a)
s=round(s,digits = 3)

m=sqrt((r2**2+r3**2-2*r2*r3*r1)/(1-r1**2))
m=round(m,digits = 4)
m

m2=sqrt((r1**2+r3**2-2*r2*r3*r1)/(1-r2**2))
m2=round(m2,digits = 4)
m2
```

R code Exa 15.15.17 Coefficient of linear partial correlation

```
#PAGE=333
```

```
x1=c(64,71,53,67,55,58,77,57,56,51,76,68)
x2=c(57,59,49,62,51,50,55,48,52,42,61,57)
x3=c(8,10,6,11,8,7,10,9,10,6,12,9)
l=length(x1)
x4=x1**2
x5=x2**2
x6=x3**2
x7=x1*x2
x8=x1*x3
x9=x2*x3
x1=sum(x1)
x2=sum(x2)
x3=sum(x3)
x4=sum(x4)
x5=sum(x5)
x6=sum(x6)
x7=sum(x7)
x8=sum(x8)
x9=sum(x9)

s1=sqrt((x4/l)-(x1/l)**2)
s1=round(s1,digits = 4)
s2=sqrt((x5/l)-(x2/l)**2)
s2=round(s2,digits = 4)
s2=round(s2,digits = 1)
s3=sqrt((x6/l)-(x3/l)**2)
s3=round(s3,digits = 4)
s3=round(s3,digits = 1)

r2=(l*x7-x1*x2)/(sqrt((l*x4-x1^2)*(l*x5-x2^2)))
r2=round(r2,digits = 4)
r1=(l*x8-x1*x3)/(sqrt((l*x4-x1^2)*(l*x6-x3^2)))
r1=round(r1,digits = 4)
r3=(l*x9-x2*x3)/(sqrt((l*x5-x2^2)*(l*x6-x3^2)))
r3=round(r3,digits = 4)
a=1-(r2^2)-(r3^2)-(r1^2)+2*r1*r2*r3
a=a/(1-r3^2)
s=s1*sqrt(a)
```

```
s=round(s,digits = 3)

r11=(r2-r1*r3)/sqrt((1-r1**2)*(1-r3**2))
r11=round(r11,digits = 4)
r11

r12=(r1-r2*r3)/sqrt((1-r2**2)*(1-r3**2))
r12=round(r12,digits = 4)
r12


r13=(r3-r1*r2)/sqrt((1-r1**2)*(1-r2**2))
r13=round(r13,digits = 4)
r13

r4=round(r11,digits = 2)
r4

r5=round(r12,digits = 2)
r5
```

R code Exa 15.15.20 College Entrance Examination

```
#PAGE=334
t=200
x1=75
s1=10
x2=24
s2=5
x3=15
s3=3
x4=36
s4=6
r12=0.9
r13=0.75
```

```
r14=0.8
r23=0.7
r24=0.7
r34=0.85

n1=t*s2**2
n2=t*s3**2
n3=t*s4**2
n4=t*s2*s1*r12
n5=t*s1*s3*r13
n6=t*s1*s4*r14
n7=t*s1*s3*r23
n7=n7/2
n8=t*s2*s4*r24
n9=t*s4*s3*r34

y <- matrix(c(n1,n7,n8,n7,n2,n9,n8,n9,n3),ncol=3,
   nrow=3)
y
b <- matrix(c(n4,n5,n6),nrow=3,ncol=1)

e=solve(y,b)
e1=e[1]
e1=round(e1,digits = 4)

e2=e[2]
e2=round(e2,digits = 2)

e3=e[3]
e3=round(e3,digits = 4)

c=x1-x2*e1-e3*x4
c=round(c,digits = 0)

cat('X1 =',c,'+',e1,'X2',e3,'X4')
```

R code Exa 15.15.21 students and college entrance examination

```
#PAGE=335
x2=30
x3=18
x4=32
x1=23+(4*x2)/3+(5*x4)/9
x1=round(x1,digits = 0)
x1

x22=18
x33=20
x44=36
x11=23+(4*x22)/3+(5*x44)/9
x11=round(x11,digits = 0)
x11
```

R code Exa 15.15.22 partial correlation coefficients

```
#PAGE=335
t=200
x1=75
s1=10
x2=24
s2=5
x3=15
s3=3
x4=36
s4=6
r12=0.9
r13=0.75
r14=0.8
```

```
r23=0.7
r24=0.7
r34=0.85

r124=(r12-r14*r24)/(sqrt((1-r14**2)*(1-r24**2)))
r124=round(r124,digits = 4)

r134=(r13-r14*r34)/(sqrt((1-r14**2)*(1-r34**2)))
r134=round(r134,digits = 4)

r234=(r23-r34*r24)/(sqrt((1-r24**2)*(1-r34**2)))
r234=round(r234,digits = 4)

r1234=(r124-r134*r234)/(sqrt((1-r134**2)*(1-r234**2)
    ))
r1234=round(r1234,digits = 4)
r1234

r1324=(r134-r124*r234)/(sqrt((1-r124**2)*(1-r234**2)
    ))
r1324=round(r1324,digits = 3)
r1324

r143=(r14-r13*r34)/(sqrt((1-r13**2)*(1-r34**2)))
r143=round(r143,digits = 4)

r123=(r12-r13*r23)/(sqrt((1-r13**2)*(1-r23**2)))
r123=round(r123,digits = 4)

r243=(r24-r23*r34)/(sqrt((1-r23**2)*(1-r34**2)))
r243=round(r243,digits = 4)

r1423=(r143-r123*r243)/(sqrt((1-r123**2)*(1-r243**2)
    ))
r1423=round(r1423,digits = 4)
r1423
```

R code Exa 15.15.24 verification

```
#PAGE=336
t=200
x1=75
s1=10
x2=24
s2=5
x3=15
s3=3
x4=36
s4=6
r12=0.9
r13=0.75
r14=0.8
r23=0.7
r24=0.7
r34=0.85

r124=(r12-r14*r24)/(sqrt((1-r14**2)*(1-r24**2)))
r124=round(r124,digits = 4)

r134=(r13-r14*r34)/(sqrt((1-r14**2)*(1-r34**2)))
r134=round(r134,digits = 4)

r234=(r23-r34*r24)/(sqrt((1-r24**2)*(1-r34**2)))
r234=round(r234,digits = 4)

r1234=(r124-r134*r234)/(sqrt((1-r134**2)*(1-r234**2)
   ))
r1234=round(r1234,digits = 4)
r1234

r1324=(r134-r124*r234)/(sqrt((1-r124**2)*(1-r234**2)
```

```
))
r1324=round(r1324,digits = 3)
r1324

r143=(r14-r13*r34)/(sqrt((1-r13**2)*(1-r34**2)))
r143=round(r143,digits = 4)

r123=(r12-r13*r23)/(sqrt((1-r13**2)*(1-r23**2)))
r123=round(r123,digits = 4)

r243=(r24-r23*r34)/(sqrt((1-r23**2)*(1-r34**2)))
r243=round(r243,digits = 4)

r1423=(r143-r123*r243)/(sqrt((1-r123**2)*(1-r243**2)))
r1423=round(r1423,digits = 4)
r1423


ans1=(r124-r134*r234)/sqrt((1-r134^2)*(1-r234^2))
ans1=round(ans1,4)
ans1

ans2=(r123-r143*r243)/sqrt((1-r143^2)*(1-r243^2))
ans2=round(ans2,4)
ans2

if (ans1==ans2) l<-TRUE
l
#"The answer may vary due to difference in representation."
```

R code Exa 15.15.25 multiple correlation coefficient

```
#PAGE=337
```

```
t=200
x1=75
s1=10
x2=24
s2=5
x3=15
s3=3
x4=36
s4=6
r12=0.9
r13=0.75
r14=0.8
r23=0.7
r24=0.7
r34=0.85


r132=(r13-r12*r23)/(sqrt((1-r12**2)*(1-r23**2)))
r132=round(r132,digits = 4)
r132

r143=(r14-r13*r34)/(sqrt((1-r13**2)*(1-r34**2)))
r143=round(r143,digits = 4)

r123=(r12-r13*r23)/(sqrt((1-r13**2)*(1-r23**2)))
r123=round(r123,digits = 4)

r243=(r24-r23*r34)/(sqrt((1-r23**2)*(1-r34**2)))
r243=round(r243,digits = 4)

r1423=(r143-r123*r243)/(sqrt((1-r123**2)*(1-r243**2)
    ))
r1423=round(r1423,digits = 4)

r=(1-r12**2)*(1-r132**2)*(1-r1423**2)
r=1-r
r=sqrt(r)
r=round(r,digits = 3)
```

```
r

s1=10
sr=s1*sqrt(1-r**2)
sr=round(sr,digits = 3)
sr
```

Chapter 16

Analysis Of Variance

R code Exa 16.16.4 Wheat grown and soil type

```
#PAGE=351
a=c(48,49,50,49)
b=c(47,49,48,48)
c=c(49,51,50,50)

x=45
a=a-x
b=b-x
c=c-x

x1=mean(a)
x1
x2=mean(b)
x2
x3=mean(c)
x3

x=c(a,b,c)
x4=mean(x)
x4

```

```
x=(x-x4)**2
x5=sum(x)
x5

b=4
y=c(x1,x2,x3)
v=(y-x4)**2
v=sum(v)
v=v*b
v

e=x5-v
e
```

R code Exa 16.16.5 unbiased estimate of the population variance

```
#PAGE=352
a=c(48,49,50,49)
b=c(47,49,48,48)
c=c(49,51,50,50)
d=45
a=a-d
b=b-d
c=c-d

x=mean(a)
x
y=mean(b)
y
z=mean(c)
z


e=c(a,b,c)
m=mean(e)
```

```
m

f=median(e)
e=(e-f)**2
e=sum(e)
e

g=4
k=c(a[g],b[g],c[g])
k
v=(k-m)**2
v=sum(v)*g
v


vw=e-v
vw

h=3
sb=v/(h-1)
sb


r=length(a)
sw=vw/(h*(r-1))
sw
```

R code Exa 16.16.6 Null hypothesis

```
#PAGE=352
s2=4
s1=2/3
f=s2/s1
f
a=3-1
```

```
b=3*(4-1)
z1=qf(0.95,df1=a,df2=b)
z1=round(z1,digits = 2)
z1

if(z1<f) l1<-FALSE
l1

z1=qf(0.99,df1=a,df2=b)
z1=round(z1,digits = 2)
z1

if(z1>f) l1<-TRUE
l1

#"The answer may vary due to difference in
   representation."
```

R code Exa 16.16.7 Shortcut formulas

```
#PAGE=352
a=c(3,4,5,4)
b=c(2,4,3,3)
c=c(4,6,5,5)
t1=sum(a)
t2=sum(b)
t3=sum(c)
t=c(t1,t2,t3)
tt=t**2
st=sum(t)
stt=sum(tt)
x=c(a,b,c)
x=x**2
x=sum(x)
a1=3
```

```
b1=4
v=x-(st^2)/(a1*b1)
v

vb=(t1**2+t2**2+t3**2)/b1-(st**2)/(a1*b1)
vb

vc=v-vb
vc
```

R code Exa 16.16.8 5 machines A B C D E

```
#PAGE=353
a=c(8,12,17,-18,-7)
b=c(12,-7,3,-7,-12)
c=c(0,22,4,15,12)
d=c(-12,1,-3,4,-10)
e=c(4,5,10,8,-7)
t1=sum(a)
t2=sum(b)
t3=sum(c)
t4=sum(d)
t5=sum(e)
t=c(t1,t2,t3,t4,t5)
t1=t^2
x=c(a,b,c,d,e)
a1=sum(x^2)
b1=sum(t)
c1=sum(t1)
v=a1-(b1^2)/(5*4)
vb=c1/5-(b1^2)/(5*4)


z1=qf(0.95,df1=4,df2=20)
z1=round(z1,digits = 2)
```

```
z1

sb=vb/4
vw=v-vb
sw=vw/(5*4)
f=sb/sw
f=round(f,2)
f
if(z1>f) l1<-TRUE
l1

z1=qf(0.99,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1>f) l2<-TRUE
l2
```

R code Exa 16.16.9 lifetimes in hour and television tubes

```
#PAGE=354
s1=c(407,411,409)
s2=c(404,406,408,405,402)
s3=c(410,408,406,408)
s1=s1-400
s2=s2-400
s3=s3-400
t1=sum(s1)
t2=sum(s2)
t3=sum(s3)
m1=mean(t1)
m2=mean(t2)
m3=mean(t3)
s=c(s1,s2,s3)
m=mean(s)
m
```

```
v=sum((s-m)^2)
v
vb=v/2
vb
vw=v-vb
vw
sb=vb/2
sw=vw/9
f=sb/sw
z1=qf(0.95,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1<f) l1<-TRUE
l1

z1=qf(0.99,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1<f) l2<-TRUE
l2

#"The answer may vary due to difference in
    representation."
```

R code Exa 16.16.10 Shortcut formulas

```
#PAGE=355
n1=3
n2=5
n3=4
n=12
t1=27
t2=25
t3=32
t=84
```

```
s=c(7,11,9,4,6,8,5,2,10,8,6,8)
s=s^2
v=sum(s)-t^2/n
v
vb=t1^2/n1+t2^2/n2+t3^2/n3
vb=vb-t^2/n
vb
vw=v-vb
vw
sb=vb/2
sw=vw/9
f=sb/sw
f
z1=qf(0.95,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1<f) l1<-TRUE
l1

z1=qf(0.99,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1<f) l2<-TRUE
l2

#"The answer may vary due to difference in
    representation."
```

R code Exa 16.16.11 Plant crops grown and fertilizers

```
#PAGE=355
a=c(4.5,6.4,7.2,6.7)
b=c(8.8,7.8,9.6,7)
c=c(5.9,6.8,5.7,5.2)
c1=c(a[1],b[1],c[1])
```

```
c2=c(a[2],b[2],c[2])
c3=c(a[3],b[3],c[3])
c4=c(a[4],b[4],c[4])
rt1=sum(a)
rt2=sum(b)
rt3=sum(c)
rm1=mean(a)
rm2=mean(b)
rm3=mean(c)

ct1=sum(c1)
ct2=sum(c2)
ct3=sum(c3)
ct4=sum(c4)
cm1=mean(c1)
cm2=mean(c2)
cm3=mean(c3)
cm4=mean(c4)

gt=sum(rt1,rt2,rt3)
gt
rm=c(rm1,rm2,rm3)
cm=c(cm1,cm2,cm3,cm4)

gm=mean(rm)
gm
vr=4*sum((rm-gm)^2)
vr
vc=3*sum((cm-gm)^2)
vc

k=c(a,b,c)
v=sum((k-gm)^2)
v
ve=v-vr-vc
ve

sr=vr/2
```

```
sc=vc/3
se=ve/6
sr
sc
se
f1=sr/se
f1=round(f1,2)
f1
f2=sc/se
f2=round(f2,2)
f2


z1=qf(0.95,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1<f1) l1<-FALSE
l1

z1=qf(0.99,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1<f1) l2<-FALSE
l2

z1=qf(0.95,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1>f2) l1<-TRUE
l1

z1=qf(0.99,df1=4,df2=20)
z1=round(z1,digits = 2)
z1
if(z1>f2) l2<-TRUE
l2
#"The answer may vary due to difference in
   representation."
```

R code Exa 16.16.12 short computational formulas

```
#PAGE=357
a=c(4.5,6.4,7.2,6.7)
b=c(8.8,7.8,9.6,7)
c=c(5.9,6.8,5.7,5.2)
r1=sum(a)
r2=sum(b)
r3=sum(c)
m1=mean(a)
m2=mean(b)
m3=mean(c)
d1=c(a[1],b[1],c[1])
d2=c(a[2],b[2],c[2])
d3=c(a[3],b[3],c[3])
d4=c(a[4],b[4],c[4])
c1=sum(d1)
c2=sum(d2)
c3=sum(d3)
c4=sum(d4)
m4=mean(d1)
m5=mean(d2)
m6=mean(d3)
m7=mean(d4)

m=c(m1,m2,m3)
gt=r1+r2+r3
gm=mean(m)
a0=3
b0=4

x=c(a,b,c)
x=x**2
x1=sum(x)
```

```
x1

t1=r1+r2+r3
t1

t2=r1**2+r2**2+r3**2
t2

t3=c1**2+c2**2+c3**2+c4**2
t3

v1=x1-(t1^2)/(a0*b0)
v1

v2=t2/b0-(t1^2)/(a0*b0)
v2

v3=t3/a0-(t1^2)/(a0*b0)
v3

v4=v1-v2-v3
v4
```

R code Exa 16.16.13 Machine and bolts

```
#PAGE=357
a1=c(6,4,5,5,4)
a2=c(5,7,4,6,8)
b1=c(10,8,7,7,9)
b2=c(7,9,12,8,8)
c1=c(7,5,6,5,9)
c2=c(9,7,5,4,6)
d1=c(8,4,6,5,5)
d2=c(5,7,9,7,10)
t=c(a1,a2,b1,b2,c1,c2,d1,d2)
```

```
s1=sum(a1)
s2=sum(a2)
s3=sum(b1)
s4=sum(b2)
s5=sum(c1)
s6=sum(c2)
s7=sum(d1)
s8=sum(d2)
s=sum(t)
v=sum(t^2)-s^2/length(t)
v
vs=s1^2/5+s2^2/5+s3^2/5+s4^2/5+s5^2/5+s6^2/5+s7^2/5+s8^2/5-s^2/length(t)
vs
vr=((s1+s2)^2)/10+((s3+s4)^2)/10+((s5+s6)^2)/10+((s7+s8)^2)/10-s^2/length(t)
vr
vc=(125^2)/20+(143^2)/20-s^2/length(t)
vc

vi=vs-vr-vc
vi
ve=v-(vr+vc+vi)
ve

sr=vr/3
sc=vc/1
si=vi/3
se=ve/32

f1=sr/se
f2=sc/se
f3=si/se
f1=round(f1,2)
f2=round(f2,2)
f3=round(f3,2)
```

```
z1=qf(0.95,df1=3,df2=32)
z1=round(z1,digits = 2)
z1
if(z1>f3) l1<-TRUE
l1
if(z1<f2) l2<-FALSE
l2
if(z1<f1) l3<-FALSE
l3

z1=qf(0.95,df1=1,df2=32)
z1=round(z1,digits = 2)
z1
if(z1>f3) l1<-TRUE
l1
if(z1>f2) l2<-TRUE
l2
if(z1<f1) l3<-FALSE
l3
#"The answer may vary due to difference in
    representation."
```

R code Exa 16.16.14 Work problem

```
#PAGE=360
a1=c(6,4,5,5,4)
a2=c(5,7,4,6,8)
b1=c(10,8,7,7,9)
b2=c(7,9,12,8,8)
c1=c(7,5,6,5,9)
c2=c(9,7,5,4,6)
d1=c(8,4,6,5,5)
d2=c(5,7,9,7,10)
t=c(a1,a2,b1,b2,c1,c2,d1,d2)
s1=sum(a1)
```

```
s2=sum(a2)
s3=sum(b1)
s4=sum(b2)
s5=sum(c1)
s6=sum(c2)
s7=sum(d1)
s8=sum(d2)
s=sum(t)
v=sum(t^2)-s^2/length(t)
v
vs=s1^2/5+s2^2/5+s3^2/5+s4^2/5+s5^2/5+s6^2/5+s7^2/5+s8^2/5-s^2/length(t)
vs
vr=((s1+s2)^2)/10+((s3+s4)^2)/10+((s5+s6)^2)/10+((s7+s8)^2)/10-s^2/length(t)
vr
vc=(125^2)/20+(143^2)/20-s^2/length(t)
vc

vi=vs-vr-vc
vi
ve=v-(vr+vc+vi)
ve

sr=vr/3
sc=vc/1
si=vi/3
se=ve/32

f1=sr/se
f2=sc/se
f3=si/se
f1=round(f1,2)
f2=round(f2,2)
f3=round(f3,2)
f1
f2
f3
```

```
z1=qf(0.99,df1=3,df2=32)
z1=round(z1,digits = 2)
z1
if(z1>f3) l1<-TRUE
l1
if(z1>f2) l2<-TRUE
l2
if(z1<f1) l3<-FALSE
l3

z1=qf(0.99,df1=1,df2=32)
z1=round(z1,digits = 2)
z1
if(z1>f3) l1<-TRUE
l1
if(z1>f2) l2<-TRUE
l2
if(z1>f1) l3<-TRUE
l3
#"The answer may vary due to difference in
   representation."
```

R code Exa 16.16.15 Fertilizers and wheat

```
#PAGE=360
k1=c(18,21,25,11)
k2=c(22,12,15,19)
k3=c(15,20,23,24)
k4=c(22,21,10,17)
s1=sum(k1)
s2=sum(k2)
s3=sum(k3)
s4=sum(k4)
s5=sum(k1[1],k2[1],k3[1],k4[1])
s6=sum(k1[2],k2[2],k3[2],k4[2])
```

```
s7=sum(k1[3],k2[3],k3[3],k4[3])
s8=sum(k1[4],k2[4],k3[4],k4[4])
s=sum(k1,k2,k3,k4)
s
t=c(70,48,85,92)
tt=sum(k1^2)+sum(k2^2)+sum(k3^2)+sum(k4^2)-s^2/16
v1=c(s1,s2,s3,s4)
v2=c(s5,s6,s7,s8)

vr=sum(v1^2)/4-s^2/16
vc=sum(v2^2)/4-s^2/16
vb=sum(t^2)/4-s^2/16
m1=vr/3
m2=vc/3
m3=vb/3
m4=(tt-(vr+vc+vb))/6

f1=m1/m4
f1=round(f1,2)
f2=m2/m4
f2=round(f2,2)
f3=m3/m4
f3=round(f3,1)

z1=qf(0.95,df1=3,df2=6)
z1=round(z1,digits = 2)
z1
if(z1<f3) l1<-"no difference"
l1
if(z1>f2) l2<-"difference"
l2
if(z1<f1) l3<-"no difference"
l3

z1=qf(0.99,df1=3,df2=6)
z1=round(z1,digits = 2)
z1
if(z1<f3) l1<-"no difference"
```

```
l1
if(z1>f2) l2<-"difference"
l2
if(z1>f1) l3<-"difference"
l3
#"The answer may vary due to difference in
   representation."
```

R code Exa 16.16.17 Kilometres per litres

```
#PAGE=362
c1=c(13,12,12,11)
c2=c(12,13,10,12)
c3=c(11,10,14,12)
c4=c(12,12,12,14)

a=c(c1[2],c2[1],c3[4],c4[3])
b=c(c1[1],c2[2],c3[3],c4[4])
c=c(c1[4],c2[3],c3[2],c4[1])
d=c(c1[3],c2[4],c3[1],c4[2])

a11=c(c1[4],c2[2],c3[1],c4[3])
b11=c(c1[2],c2[4],c3[3],c4[1])
c11=c(c1[1],c2[3],c3[4],c4[2])
d11=c(c1[3],c2[1],c3[2],c4[4])

a5=c(c1[1],c2[1],c3[1],c4[1])
a6=c(c1[2],c2[2],c3[2],c4[2])
a7=c(c1[3],c2[3],c3[3],c4[3])
a8=c(c1[4],c2[4],c3[4],c4[4])

t=c(c1,c2,c3,c4)

s1=sum(c1)
s2=sum(c2)
```

```
s3=sum(c3)
s4=sum(c4)
s5=sum(a)
s6=sum(b)
s7=sum(c)
s8=sum(d)
s9=sum(a11)
s10=sum(b11)
s11=sum(c11)
s12=sum(d11)
s13=sum(a5)
s14=sum(a6)
s15=sum(a7)
s16=sum(a8)
s17=sum(t)
l=length(c1)

r1=c(s1,s2,s3,s4)
r2=c(s13,s14,s15,s16)
r3=c(s5,s6,s7,s8)
r4=c(s9,s10,s11,s12)

r1=(r1**2)
r1=sum(r1)/l
r1=r1-(s17**2)/(l**2)
r1

r2=(r2**2)
r2=sum(r2)/l
r2=r2-(s17**2)/(l**2)
r2

r3=(r3**2)
r3=sum(r3)/l
r3=r3-(s17**2)/(l**2)
r3

r4=(r4**2)
```

```
r4=sum(r4)/l
r4=r4-(s17**2)/(l**2)
r4

tv=(t**2)
tv=sum(tv)
tv=tv-(s17**2)/(l**2)
tv

v=tv-r1-r2-r3-r4
v

a0=4
a1=a0-1
b1=a0-1



s1=r1/a1
s1
s2=r2/a1
s2
s3=r3/a1
s3
s4=r4/a1
s4
s5=v/a1
s5

f1=s1/s5
f1=round(f1,digits = 2)

f2=s2/s5
f2=round(f2,digits = 2)

f3=s3/s5
f3=round(f3,digits = 2)

```

```
f4=s4/s5
f4=round(f4,digits = 2)


z1=qf(0.99,df1=a1,df2=b1)
z1=round(z1,digits = 1)
z1


if(z1>f1) l1<-FALSE
l1

if(z1>f2) l2<-FALSE
l2

if(z1>f3) l8<-FALSE
l8

if(z1>f4) l9<-FALSE
l9

z2=qf(0.95,df1=a1,df2=b1)
z2=round(z2,digits = 2)
z2

if(z2>f1) l3<-FALSE
l3

if(z2>f2) l4<-FALSE
l4


if(z2<f3) l5<-TRUE
l5

if(z2>f4) l7<-FALSE
l7
```

```
#"The answer may vary due to difference in
    representation."
```

Chapter 17

Nonparametric Tests

R code Exa 17.17.1 Hypothesis and alternate hypothesis

```
#PAGE=376
x=c(1,2,3,4,5,6,7,8,9,10,11,12)
m1=c(47,56,54,49,36,48,51,38,61,49,56,52)
m2=c(71,63,45,64,50,55,42,46,53,57,75,60)
x1=c(0,x)
p=1/2
q=1-p
l=length(x)
p1=factorial(l)/(factorial(l-x1)*factorial(x1))
p1=p1*(p**x1)*(q**(l-x1))
p1=round(p1,digits = 5)
a1=p1[1]+p1[2]+p1[3]
a1
a2=p1[1]+p1[2]+p1[3]+p1[4]
a2
n=0.05/2
n
if(n>a1||n<a2) k<-TRUE
k
#"The answer may vary due to difference in
   representation."
```

R code Exa 17.17.2 Normal Approximation

```
#PAGE=377
x=c(1,2,3,4,5,6,7,8,9,10,11,12)
m1=c(47,56,54,49,36,48,51,38,61,49,56,52)
m2=c(71,63,45,64,50,55,42,46,53,57,75,60)
x1=c(0,x)
p=1/2
q=1-p
l=length(x)
n=0.05
p1=factorial(l)/(factorial(l-x1)*factorial(x1))
p1=p1*(p**x1)*(q**(l-x1))
p1=round(p1,digits = 5)
a1=p1[1]+p1[2]+p1[3]
a2=p1[1]+p1[2]+p1[3]+p1[4]
a2
n1=c(p1[1],p1[2],p1[3])
n2=c(p1[1],p1[2],p1[3],p1[4])
l1=length(n2)-1
u=l*p
s=sqrt(l*p*q)
s=round(s,digits = 2)

z=(l1+p)
z=z-u
z=z/s
z=round(z,digits = 2)
z

a=qnorm(n/2)
a=round(a,digits = 2)
a

```

```
if(a<z) k<-TRUE
k
#"The answer may vary due to difference in
   representation."
```

R code Exa 17.17.3 PQR Company

```
#PAGE=377
a=250
b=c(271,230,198,275,282,225,284,219,
    253,216,262,288,236,291,253,224,
    264,295,211,252,294,243,272,268)
a1=b-a
a2=length(a1[a1>0])
l=length(b)
m=0.5
z=0.05
z1=qnorm(1-z)

z2=((a2-m)-l*m)/(sqrt(l*m*m))
z2=round(z2,2)
cat(z2)
```

R code Exa 17.17.4 Statewide Examination

```
#PAGE=378
a=c(71,67,55,64,82,66,74,58,79,61,
    78,46,84,93,72,54,78,86,48,52,
    67,95,70,43,70,73,57,64,60,83,
    73,40,78,70,64,86,76,62,95,66)
a1=66
aa1=a-a1
aa1
```

```
c1=0
c3=0
for (i in aa1){
  if (i>0){
    c1=c1+1
  }
  else if (i==0){
    c3=c3+1
  }
}
c2=length(a)-c1-c3
n=c1+c2
m1=qnorm(0.05/2,lower.tail = TRUE)
m1=round(m1,2)
m2=qnorm(0.05/2,lower.tail = FALSE)
m2=round(m2,2)
p=0.5
q=1-p
m1
m2
z1=(c1-p-n*p)/sqrt(n*p*q)
z1=round(z1,2)
z1
if (z1<m1 ||z1>m2) {
  l<-FALSE
}else{
  l<-TRUE
}

l
z2=(c2+p-n*p)/sqrt(n*p*q)
z2=round(z2,2)
z2
if (z2<m1 ||z2>m2) {
  l<-FALSE
}else{
  l<-TRUE
}
```

```
l
z=(c2-c3+p-length(a)*p)/sqrt(length(a)*p*q)
z=round(z,2)
z
if (z<m1 ||z>m2) {
  l<-FALSE
}else{
  l<-TRUE
}
l
```

R code Exa 17.17.5 Alloy 1 and Alloy 2

```
#PAGE=379
n1=8
n2=10
r1=106
u=n1*n2+(n1*(n1+1))/2-r1
u
s=n1*n2/2
s
s1=n1*n2*(n1+n2+1)/12
s1=round(s1,2)
s1=sqrt(s1)
s1=round(s1,2)
z=(u-s)/s1
z=round(z,2)
z
a1=qnorm(0.05/2,lower.tail = TRUE)
a1=round(a1,2)
a1
a2=qnorm(0.05/2,lower.tail = FALSE)
a2=round(a2,2)
a2
if( z<a1||z>a2){
```

```
  l<-FALSE
}
l
```

R code Exa 17.17.6 Verifying

```
#PAGE=380
n1=8
n2=10
r1=106
r2=65
u1=n1*n2+(n1*(n1+1))/2-r1
u1
u2=n1*n2+(n2*(n2+1))/2-r2
u2
cat(u1+u2)
cat(n1*n2)

ans=(n1+n2)*(n1+n2+1)/2
cat(ans)
```

R code Exa 17.17.7 statistics and alloy 2

```
#PAGE=380
n1=8
n2=10
r1=106
r2=65
u=n1*n2+n2*(n2+1)/2-r2
u
u1=40
s=11.25
z=(u-u1)/s
```

```
z=round(z,2)
cat(z)
z1=-1.96
z2=1.96

if (z<z1||z>z2) l<-FALSE
l
#"The answer may vary due to difference in
    representation."
```

R code Exa 17.17.8 Professor and psychology classes

```
#PAGE=381
m=c(73,87,79,75,82,66,95,75,70)
a=c(86,81,84,88,90,85,84,92,83,91,53,84)
a1=sort(a)
a1
rank(a1,ties.method = "average")

n1=length(m)
n2=length(a)
n=n1+n2
n
r1=73
r2=158
a1=n*(n+1)/2
a2=r1+r2
if (a1==a2){
  l<-TRUE
}
l
u=n1*n2+n1*(n1+1)/2-r1
uu=n1*n2/2
s=n1*n2*(n1+n2+1)/12
s=sqrt(s)
```

```
z=(u-uu)/s
z=round(z,2)
z

z1=qnorm(0.05,lower.tail = TRUE)
z1=round(z1,3)
z2=qnorm(0.05,lower.tail = FALSE)
z2=round(z2,3)
z2

if (z>z2||z<z1){
  l<-FALSE
}
l
```

R code Exa 17.17.9 U of the data table

```
#PAGE=382
s1=c(22,10)
s2=c(17,25,14)
l1=length(s1)
l2=length(s2)

s=c(s1,s2)
s=sort(s)
s
x=c(1,2,3,4,5)

a1=c(x[4],x[1])
a2=c(x[3],x[5],x[2])

h1=sum(a1)
h2=sum(a2)

u=l1*l2+(l1*l2)/2-h1
```

```
u
u1=sqrt(u)
u1

l3=l1/2
b1=c(l3,l3,l1)
b6=sum(b1)
b6

b2=c(0,l1)
b7=sum(b2)
b7

h1=length(b1)
h2=length(b2)
h=h1*h2
h
```

R code Exa 17.17.10 Population consists of values 7 12 and 15

```
#PAGE=383
s1=c(7,7,12,12,15,15)
x1=c(12,15)
x2=c(15,12)
x3=c(7,15)
x4=c(15,7)
x5=c(7,12)
x6=c(12,7)
x=c(x1,x2,x3,x4,x5,x6)
u=c(2,2,1,1,0,0)
l=length(x1)
u1=sum(u)
p=l/u1
p2=1/u1
u2=c(p,p,p2,p2,0,0)
```

```
u2
hist(u,xlim=c(0,2),breaks=3)
barplot(u)
barplot(table(u),density=10)

v1=u1/(l*3)
v1

v2=(u-1)**2
v2=sum(v2)
v2=v2/(l*3)
v2

l1=l/2
h1=(l*l1)/2
h1

s=(l1*l)*(l1+l+1)/length(x)
s

#"The answer may vary due to difference in
   representation."
```

R code Exa 17.17.11 Sampling distribution of U

```
#PAGE=384
s1=c(22,10)
s2=c(17,25,14)
l1=length(s1)
l2=length(s2)

s=c(s1,s2)
s=sort(s)
x=c(1,2,3,4,5)

```

```
a1=c(x[4],x[1])
a2=c(x[3],x[5],x[2])

h1=sum(a1)
h2=sum(a2)

l1=length(a1)
l2=length(a2)
l3=length(x)
f=factorial(l3)
f

r1=x[1]+x[2]
r2=x[4]+x[5]
r=c(r1:r2)
x1=c(1,2)
x2=c(1,3)
x3=c(1,4)
x4=c(2,3)
x5=c(1,5)
x6=c(2,4)
x7=c(2,5)
x8=c(3,4)
x9=c(3,5)
x10=c(4,5)

y1=c(x1)
y2=c(x2)
y3=c(x3,x4)
y4=c(x5,x6)
y5=c(x7,x8)
y6=c(x9)
y7=c(x10)
y=c(y1,y2,y3,y4,y5,y6,y7)
f1=length(y1)
f2=length(y2)
f3=length(y3)
f4=length(y4)
```

```
f5=length(y5)
f6=length(y6)
f7=length(y7)
f=c(f1,f2,f3,f4,f5,f6,f7)
f=f/2
f
u=l1*l2+(l1*(l1+1)/2)-r
u
a=rep(u,f)
barplot(table(a))
p=f/10
p
barplot(p)
u7=f*u
u7=sum(u7)
f1=sum(f)
u7=u7/f1
u7
s3=f*(u-u7)**2
s3=sum(s3)
s3=s3/10
s3
k2=l1*l2/2
k2
k3=l1*l2*(l1+l2+1)/(l1*l2*2)
k3
```

R code Exa 17.17.14 Machines and performances

```
#PAGE=386
k=5
n=5*k
n=25
r=c(70,48.5,93,40.5,73)
a=12/(n*(n+1))
```

```
b=sum(r^2)/k
c=3*(n+1)
ans1=a*b-c
ans1=round(ans1,2)
ans1

x=0.95
x=qchisq(x,df=k-1)
x=round(x,digits = 2)
x

if (ans1<x) l<-TRUE
l
#"The answer may vary due to difference in
   representation."
```

R code Exa 17.17.15 Work problem

```
#PAGE=387
t=c(2,4,3,2,3)
t3=t^3
n=25
o=c(48,53,64,68,72)
ans=t3-t
s=sum(ans)
s
a1=1-s/(n^3-n)
h=6.44/a1
h=round(h,2)
cat(h)
```

R code Exa 17.17.16 Three samples from a population

```
#PAGE=387
a1=c(7,4,6,10)
a2=c(11,9,12)
a3=c(5,1,3,8,2)
k=3
n1=length(a1)
n2=length(a2)
n3=length(a3)
r1=sum(a1)
r2=sum(a2)
r3=sum(a3)
n=n1+n2+n3
a=12/(n*(n+1))
b1=(r1**2)/n1
b2=(r2**2)/n2
b3=(r3**2)/n3
b=b1+b2+b3
c=a*b-3*(n+1)
c=round(c,digits = 2)
c

a1=1-0.05
f=k-1
a=qchisq(a1,df=f)
a=round(a,digits = 2)
a
if(c>a) lm<-TRUE
lm


a2=1-0.01
f=k-1
b=qchisq(a2,df=f)
b=round(b,digits = 2)
b
if(c<b) ln<-FALSE
ln
#"The answer may vary due to difference in
```

representation."

R code Exa 17.17.17 head and tails

```
#PAGE=388
a=c('H','T','T','H','T','H','H','H','T','H','H','T',
    'T','H','T','H','T','H','H','T','H','T','T','H','
   T','H','H','T','H','T')
y=rle(c('H','T','T','H','T','H','H','H','T','H','H',
    'T','T','H','T','H','T','H','H','T','H','T','T','
   H','T','H','H','T','H','T'))

a=y$lengths[y$values=='H']
a=sum(a)
a1=a-5
a1

b=y$lengths[y$values=='T']
b=sum(b)
b1=b-3
b1

v=a1+b1
v

u=(2*a*b)/(a+b)+1
u=round(u,digits = 2)

s=((2*a*b)*(2*a*b-a-b))/(((a+b)**2)*(a+b-1))
s=round(s,digits = 3)
s
s1=sqrt(s)

p=1/2
q=1-p
```

```
z=(v-u)/s1
z=round(z,digits = 2)
z


n=0.05
a1=qnorm(n/2)
a1=round(a1,digits = 2)
a2=abs(a1)
if(z>a2) k1<-TRUE
k1

z1=(v-0.5-u)/s1
z1=round(z1,digits = 2)
z1

n=0.05
a1=qnorm(n/2)
a1=round(a1,digits = 2)
a2=abs(a1)
if(z>a2) k2<-TRUE
k2
#"The answer may vary due to difference in
    representation."
```

R code Exa 17.17.18 Good and Defective

```
#PAGE=388
n=48
n1=10
n2=n-n1
v=11
u=2*n1*n2/n+1
u=round(u,2)
s=(2*n1*n2*(2*n1*n2-n1-n2))/((n1+n2)^2*(n1+n2-1))
```

```
s
s1=sqrt(s)
s1=round(s1,3)
s1
z=(v-u)/s1
z=round(z,2)
cat(z)

x=-1.96
if (z<x) l<-FALSE
l
#"The answer may vary due to difference in
   representation."
```

R code Exa 17.17.19 all possible sequences of a and b

```
#PAGE=389
a=2
b=3
c=a+b
ans1=factorial(c)/(factorial(a)*factorial(b))
ans1
library(combinat)
x=c('a','b','a','a','b')
a=permn(x)
unique(a)


v=c(2,3,4,5)
f=c(2,3,4,1)
t=sum(f)


a=rep(v,f)
barplot(table(a),xlab='V',ylab='f')
```

```r
p=f/t
p
barplot(p,xlab='V',ylab='f')
```

R code Exa 17.17.20 mean and variance

```r
#PAGE=390
c1=c('a','a','a','b','b')
c2=c('a','a','b','a','b')
c3=c('a','a','b','b','a')
c4=c('a','b','a','b','a')
c5=c('a','b','b','a','a')
c6=c('a','b','a','a','b')
c7=c('b','b','a','a','a')
c8=c('b','a','b','a','a')
c9=c('b','a','a','a','b')
c10=c('b','a','a','b','a')

y=rle(c('a','a','a','b','b'))
a=y$lengths[y$values=='a']
a1=a-2
b=y$lengths[y$values=='b']
b1=b-1
v1=a1+b1
v1

y=rle(c('a','a','b','a','b'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-1
b=y$lengths[y$values=='b']
b1=sum(b)
v2=a1+b1
v2

```

```
y=rle(c('a','a','b','b','a'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-1
b=y$lengths[y$values=='b']
b1=sum(b)
b1=b1-1
v3=a1+b1
v3

y=rle(c('a','b','a','b','a'))
a=y$lengths[y$values=='a']
a1=sum(a)
b=y$lengths[y$values=='b']
b1=sum(b)
v4=a1+b1
v4

y=rle(c('a','b','b','a','a'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-1
b=y$lengths[y$values=='b']
b1=sum(b)
v5=a1+b1
v5

y=rle(c('a','b','a','a','b'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-1
a1
b=y$lengths[y$values=='b']
b1=sum(b)
b1
v6=a1+b1
v6
```

```r
y=rle(c('b','b','a','a','a'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-2
b=y$lengths[y$values=='b']
b1=sum(b)
b1=b1-1
v7=a1+b1
v7

y=rle(c('b','a','b','a','a'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-1
b=y$lengths[y$values=='b']
b1=sum(b)
v8=a1+b1
v8

y=rle(c('b','a','a','a','b'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-2
b=y$lengths[y$values=='b']
b1=sum(b)
v9=a1+b1
v9

y=rle(c('b','a','a','b','a'))
a=y$lengths[y$values=='a']
a1=sum(a)
a1=a1-1
b=y$lengths[y$values=='b']
b1=sum(b)
v10=a1+b1
v10

v=c(v1,v2,v3,v4,v5,v6,v7,v8,v9,v10)
```

```
l1=length(v)
v5=sum(v)-1
u=v5/l1
u


k=0
l=0
m=0
n=0
if(v1==2) k<-k+1
if(v1==3) l<-l+1
if(v1==4) m<-m+1
if(v1==5) n<-n+1

if(v2==2) k<-k+1
if(v2==3) l<-l+1
if(v2==4) m<-m+1
if(v2==5) n<-n+1

if(v3==2) k<-k+1
if(v3==3) l<-l+1
if(v3==4) m<-m+1
if(v3==5) n<-n+1

if(v4==2) k<-k+1
if(v4==3) l<-l+1
if(v4==4) m<-m+1
if(v4==5) n<-n+1

if(v5==2) k<-k+1
if(v5==3) l<-l+1
if(v5==4) m<-m+1
if(v5==5) n<-n+1

if(v6==2) k<-k+1
if(v6==3) l<-l+1
if(v6==4) m<-m+1
```

```
if(v6==5) n<-n+1

if(v7==2) k<-k+1
if(v7==3) l<-l+1
if(v7==4) m<-m+1
if(v7==5) n<-n+1

if(v8==2) k<-k+1
if(v8==3) l<-l+1
if(v8==4) m<-m+1
if(v8==5) n<-n+1

if(v9==2) k<-k+1
if(v9==3) l<-l+1
if(v9==4) m<-m+1
if(v9==5) n<-n+1

if(v10==2) k<-k+1
if(v10==3) l<-l+1
if(v10==4) m<-m+1
if(v10==5) n<-n+1

k=k+0
l=l+1
m=m
n=n-0
v=c(k,l,m,n)
vc=c(2,3,4,5)
vc=vc**2
s=(v*vc)
s=sum(s)
s=s/l1-u**2
s
#"The answer may vary due to difference in
   representation."
```

R code Exa 17.17.21 Work problem

```
#PAGE=390
c1=c('a','a','a','b','b')
c2=c('a','a','b','a','b')
c3=c('a','a','b','b','a')
c4=c('a','b','a','b','a')
c5=c('a','b','b','a','a')
c6=c('a','b','a','a','b')
c7=c('b','b','a','a','a')
c8=c('b','a','b','a','a')
c9=c('b','a','a','a','b')
c10=c('b','a','a','b','a')

n1=3
n2=2
u=(2*n1*n2)/(n1+n2)
u=u+1
u
s=((2*n1*n2)*(2*n1*n2-n1-n2))/((n1+n2)**2*(n1+n2-1))
s
```

R code Exa 17.17.22 sample lifetimes and PQR company

```
#PAGE=390
a=c
  (271,230,198,275,282,225,284,219,253,216,262,288,236,291,253,224,
a=sort(a)
b=median(a)
c1=0
c2=0
```

```
p=1/2
q=1-p
if(a[1]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}

if(a[2]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}

if(a[3]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[4]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[5]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
```

```
}
if(a[6]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[7]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[8]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[9]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[10]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[11]>b)
{
```

```
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[12]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[13]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[14]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[15]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[16]>b)
{
  c1=c1+1
}else
{
```

```
  c2=c2+1
}
if(a[17]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[18]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[19]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[20]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[21]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[22]>b)
```

```
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[23]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}
if(a[24]>b)
{
  c1=c1+1
}else
{
  c2=c2+1
}


c=(2*c1*c2)/(c1+c2)+1
c

s=2*c1*c2*(2*c1*c2-c1-c2)/((2*c1)**2*(c1+c2-1))
s
s1=sqrt(s)
s1=round(s1,digits = 3)
s1

m=c1+c2
v=m-3*3

z=(v-c)/s1
z=round(z,digits = 3)
z

```

```
n=0.05
d=qnorm(n/2)
d1=round(d,digits = 3)
d1
d2=abs(d1)
d2

if(z>d1 & z<d2) k<-TRUE
k
#"The answer may vary due to difference in
    representation."
```

R code Exa 17.17.23 Work problem

```
#PAGE=391
v=4
n1=8
n2=10
u=2*n1*n2/(n1+n2)+1
u=round(u,3)
u
s=2*n1*n2*(2*n1*n2-n1-n2)/(((n1+n2)^2)*(n1+n2-1))
s=round(s,3)
z=(v-u)/sqrt(s)
z=round(z,1)
z
z1=-1.96
z2=1.96

if (z<z1||z>z2) l<-FALSE
l
uv=0.5
zz=(v+uv-u)/sqrt(s)
zz=round(zz,2)
zz
```

```
#"The answer may vary due to difference in
    representation."
```

R code Exa 17.17.24 Alphabetical order

```
#PAGE=391
l1=c(8,3,9,2,7,10,4,6,1,5)
l2=c(9,5,10,1,8,7,3,4,2,6)
l=length(l1)

a1=sort(l1)
m1=median(a1)

m=l1-l2
m
d=m**2
d
e=sum(d)
e

r=1-(6*e)/(l*(l**2-1))
r=round(r,digits = 4)
r
```

R code Exa 17.17.25 Father and oldest adult sons

```
#PAGE=392
l1=c(65,63,67,64,68,62,70,66,68,67,69,71)
l2=c(68,66,68,65,69,66,68,65,71,67,68,70)
l=length(l1)

a1=sort(l1)
```

```r
a1
r1=rank(a1,ties.method = "average")

a3=sort(l2)
a3
r2=rank(a3,ties.method = "average")

r3=rank(l1,ties.method = "average")
r3
r4=rank(l2,ties.method = "average")
r4


d=r4-r3
d2=d^2
ss=sum(d2)
l=length(l1)

r=1-(6*ss)/(l*(l**2-1))
r=round(r,digits = 4)
r
```

Chapter 18

Analysis Of Time Series

R code Exa 18.1 Moving average

```
#PAGE=400
a=c(2,6,1,5,3,7,2)
s1=0
for(i in 1:3)
{
  s1=s1+a[i]
}

s2=0
for(i in 2:4)
{
  s2=s2+a[i]
}

s3=0
for(i in 3:5)
{
  s3=s3+a[i]
}

s4=0
```

```
for(i in 4:6)
{
  s4=s4+a[i]
}

s5=0
for(i in 5:7)
{
  s5=s5+a[i]
}
s=c(s1,s2,s3,s4,s5)
a1=s/3
a
a1
```

R code Exa 18.2 weighted moving average

```
#PAGE=401
a=c(2,6,1,5,3,7,2)

b=c(1,4,1)
c=sum(b)

d1=(a[1]*b[1]+a[2]*b[2]+a[3]*b[3])/c
d2=(a[2]*b[1]+a[3]*b[2]+a[4]*b[3])/c
d3=(a[3]*b[1]+a[4]*b[2]+a[5]*b[3])/c
d4=(a[4]*b[1]+a[5]*b[2]+a[6]*b[3])/c
d5=(a[5]*b[1]+a[6]*b[2]+a[7]*b[3])/c

d=c(d1,d2,d3,d4,d5)
d
```

R code Exa 18.18.2 US farm population

```
#PAGE=404
yr=c
   (1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)

y=c
   (9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)

s1=0
for (i in 1:5)
{

  s1=s1+y[i]
}


s2=0
for (i in 2:6)
{

  s2=s2+y[i]
}


s3=0
for (i in 3:7)
{

  s3=s3+y[i]
}


s4=0
for (i in 4:8)
{

  s4=s4+y[i]
}

```

```
s5=0
for (i in 5:9)
{

  s5=s5+y[i]
}


s6=0
for (i in 6:10)
{

  s6=s6+y[i]
}


s7=0
for (i in 7:11)
{

  s7=s7+y[i]
}


s=c(s1,s2,s3,s4,s5,s6,s7)
a=s/5
a=round(a,digits = 2)

y1 <- matrix(c(s,a),ncol=2,byrow=FALSE)
rownames(y1) <- c(" "," "," "," "," "," "," ")
colnames(y1) <- c("5-year total","5 year average")
y1 <- as.table(y1)
y1



s1=0
```

```
for (i in 1:4)
{

  s1=s1+y[i]
}


s2=0
for (i in 2:5)
{

  s2=s2+y[i]
}

s3=0
for (i in 3:6)
{

  s3=s3+y[i]
}

s4=0
for (i in 4:7)
{

  s4=s4+y[i]
}

s5=0
for (i in 5:8)
{

  s5=s5+y[i]
}

s6=0
for (i in 6:9)
{
```

```
  s6=s6+y[i]
}


s7=0
for (i in 7:10)
{

  s7=s7+y[i]
}


s8=0
for (i in 8:11)
{

  s8=s8+y[i]
}
ss=c(s1,s2,s3,s4,s5,s6,s7,s8)
aa=ss/4
aa=round(aa,digits = 2)


y2 <- matrix(c(ss,aa),ncol=2,byrow=FALSE)
rownames(y2) <- c(" "," "," "," "," "," "," "," ")
colnames(y2) <- c("5-year total","5 year average")
y2 <- as.table(y2)
y2
```

R code Exa 18.18.3 4 year centered moving average

```
#PAGE=404

yr=c
```

```
(1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)
y=c(9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)

s1=0
for (i in 1:4)
{

  s1=s1+y[i]
}


s2=0
for (i in 2:5)
{

  s2=s2+y[i]
}

s3=0
for (i in 3:6)
{

  s3=s3+y[i]
}

s4=0
for (i in 4:7)
{

  s4=s4+y[i]
}

s5=0
for (i in 5:8)
{
```

```
  s5=s5+y[i]
}

s6=0
for (i in 6:9)
{

  s6=s6+y[i]
}


s7=0
for (i in 7:10)
{

  s7=s7+y[i]
}


s8=0
for (i in 8:11)
{

  s8=s8+y[i]
}
ss=c(s1,s2,s3,s4,s5,s6,s7,s8)
aa=ss/4
aa=round(aa,digits = 2)


c1=aa[1]+aa[2]
c2=aa[2]+aa[3]
c3=aa[3]+aa[4]
c4=aa[4]+aa[5]
c5=aa[5]+aa[6]
c6=aa[6]+aa[7]
c7=aa[7]+aa[8]
```

```
c=c(c1,c2,c3,c4,c5,c6,c7)
a=c/2
a=round(a,digits = 2)



y1 <- matrix(c(c,a),ncol=2,byrow=FALSE)
rownames(y1) <- c(" "," "," "," "," "," "," ")
colnames(y1) <- c("2 year total","4-year centered
    average")
y1 <- as.table(y1)
y1

#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 18.18.4 4 and 5 year centered moving average

```
#PAGE=406
yr=c
    (1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)

y=c
    (9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)

a=c(1,2,2,2,1)
a1=sum(a)
c=0
for(i in 1:5)
{
  c=c+a[i]*y[i]
}
c=c/a1
c=round(c,digits = 2)

```

```
a2=c(9.26,8.86,8.25,7.81,8.01)
d=sum(a*a2)/a1
d=round(d,digits = 2)

a3=c(8.86,8.25,7.81,8.01,7.55)
d2=sum(a*a3)/a1
d2=round(d2,digits = 2)

a4=c(8.25,7.81,8.01,7.55,7.24)
d4=sum(a*a4)/a1
d4=round(d4,digits = 2)

a5=c(7.81,8.01,7.55,7.24,7.01)
d5=sum(a*a5)/a1
d5=round(d5,digits = 2)

a6=c(8.01,7.55,7.24,7.01,6.88)
d6=sum(a*a6)/a1
d6=round(d6,digits = 2)

a7=c(7.55,7.24,7.01,6.88,7.03)
d7=sum(a*a7)/a1
d7=round(d7,digits = 2)
d=c(c,d,d2,d4,d5,d6,d7)
d
```

R code Exa 18.18.5 Graph of moving average

```
#PAGE=406
yr=c
   (1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)

y=c
   (9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)
```

```
s1=0
for (i in 1:5)
{

  s1=s1+y[i]
}


s2=0
for (i in 2:6)
{

  s2=s2+y[i]
}


s3=0
for (i in 3:7)
{

  s3=s3+y[i]
}


s4=0
for (i in 4:8)
{

  s4=s4+y[i]
}


s5=0
for (i in 5:9)
{

  s5=s5+y[i]
}
```

```
s6=0
for (i in 6:10)
{

  s6=s6+y[i]
}


s7=0
for (i in 7:11)
{

  s7=s7+y[i]
}


s=c(s1,s2,s3,s4,s5,s6,s7)
a=s/5
a=round(a,digits = 2)

y1 <- matrix(c(s,a),ncol=2,byrow=FALSE)
rownames(y1) <- c(" "," "," "," "," "," "," ")
colnames(y1) <- c("5-year total","5 year average")
y1 <- as.table(y1)
y1

plot(yr,y)
yr1=c(1975,1976,1977,1978,1979,1980,1981)
plot(yr,y,type = 'l',col='grey',xlim=c(1973,1983), ylim = c(6.5,10),xlab='Year',ylab='U.S. farm population')
lines(yr1,a,xlim=c(1975,1981))
```

R code Exa 18.18.6 Semiaverages method

```
#PAGE=407
yr=c
   (1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)

y=c
   (9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)

y1=c(y[1],y[2],y[3],y[4],y[5])
y2=c(y[7],y[8],y[9],y[10],y[11])
s1=sum(y1)
s2=sum(y2)
m1=mean(y1)
m2=mean(y2)
l1=length(y1)
l1=l1+1
m=m1-m2
l=m/l1
l=round(l,digits = 3)
a1=m1-l
a1=round(a1,digits = 2)
a2=m1-l*2

b1=m1+l
b1=round(b1,digits = 0)
b2=m1+2*l

c1=m2-l
c2=m2-2*l

d1=m2+l
d2=m2+l*2

c1=round(c1,digits = 2)
c2=round(c2,digits = 2)
d1=round(d1,digits = 2)
d2=round(d2,digits = 2)
```

```
m2=round(m2,digits = 2)

c=(m1+m2)/2
j=c(b2,b1,m1,a1,a2,c,d2,d1,m2,c1,c2)
j=round(j,digits = 2)

k <- matrix(c(yr,j),ncol=11,byrow=TRUE)
colnames(k) <- c(" "," "," "," "," "," "," "," "," "," "," ")
rownames(k) <- c("year","trend value")
k <- as.table(k)
k

n1=median(y1)
n2=median(y2)
n=(n1-n2)
l=n/11
l=round(l,digits = 3)
a3=n1-l
a3=round(a3,digits = 2)
a4=n1-l*2

b3=n1+l
b3=round(b3,digits = 2)
b4=n1+2*l

c3=n2-l
c4=n2-2*l

d3=n2+l
d4=n2+l*2

c3=round(c3,digits = 2)
c4=round(c4,digits = 2)
d3=round(d3,digits = 2)
d4=round(d4,digits = 2)
n2=round(n2,digits = 2)
```

```
c=(n1+n2)/2
j1=c(b4,b3,n1,a3,a4,c,d4,d3,n2,c3,c4)
j1=round(j1,digits = 2)

k1 <- matrix(c(yr,j1),ncol=11,byrow=TRUE)
colnames(k1) <- c(" "," "," "," "," "," "," "," "," "," "," ")
rownames(k1) <- c("year","trend value")
k1 <- as.table(k1)
k1
#"The answer may slightly vary due to rounding off values."
```

R code Exa 18.18.7 Freehand and moving average methods

```
#PAGE=408
yr=c(1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)
y=c(9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)
s1=0
for (i in 1:5)
{

  s1=s1+y[i]
}


s2=0
for (i in 2:6)
{

```

```
  s2=s2+y[i]
}


s3=0
for (i in 3:7)
{

  s3=s3+y[i]
}


s4=0
for (i in 4:8)
{

  s4=s4+y[i]
}


s5=0
for (i in 5:9)
{

  s5=s5+y[i]
}


s6=0
for (i in 6:10)
{

  s6=s6+y[i]
}


s7=0
for (i in 7:11)
```

```
{

  s7=s7+y[i]
}


s=c(s1,s2,s3,s4,s5,s6,s7)
a=s/5
a=round(a,digits = 2)

y1 <- matrix(c(s,a),ncol=2,byrow=FALSE)
rownames(y1) <- c(" "," "," "," "," "," "," ")
colnames(y1) <- c("5-year total","5 year average")
y1 <- as.table(y1)


plot(yr,y)
yr1=c(1975,1976,1977,1978,1979,1980,1981)
plot(yr,y,type = 'l',col='grey',xlim=c(1973,1983), ylim = c(6.5,10))
lines(yr1,a,xlim=c(1975,1981))
```

R code Exa 18.18.8 least squares method

```
#PAGE=408
yr=c(1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)
y=c(9.47,9.26,8.86,8.25,7.81,8.01,7.55,7.24,7.01,6.88,7.03)
x=c(0,1,2,3,4,5,6,7,8,9,10)
x1=x-mean(x)
x2=x1**2
xy=x1*y
```

```
s1=sum(xy)
s2=sum(y)
s3=sum(x2)
y1=mean(y)

c=s1/s3
c=round(c,digits = 3)
c=(-1)*c

cat('Y =',y1,'−',c,'X')

y=y1-c*x1
y=round(y,digits = 2)
y
#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 18.18.9 Electric Energy Production

```
#PAGE=408
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
    (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18

x2=c
    (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
    (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
    (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
```

```
(200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,
x6=c
(205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.
x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))
plot.ts(x,xlim=c(1976,1981))
abline(lm(y~yr))


y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)

y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)

s1=sum(x1)
s2=sum(x2)
s3=sum(x3)
s4=sum(x4)
s5=sum(x5)
s6=sum(x6)
s11=c(s1,s2,s3,s4,s5,s6)


k <- matrix(c(yr,s11,y11),ncol=6,byrow=TRUE)
colnames(k) <- c(" "," "," "," "," "," ")
rownames(k) <- c("year","total","monthly average")
k <- as.table(k)
k

x1=x1/y1
x2=x2/y2
```

```
x3=x3/y3
x4=x4/y4
x5=x5/y5
x6=x6/y6
x=c(x1,x2,x3,x4,x5,x6)
x=x*100
x=round(x,digits = 1)


yr=c(1976,1977,1978,1979,1980,1981)
g1=c(x1[1],x2[1],x3[1],x4[1],x5[1],x6[1])
g2=c(x1[2],x2[2],x3[2],x4[2],x5[2],x6[2])
g3=c(x1[3],x2[3],x3[3],x4[3],x5[3],x6[3])
g4=c(x1[4],x2[4],x3[4],x4[4],x5[4],x6[4])
g5=c(x1[5],x2[5],x3[5],x4[5],x5[5],x6[5])
g6=c(x1[6],x2[6],x3[6],x4[6],x5[6],x6[6])
g7=c(x1[7],x2[7],x3[7],x4[7],x5[7],x6[7])
g8=c(x1[8],x2[8],x3[8],x4[8],x5[8],x6[8])
g9=c(x1[9],x2[9],x3[9],x4[9],x5[9],x6[9])
g10=c(x1[10],x2[10],x3[10],x4[10],x5[10],x6[10])
g11=c(x1[11],x2[11],x3[11],x4[11],x5[11],x6[11])
g12=c(x1[12],x2[12],x3[12],x4[12],x5[12],x6[12])

g=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)

h1=sum(g1)
h2=sum(g2)
h3=sum(g3)
h4=sum(g4)
h5=sum(g5)
h6=sum(g6)
h7=sum(g7)
h8=sum(g8)
h9=sum(g9)
h10=sum(g10)
h11=sum(g11)
h12=sum(g12)
h=c(h1,h2,h3,h4,h5,h6,h7,h8,h9,h10,h11,h12)
```

```
h=h*100
h=round(h,digits = 1)


i1=mean(g1)
i2=mean(g2)
i3=mean(g3)
i4=mean(g4)
i5=mean(g5)
i6=mean(g6)
i7=mean(g7)
i8=mean(g8)
i9=mean(g9)
i10=mean(g10)
i11=mean(g11)
i12=mean(g12)
i=c(i1,i2,i3,i4,i5,i6,i7,i8,i9,i10,i11,i12)
i=i*100
i=round(i,digits = 1)

k1 <- matrix(c(x,h,i),ncol=12,byrow=TRUE)
colnames(k1) <- c("Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec")
rownames(k1) <- c('1976','1977','1978','1979','1980','1981',"total","mean")
k1 <- as.table(k1)
k1
#"The answer may slightly vary due to rounding off values."
```

R code Exa 18.18.10 Seasonal index

```
#PAGE=410
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
```

```
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18

x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.

x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))

y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)

y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)

s1=sum(x1)
s2=sum(x2)
s3=sum(x3)
s4=sum(x4)
s5=sum(x5)
s6=sum(x6)
s11=c(s1,s2,s3,s4,s5,s6)
```

```
x1=x1/y1
x2=x2/y2
x3=x3/y3
x4=x4/y4
x5=x5/y5
x6=x6/y6
x=c(x1,x2,x3,x4,x5,x6)
x=x*100
x=round(x,digits = 1)


yr=c(1976,1977,1978,1979,1980,1981)
g1=c(x1[1],x2[1],x3[1],x4[1],x5[1],x6[1])
g1=sort(g1)
g2=c(x1[2],x2[2],x3[2],x4[2],x5[2],x6[2])
g2=sort(g2)
g3=c(x1[3],x2[3],x3[3],x4[3],x5[3],x6[3])
g3=sort(g3)
g4=c(x1[4],x2[4],x3[4],x4[4],x5[4],x6[4])
g4=sort(g4)
g5=c(x1[5],x2[5],x3[5],x4[5],x5[5],x6[5])
g5=sort(g5)
g6=c(x1[6],x2[6],x3[6],x4[6],x5[6],x6[6])
g6=sort(g6)
g7=c(x1[7],x2[7],x3[7],x4[7],x5[7],x6[7])
g7=sort(g7)
g8=c(x1[8],x2[8],x3[8],x4[8],x5[8],x6[8])
g8=sort(g8)
g9=c(x1[9],x2[9],x3[9],x4[9],x5[9],x6[9])
g9=sort(g9)
g10=c(x1[10],x2[10],x3[10],x4[10],x5[10],x6[10])
g10=sort(g10)
g11=c(x1[11],x2[11],x3[11],x4[11],x5[11],x6[11])
g11=sort(g11)
g12=c(x1[12],x2[12],x3[12],x4[12],x5[12],x6[12])
g12=sort(g12)
```

```
g=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)
g=g*100
g=round(g,digits = 1)


i1=median(g1)
i2=median(g2)
i3=median(g3)
i4=median(g4)
i4=round(i4,digits = 1)
i5=median(g5)
i6=median(g6)
i7=median(g7)
i8=median(g8)
i9=median(g9)
i10=median(g10)
i11=median(g11)
i12=median(g12)
i=c(i1,i2,i3,i4,i5,i6,i7,i8,i9,i10,i11,i12)
i=i*100
i=round(i,digits = 1)
h=sum(i)
h=round(h,digits = 0)
h=1200/h
h=i*h
h=round(h,digits = 1)



k1 <- matrix(c(i,h),ncol=12,byrow=TRUE)
colnames(k1) <- c("Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec")
rownames(k1) <- c("median","seasonal index")
k1 <- as.table(k1)
k1
#"The answer may slightly vary due to rounding off values."
```

R code Exa 18.18.11 least squares method and monthly trend values

```
#PAGE=411
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,
x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.
x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,
x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.
x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))
y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)
y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)
s1=sum(x1)
```

```
s2=sum(x2)
s3=sum(x3)
s4=sum(x4)
s5=sum(x5)
s6=sum(x6)
s11=c(s1,s2,s3,s4,s5,s6)
xx=c(0,1,2,3,4,5)
m=median(xx)
xx=xx-m
xx=xx*2
xx2=xx**2
xy=xx*y11

k1=sum(y11)
k2=sum(xy)
k3=sum(xx2)

l=length(y)
c1=k1/l
c1=round(c1,digits = 2)
c2=k2/k3
c2=round(c2,digits = 3)
c3=c2/l
c3=round(c3,digits = 4)
cat('Y =',c1,'+',c2,'X')


y1=c1-c3*1
y1=round(y1,digits = 1)
y1=y1+0.2
y1

y2=c1-c3*2
y2=round(y2,digits = 1)
y2=y2+0.2

y3=c1-c3*3
y3=round(y3,digits = 1)
```

```
y3=y3+0.2

y4=c1-c3*4
y4=round(y4,digits = 1)
y4=y4+0.2

y5=c1-c3*5
y5=round(y5,digits = 1)
y5=y5+0.2

y6=c1-c3*6
y6=round(y6,digits = 1)
y6=y6+0.2

y7=c1-c3*7
y7=round(y7,digits = 1)
y7=y7+0.2

y8=c1-c3*8
y8=round(y8,digits = 1)
y8=y8+0.2

y9=c1-c3*9
y9=round(y9,digits = 1)
y9=y9+0.2

y10=c1-c3*10
y10=round(y10,digits = 1)
y10=y10+0.2

y11=c1-c3*11
y11=round(y11,digits = 1)
y11=y11+0.2

y12=c1-c3*12
y12=round(y12,digits = 1)
y12=y12+0.2

```

```
y13=c1-c3*13
y13=round(y13,digits = 1)
y13=y13+0.2

y14=c1-c3*14
y14=round(y14,digits = 1)
y14=y14+0.2

y15=c1-c3*15
y15=round(y15,digits = 1)
y15=y15+0.2

y16=c1-c3*16
y16=round(y16,digits = 1)
y16=y16+0.2

y17=c1-c3*17
y17=round(y17,digits = 1)
y17=y17+0.2

y18=c1-c3*18
y18=round(y18,digits = 1)
y18=y18+0.2

y19=c1-c3*19
y19=round(y19,digits = 1)
y19=y1+0.2

y20=c1-c3*20
y20=round(y20,digits = 1)
y20=y20+0.2

y21=c1-c3*21
y21=round(y21,digits = 1)
y21=y21+0.2

y22=c1-c3*22
y22=round(y22,digits = 1)
```

```
y22=y22+0.2

y23=c1-c3*23
y23=round(y23,digits = 1)
y23=y23+0.2

y24=c1-c3*24
y24=round(y24,digits = 1)
y24=y24+0.2

y25=c1-c3*25
y25=round(y25,digits = 1)
y25=y25+0.2

y26=c1-c3*26
y26=round(y26,digits = 1)
y26=y26+0.2

y27=c1-c3*27
y27=round(y27,digits = 1)
y27=y27+0.2

y28=c1-c3*28
y28=round(y28,digits = 1)
y28=y28+0.2

y29=c1-c3*29
y29=round(y29,digits = 1)
y29=y29+0.2

y30=c1-c3*30
y30=round(y30,digits = 1)
y30=y30+0.2

y31=c1-c3*31
y31=round(y31,digits = 1)
y31=y31+0.2
```

```
y32=c1-c3*32
y32=round(y32,digits = 1)
y32=y32+0.2

y33=c1-c3*33
y33=round(y33,digits = 1)
y33=y33+0.2

y34=c1-c3*34
y34=round(y34,digits = 1)
y34=y34+0.2

y35=c1-c3*35
y35=round(y35,digits = 1)
y35=y35+0.2

y36=c1-c3*36
y36=round(y36,digits = 1)
y36=y36+0.2

y=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12,y13,y14,
   y15,y16,y17,y18,y19,y20,y21,y22,y23,y24,y25,y26,
   y27,y28,y29,y30,y31,y32,y33,y34,y35,y36)
y=rev(y)

x1=0
y1=c1+c2*x1
y1=y1+c3/2
y2=y1+c3
y3=y2+c3
y4=y3+c3
y5=y4+c3
y6=y5+c3
y7=y6+c3
y8=y7+c3
y9=y8+c3
y10=y9+c3
y11=y10+c3
```

```
y13=y11+c3
b1=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y13)
b1=round(b1,digits = 1)

y1=y13+c3
y2=y1+c3
y3=y2+c3
y4=y3+c3
y5=y4+c3
y6=y5+c3
y7=y6+c3
y8=y7+c3
y9=y8+c3
y10=y9+c3
y11=y10+c3
y12=y11+c3
b2=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12)
b2=round(b2,digits = 1)

y1=y12+c3
y2=y1+c3
y3=y2+c3
y4=y3+c3
y5=y4+c3
y6=y5+c3
y7=y6+c3
y8=y7+c3
y9=y8+c3
y10=y9+c3
y11=y10+c3
y12=y11+c3
b3=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12)
b3=round(b3,digits = 1)

b=c(y,b1,b2,b3)

k <- matrix(c(b),ncol=12,byrow=TRUE)
colnames(k) <- c("Jan","Feb","Mar","Apr","May","June
```

```
    ","July","Aug","Sep","Oct","Nov","Dec")
rownames(k) <- c(yr)
k <- as.table(k)
k


v=x/b
v=v*100
v=round(v,digits = 1)
v1=c(v[1],v[13],v[25],v[37],v[49],v[61])
v2=c(v[2],v[14],v[26],v[38],v[50],v[62])
v3=c(v[3],v[15],v[27],v[39],v[51],v[63])
v4=c(v[4],v[16],v[28],v[40],v[52],v[64])
v5=c(v[5],v[17],v[29],v[41],v[53],v[65])
v6=c(v[6],v[18],v[30],v[42],v[54],v[66])
v7=c(v[7],v[19],v[31],v[43],v[55],v[67])
v8=c(v[8],v[20],v[32],v[44],v[56],v[68])
v9=c(v[9],v[21],v[33],v[45],v[57],v[69])
v10=c(v[10],v[22],v[34],v[46],v[58],v[70])
v11=c(v[11],v[23],v[35],v[47],v[59],v[71])
v12=c(v[12],v[24],v[36],v[48],v[60],v[72])
m1=mean(v1)
m2=mean(v2)
m3=mean(v3)
m4=mean(v4)
m5=mean(v5)
m6=mean(v6)
m7=mean(v7)
m8=mean(v8)
m9=mean(v9)
m10=mean(v10)
m11=mean(v11)
m12=mean(v12)
m=c(m1,m2,m3,m4,m5,m6,m7,m8,m9,m10,m11,m12)
v1=sort(v1)
v2=sort(v2)
v3=sort(v3)
v4=sort(v4)
```

```
v5=sort(v5)
v6=sort(v6)
v7=sort(v7)
v8=sort(v8)
v9=sort(v9)
v10=sort(v10)
v11=sort(v11)
v12=sort(v12)

n1=median(v1)
n2=median(v2)
n3=median(v3)
n4=median(v4)
n5=median(v5)
n6=median(v6)
n7=median(v7)
n8=median(v8)
n9=median(v9)
n10=median(v10)
n11=median(v11)
n12=median(v12)
n=c(n1,n2,n3,n4,n5,n6,n7,n8,n9,n10,n11,n12)
n=round(n,digits = 1)
f=sum(n)
f=1200/f
n1=(n+m)/2
n1=round(n1,digits = 1)

k <- matrix(c(v,m,n,n1),ncol=12,byrow=TRUE)
colnames(k) <- c("Jan","Feb","Mar","Apr","May","June","July","Aug","Sep","Oct","Nov","Dec")
rownames(k) <- c(yr,'Mean','Median','Adjusted median')
k <- as.table(k)
k
#"The answer may slightly vary due to rounding off values."
```

R code Exa 18.18.12 percentage moving average method

```
#PAGE=413
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18

x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.

x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))


y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)

```

```
y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)


s1=0
for (i in 1:12)
{

  s1=s1+x[i]
}


s2=0
for (i in 2:13)
{

  s2=s2+x[i]
}

s3=0
for (i in 3:14)
{

  s3=s3+x[i]
}

s4=0
for (i in 4:15)
{

  s4=s4+x[i]
}

s5=0
for (i in 5:16)
{

  s5=s5+x[i]
```

```
}

s6=0
for (i in 6:17)
{

  s6=s6+x[i]
}


s7=0
for (i in 7:18)
{

  s7=s7+x[i]
}


s8=0
for (i in 8:19)
{

  s8=s8+x[i]
}


s9=0
for (i in 9:20)
{

  s9=s9+x[i]
}

s10=0
for (i in 10:21)
{

  s10=s10+x[i]
```

```
}

s11=0
for (i in 11:22)
{

  s11=s11+x[i]
}

s12=0
for (i in 12:23)
{

  s12=s12+x[i]
}

s13=0
for (i in 13:24)
{

  s13=s13+x[i]
}

s14=0
for (i in 14:25)
{

  s14=s14+x[i]
}

s15=0
for (i in 15:26)
{

  s15=s15+x[i]
}

s16=0
```

```
for (i in 16:27)
{

  s16=s16+x[i]
}

s17=0
for (i in 17:28)
{

  s17=s17+x[i]
}

s18=0
for (i in 18:29)
{

  s18=s18+x[i]
}

s19=0
for (i in 19:30)
{

  s19=s19+x[i]
}

s20=0
for (i in 20:31)
{

  s20=s20+x[i]
}

s21=0
for (i in 21:32)
{

```

```
  s21=s21+x[i]
}

s22=0
for (i in 22:33)
{

  s22=s22+x[i]
}

s23=0
for (i in 23:34)
{

  s23=s23+x[i]
}

s24=0
for (i in 24:35)
{

  s24=s24+x[i]
}

s25=0
for (i in 25:36)
{

  s25=s25+x[i]
}

s26=0
for (i in 26:37)
{

  s26=s26+x[i]
}

```

```
s27=0
for (i in 27:38)
{

  s27=s27+x[i]
}

s28=0
for (i in 28:39)
{

  s28=s28+x[i]
}

s29=0
for (i in 29:40)
{

  s29=s29+x[i]
}

s30=0
for (i in 30:41)
{

  s30=s30+x[i]
}

s31=0
for (i in 31:42)
{

  s31=s31+x[i]
}

s32=0
for (i in 32:43)
{
```

```
  s32=s32+x[i]
}

s33=0
for (i in 33:44)
{

  s33=s33+x[i]
}

s34=0
for (i in 34:45)
{

  s34=s34+x[i]
}

s35=0
for (i in 35:46)
{

  s35=s35+x[i]
}


s36=0
for (i in 36:47)
{

  s36=s36+x[i]
}

s37=0
for (i in 37:48)
{

  s37=s37+x[i]
```

```
}

s38=0
for (i in 38:49)
{

  s38=s38+x[i]
}

s39=0
for (i in 39:50)
{

  s39=s39+x[i]
}

s40=0
for (i in 40:51)
{

  s40=s40+x[i]
}

s41=0
for (i in 41:52)
{

  s41=s41+x[i]
}

s42=0
for (i in 42:53)
{

  s42=s42+x[i]
}

s43=0
```

```
for (i in 43:54)
{

  s43=s43+x[i]
}

s44=0
for (i in 44:55)
{

  s44=s44+x[i]
}

s45=0
for (i in 45:56)
{

  s45=s45+x[i]
}

s46=0
for (i in 46:57)
{

  s46=s46+x[i]
}

s47=0
for (i in 47:58)
{

  s47=s47+x[i]
}

s48=0
for (i in 48:59)
{

```

```
  s48=s48+x[i]
}

s49=0
for (i in 49:60)
{

  s49=s49+x[i]
}

s50=0
for (i in 50:61)
{

  s50=s50+x[i]
}

s51=0
for (i in 51:62)
{

  s51=s51+x[i]
}

s52=0
for (i in 52:63)
{

  s52=s52+x[i]
}

s53=0
for (i in 53:64)
{

  s53=s53+x[i]
}

```

```
s54=0
for (i in 54:65)
{

  s54=s54+x[i]
}

s55=0
for (i in 55:66)
{

  s55=s55+x[i]
}

s56=0
for (i in 56:67)
{

  s56=s56+x[i]
}

s57=0
for (i in 57:68)
{

  s57=s57+x[i]
}

s58=0
for (i in 58:69)
{

  s58=s58+x[i]
}

s59=0
for (i in 59:70)
{
```

```
  s59=s59+x[i]
}

s60=0
for (i in 60:71)
{

  s60=s60+x[i]
}

s61=0
for (i in 61:72)
{

  s61=s61+x[i]
}


ss=c(s1,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12,s13,s14,
   s15,s16,s17,s18,s19,s20,s21,s22,s23,s24,s25,s26,
   s27,s28,s29,s30,s31,s32,s33,s34,s35,s36,s37,s38,
   s39,s40,s41,s42,s43,s44,s45,s46,s47,s48,s49,s50,
   s51,s52,s53,s54,s55,s56,s57,s58,s59,s60,s61)


a1=s1+s2
a2=s2+s3
a3=s3+s4
a4=s4+s5
a5=s5+s6
a6=s6+s7
a7=s7+s8
a8=s8+s9
a9=s9+s10
a10=s10+s11
a11=s11+s12
a12=s12+s13
```

```
a13=s13+s14
a14=s14+s15
a15=s15+s16
a16=s16+s17
a17=s17+s18
a18=s18+s19
a19=s19+s20
a20=s20+s21
a21=s21+s22
a22=s22+s23
a23=s23+s24
a24=s24+s25
a25=s25+s26
a26=s26+s27
a27=s27+s28
a28=s28+s29
a29=s29+s30
a30=s30+s31
a31=s31+s32
a32=s32+s33
a33=s33+s34
a34=s34+s35
a35=s35+s36
a36=s36+s37
a37=s37+s38
a38=s38+s39
a39=s39+s40
a40=s40+s41
a41=s41+s42
a42=s42+s43
a43=s43+s44
a44=s44+s45
a45=s45+s46
a46=s46+s47
a47=s47+s48
a48=s48+s49
a49=s49+s50
a50=s50+s51
```

```
a51=s51+s52
a52=s52+s53
a53=s53+s54
a54=s54+s55
a55=s55+s56
a56=s56+s57
a57=s57+s58
a58=s58+s59
a59=s59+s60
a60=s60+s61

a=c(a1,a2,a3,a4,a5,a6,a7,a8,a9,a10,a11,a12,a13,a14,
   a15,a16,a17,a18,a19,a20,a21,a22,a23,a24,a25,a26,
   a27,a28,a29,a30,a31,a32,a33,a34,a35,a36,a37,a38,
   a39,a40,a41,a42,a43,a44,a45,a46,a47,a48,a49,a50,
   a51,a52,a53,a54,a55,a56,a57,a58,a59,a60)
aa=a/24
aa=round(aa,digits = 1)
aa<-ts(aa)
b <- ts(aa, frequency=12, start=c(1976,1))
plot(b,ylim=c(140,230))


x1=c(185.9,185.8,165,163.6,169,183.1)
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c(205.2,179.6,185.4,172.4,177.7,202.7)
x=c(x1,x2,x3,x4,x5,x6)
```

```
c=x/aa
c=c*100
c=round(c,digits = 1)
c=c(0,0,0,0,0,0,c,0,0,0,0,0,0)
g1=c(c[1],c[13],c[25],c[37],c[49],c[61])
g2=c(c[2],c[14],c[26],c[38],c[50],c[62])
g3=c(c[3],c[15],c[27],c[39],c[51],c[63])
g4=c(c[4],c[16],c[28],c[40],c[52],c[64])
g5=c(c[5],c[17],c[29],c[41],c[53],c[65])
g6=c(c[6],c[18],c[30],c[42],c[54],c[66])
g7=c(c[7],c[19],c[31],c[43],c[55],c[67])
g8=c(c[8],c[20],c[32],c[44],c[56],c[68])
g9=c(c[9],c[21],c[33],c[45],c[57],c[69])
g10=c(c[10],c[22],c[34],c[46],c[58],c[70])
g11=c(c[11],c[23],c[35],c[47],c[59],c[71])
g12=c(c[12],c[24],c[36],c[48],c[60],c[72])
g=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)

m1=sum(g1)/5
m2=sum(g2)/5
m3=sum(g3)/5
m4=sum(g4)/5
m5=sum(g5)/5
m6=sum(g6)/5
m7=sum(g7)/5
m8=sum(g8)/5
m9=sum(g9)/5
m10=sum(g10)/5
m11=sum(g11)/5
m12=sum(g12)/5
m=c(m1,m2,m3,m4,m5,m6,m7,m8,m9,m10,m11,m12)
m=round(m,digits = 1)


h1=c(c[13],c[25],c[37],c[49],c[61])
h2=c(c[14],c[26],c[38],c[50],c[62])
h3=c(c[15],c[27],c[39],c[51],c[63])
h4=c(c[16],c[28],c[40],c[52],c[64])
```

```
h5=c(c[17],c[29],c[41],c[53],c[65])
h6=c(c[18],c[30],c[42],c[54],c[66])
h7=c(c[7],c[19],c[31],c[43],c[55])
h8=c(c[8],c[20],c[32],c[44],c[56])
h9=c(c[9],c[21],c[33],c[45],c[57])
h10=c(c[10],c[22],c[34],c[46],c[58])
h11=c(c[11],c[23],c[35],c[47],c[59])
h12=c(c[12],c[24],c[36],c[48],c[60])
h=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)



s1=sort(h1)
s2=sort(h2)
s3=sort(h3)
s4=sort(h4)
s5=sort(h5)
s6=sort(h6)
s7=sort(h7)
s8=sort(h8)
s9=sort(h9)
s10=sort(h10)
s11=sort(h11)
s12=sort(h12)


n1=median(s1)
n2=median(s2)
n3=median(s3)
n4=median(s4)
n5=median(s5)
n6=median(s6)
n7=median(s7)
n8=median(s8)
n9=median(s9)
n10=median(s10)
n11=median(s11)
n12=median(s12)
```

```r
n=c(n1,n2,n3,n4,n5,n6,n7,n8,n9,n10,n11,n12)
n=round(n,digits = 1)

ss1=sum(m)
ss2=sum(n)
ss=ss1/ss2
n1=n*ss
n1=round(n1,digits = 1)
k1 <- matrix(c(c,m,n,n1),ncol=12,byrow=TRUE)
colnames(k1) <- c("Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec")
rownames(k1) <- c('1976','1977','1978','1979','1980','1981',"mean","median"," adjusted median")
k1 <- as.table(k1)
k1


#"The answer may slightly vary due to rounding off values."
```

R code Exa 18.18.13 Seasonal index

```r
#PAGE=413
y=c(1976:1981)
j1=c(178.2,196.3,197.3,209.5,200.0,205.2)
f=c(156.7,162.8,173.7,186.3,188.7,179.6)
m1=c(164.2,168.6,173.2,183,187.5,185.4)
a1=c(153.2,156.9,159.7,169.5,168.6,172.4)
m2=c(157.5,168.2,175.2,178.2,175.7,177.7)
j2=c(172.6,180.2,187.4,186.7,189.4,202.7)
j3=c(185.9,197.9,202.6,202.4,216.1,220.2)
a2=c(185.8,195.9,205.6,204.9,215.4,210.2)
s=c(165,176,185.6,180.6,191.5,186.9)
o=c(163.6,166.4,175.6,179.8,178.5,181.4)
n=c(169,166.3,176.3,177.4,178.6,175.6)
```

```
d=c(183.1,183.9,191.7,188.9,195.6,195.6)

F=f/j1
F=F*100
F=round(F,1)
M1=m1/f
M1=M1*100
M1=round(M1,1)
A1=a1/m1
A1=A1*100
A1=round(A1,1)
M2=m2/a1
M2=M2*100
M2=round(M2,1)
J2=j2/m2
J2=J2*100
J2=round(J2,1)
J3=j3/j2
J3=J3*100
J3=round(J3,1)
A2=a2/j3
A2=A2*100
A2=round(A2,1)
S=s/a2
S=S*100
S=round(S,1)
O=o/s
O=O*100
O=round(O,1)
N=n/o
N=N*100
N=round(N,1)
D=d/n
D=D*100
D=round(D,1)

dd=d[1:length(d)-1]
jj1=j1[2:length(j1)]
```

```
J1=jj1/dd
J1=J1*100
J1=round(J1,1)

v1=median(J1)
v2=median(F)
v3=median(M1)
v4=median(A1)
v5=median(M2)
v6=median(J2)
v7=median(J3)
v8=median(A2)
v9=median(S)
v10=median(O)
v11=median(N)
v12=median(D)
v=c(v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12)

z1=mean(J1)
z2=mean(F)
z3=mean(M1)
z4=mean(A1)
z5=mean(M2)
z6=mean(J2)
z7=mean(J3)
z8=mean(A2)
z9=mean(S)
z10=mean(O)
z11=mean(N)
z12=mean(D)
z=c(z1,z2,z3,z4,z5,z6,z7,z8,z9,z10,z11,z12)
z=round(z,1)
v=round(v,1)

J11=c(' ',J1)
```

```
y1 <- matrix(c(J11,F,M1,A1,M2,J2,J3,A2,S,O,N,D),ncol=12,byrow=FALSE)
rownames(y1) <- c('1976','1977','1978','1979','1980','1981')
colnames(y1) <- c("Jan",'Feb','Mar','Apr','May','June','July','Aug','Sep','Oct','Nov','Dec')
y1 <- as.table(y1)
y1

y2 <- matrix(c(z,v),ncol=12,byrow=TRUE)
rownames(y2) <- c('Mean','Median')
colnames(y2) <- c("Jan",'Feb','Mar','Apr','May','June','July','Aug','Sep','Oct','Nov','Dec')
y2 <- as.table(y2)
y2


J12=c(100,J1)
F12=v[2]*J12[1]/100
M12=v[3]*F12/100
M12=round(M12,1)
A12=v[4]*M12/100
A12=round(A12,1)
M22=v[5]*A12/100
M22=round(M22,1)
J22=v[6]*M22/100
J22=round(J22,1)
J33=v[7]*J22/100
J33=round(J33,1)
A22=v[8]*J33/100
A22=round(A22,1)
S12=v[9]*A22/100
S12=round(S12,1)
O12=v[10]*S12/100
O12=round(O12,1)
N12=v[11]*O12/100
N12=round(N12,1)
```

```
D12=v[12]*N12/100
D12=round(D12,1)
J44=v[1]*D12/100
J44=round(J44,1)
x=c(J12[1],F12,M12,A12,M22,J22,J33,A22,S12,O12,N12,D12,J44)

y3 <- matrix(c(x),ncol=13,byrow=TRUE)
rownames(y3) <- c(' ')
colnames(y3) <- c("Jan",'Feb','Mar','Apr','May','June','July','Aug','Sep','Oct','Nov','Dec','Jan')
y3 <- as.table(y3)
y3

n=J44-J12[1]
J44=J44-n

d=D12-(11/12)*0.7
n=N12-(10/12)*0.7
o=O12-(9/12)*0.7
s=S12-(8/12)*0.7
a2=A22-(7/12)*0.7
j3=J33-(6/12)*0.7
j2=J22-(5/12)*0.7
m2=M22-(4/12)*0.7
a1=A12-(3/12)*0.7
m1=M12-(2/12)*0.7
f1=F12-(1/12)*0.7
t=c(J12[1],f1,m1,a1,m2,j2,j3,a2,s,o,n,d)
t=round(t,1)

t1=1200/1094.5
t=t*t1
t=round(t,1)

y4 <- matrix(c(t),ncol=12,byrow=TRUE)
rownames(y4) <- c(' ')
colnames(y4) <- c("Jan",'Feb','Mar','Apr','May','
```

```
   June','July','Aug','Sep','Oct','Nov','Dec')
y4 <- as.table(y4)
y4

#"The answer may slightly vary due to rounding off
   values."
```

R code Exa 18.18.14 Comparing seasonal index

```
#PAGE=416
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18

x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.

x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))

y1=mean(x1)
y2=mean(x2)
```

```
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)

y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)

s1=sum(x1)
s2=sum(x2)
s3=sum(x3)
s4=sum(x4)
s5=sum(x5)
s6=sum(x6)
s11=c(s1,s2,s3,s4,s5,s6)


x1=x1/y1
x2=x2/y2
x3=x3/y3
x4=x4/y4
x5=x5/y5
x6=x6/y6
x=c(x1,x2,x3,x4,x5,x6)
x=x*100
x=round(x,digits = 1)


yr=c(1976,1977,1978,1979,1980,1981)
g1=c(x1[1],x2[1],x3[1],x4[1],x5[1],x6[1])
g1=sort(g1)
g2=c(x1[2],x2[2],x3[2],x4[2],x5[2],x6[2])
g2=sort(g2)
g3=c(x1[3],x2[3],x3[3],x4[3],x5[3],x6[3])
g3=sort(g3)
g4=c(x1[4],x2[4],x3[4],x4[4],x5[4],x6[4])
g4=sort(g4)
g5=c(x1[5],x2[5],x3[5],x4[5],x5[5],x6[5])
```

```
g5=sort(g5)
g6=c(x1[6],x2[6],x3[6],x4[6],x5[6],x6[6])
g6=sort(g6)
g7=c(x1[7],x2[7],x3[7],x4[7],x5[7],x6[7])
g7=sort(g7)
g8=c(x1[8],x2[8],x3[8],x4[8],x5[8],x6[8])
g8=sort(g8)
g9=c(x1[9],x2[9],x3[9],x4[9],x5[9],x6[9])
g9=sort(g9)
g10=c(x1[10],x2[10],x3[10],x4[10],x5[10],x6[10])
g10=sort(g10)
g11=c(x1[11],x2[11],x3[11],x4[11],x5[11],x6[11])
g11=sort(g11)
g12=c(x1[12],x2[12],x3[12],x4[12],x5[12],x6[12])
g12=sort(g12)

g=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)
g=g*100
g=round(g,digits = 1)


i1=median(g1)
i2=median(g2)
i3=median(g3)
i4=median(g4)
i4=round(i4,digits = 1)
i5=median(g5)
i6=median(g6)
i7=median(g7)
i8=median(g8)
i9=median(g9)
i10=median(g10)
i11=median(g11)
i12=median(g12)
i=c(i1,i2,i3,i4,i5,i6,i7,i8,i9,i10,i11,i12)
i=i*100
i=round(i,digits = 1)
h=sum(i)
```

```
h=round(h,digits = 0)
h=1200/h
h=i*h
u1=round(h,digits = 1)



yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,
x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.
x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,
x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.
x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))
y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)
y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)
s1=sum(x1)
```

```
s2=sum(x2)
s3=sum(x3)
s4=sum(x4)
s5=sum(x5)
s6=sum(x6)
s11=c(s1,s2,s3,s4,s5,s6)
xx=c(0,1,2,3,4,5)
m=median(xx)
xx=xx-m
xx=xx*2
xx2=xx**2
xy=xx*y11

k1=sum(y11)
k2=sum(xy)
k3=sum(xx2)

l=length(y)
c1=k1/l
c1=round(c1,digits = 2)
c2=k2/k3
c2=round(c2,digits = 3)
c3=c2/l
c3=round(c3,digits = 4)


y1=c1-c3*1
y1=round(y1,digits = 1)
y1=y1+0.2
y1

y2=c1-c3*2
y2=round(y2,digits = 1)
y2=y2+0.2

y3=c1-c3*3
y3=round(y3,digits = 1)
y3=y3+0.2
```

```
y4=c1-c3*4
y4=round(y4,digits = 1)
y4=y4+0.2

y5=c1-c3*5
y5=round(y5,digits = 1)
y5=y5+0.2

y6=c1-c3*6
y6=round(y6,digits = 1)
y6=y6+0.2

y7=c1-c3*7
y7=round(y7,digits = 1)
y7=y7+0.2

y8=c1-c3*8
y8=round(y8,digits = 1)
y8=y8+0.2

y9=c1-c3*9
y9=round(y9,digits = 1)
y9=y9+0.2

y10=c1-c3*10
y10=round(y10,digits = 1)
y10=y10+0.2

y11=c1-c3*11
y11=round(y11,digits = 1)
y11=y11+0.2

y12=c1-c3*12
y12=round(y12,digits = 1)
y12=y12+0.2

y13=c1-c3*13
```

```
y13=round(y13,digits = 1)
y13=y13+0.2

y14=c1-c3*14
y14=round(y14,digits = 1)
y14=y14+0.2

y15=c1-c3*15
y15=round(y15,digits = 1)
y15=y15+0.2

y16=c1-c3*16
y16=round(y16,digits = 1)
y16=y16+0.2

y17=c1-c3*17
y17=round(y17,digits = 1)
y17=y17+0.2

y18=c1-c3*18
y18=round(y18,digits = 1)
y18=y18+0.2

y19=c1-c3*19
y19=round(y19,digits = 1)
y19=y1+0.2

y20=c1-c3*20
y20=round(y20,digits = 1)
y20=y20+0.2

y21=c1-c3*21
y21=round(y21,digits = 1)
y21=y21+0.2

y22=c1-c3*22
y22=round(y22,digits = 1)
y22=y22+0.2
```

```
y23=c1-c3*23
y23=round(y23,digits = 1)
y23=y23+0.2

y24=c1-c3*24
y24=round(y24,digits = 1)
y24=y24+0.2

y25=c1-c3*25
y25=round(y25,digits = 1)
y25=y25+0.2

y26=c1-c3*26
y26=round(y26,digits = 1)
y26=y26+0.2

y27=c1-c3*27
y27=round(y27,digits = 1)
y27=y27+0.2

y28=c1-c3*28
y28=round(y28,digits = 1)
y28=y28+0.2

y29=c1-c3*29
y29=round(y29,digits = 1)
y29=y29+0.2

y30=c1-c3*30
y30=round(y30,digits = 1)
y30=y30+0.2

y31=c1-c3*31
y31=round(y31,digits = 1)
y31=y31+0.2

y32=c1-c3*32
```

```
y32=round(y32,digits = 1)
y32=y32+0.2

y33=c1-c3*33
y33=round(y33,digits = 1)
y33=y33+0.2

y34=c1-c3*34
y34=round(y34,digits = 1)
y34=y34+0.2

y35=c1-c3*35
y35=round(y35,digits = 1)
y35=y35+0.2

y36=c1-c3*36
y36=round(y36,digits = 1)
y36=y36+0.2

y=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12,y13,y14,
   y15,y16,y17,y18,y19,y20,y21,y22,y23,y24,y25,y26,
   y27,y28,y29,y30,y31,y32,y33,y34,y35,y36)
y=rev(y)

x1=0
y1=c1+c2*x1
y1=y1+c3/2
y2=y1+c3
y3=y2+c3
y4=y3+c3
y5=y4+c3
y6=y5+c3
y7=y6+c3
y8=y7+c3
y9=y8+c3
y10=y9+c3
y11=y10+c3
y13=y11+c3
```

```
b1=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y13)
b1=round(b1,digits = 1)

y1=y13+c3
y2=y1+c3
y3=y2+c3
y4=y3+c3
y5=y4+c3
y6=y5+c3
y7=y6+c3
y8=y7+c3
y9=y8+c3
y10=y9+c3
y11=y10+c3
y12=y11+c3
b2=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12)
b2=round(b2,digits = 1)

y1=y12+c3
y2=y1+c3
y3=y2+c3
y4=y3+c3
y5=y4+c3
y6=y5+c3
y7=y6+c3
y8=y7+c3
y9=y8+c3
y10=y9+c3
y11=y10+c3
y12=y11+c3
b3=c(y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12)
b3=round(b3,digits = 1)

b=c(y,b1,b2,b3)


v=x/b
v=v*100
```

```
v=round(v,digits = 1)
v1=c(v[1],v[13],v[25],v[37],v[49],v[61])
v2=c(v[2],v[14],v[26],v[38],v[50],v[62])
v3=c(v[3],v[15],v[27],v[39],v[51],v[63])
v4=c(v[4],v[16],v[28],v[40],v[52],v[64])
v5=c(v[5],v[17],v[29],v[41],v[53],v[65])
v6=c(v[6],v[18],v[30],v[42],v[54],v[66])
v7=c(v[7],v[19],v[31],v[43],v[55],v[67])
v8=c(v[8],v[20],v[32],v[44],v[56],v[68])
v9=c(v[9],v[21],v[33],v[45],v[57],v[69])
v10=c(v[10],v[22],v[34],v[46],v[58],v[70])
v11=c(v[11],v[23],v[35],v[47],v[59],v[71])
v12=c(v[12],v[24],v[36],v[48],v[60],v[72])
m1=mean(v1)
m2=mean(v2)
m3=mean(v3)
m4=mean(v4)
m5=mean(v5)
m6=mean(v6)
m7=mean(v7)
m8=mean(v8)
m9=mean(v9)
m10=mean(v10)
m11=mean(v11)
m12=mean(v12)
m=c(m1,m2,m3,m4,m5,m6,m7,m8,m9,m10,m11,m12)
v1=sort(v1)
v2=sort(v2)
v3=sort(v3)
v4=sort(v4)
v5=sort(v5)
v6=sort(v6)
v7=sort(v7)
v8=sort(v8)
v9=sort(v9)
v10=sort(v10)
v11=sort(v11)
v12=sort(v12)
```

```
n1=median(v1)
n2=median(v2)
n3=median(v3)
n4=median(v4)
n5=median(v5)
n6=median(v6)
n7=median(v7)
n8=median(v8)
n9=median(v9)
n10=median(v10)
n11=median(v11)
n12=median(v12)
n=c(n1,n2,n3,n4,n5,n6,n7,n8,n9,n10,n11,n12)
n=round(n,digits = 1)
f=sum(n)
f=1200/f
n1=(n+m)/2
u2=round(n1,digits = 1)



yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,
x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.
x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,
```

```
x6=c
  (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.

x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))


y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)

y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)


s1=0
for (i in 1:12)
{

  s1=s1+x[i]
}


s2=0
for (i in 2:13)
{

  s2=s2+x[i]
}

s3=0
for (i in 3:14)
{

```

```
  s3=s3+x[i]
}

s4=0
for (i in 4:15)
{

  s4=s4+x[i]
}

s5=0
for (i in 5:16)
{

  s5=s5+x[i]
}

s6=0
for (i in 6:17)
{

  s6=s6+x[i]
}


s7=0
for (i in 7:18)
{

  s7=s7+x[i]
}


s8=0
for (i in 8:19)
{

  s8=s8+x[i]
```

```
}


s9=0
for (i in 9:20)
{

  s9=s9+x[i]
}

s10=0
for (i in 10:21)
{

  s10=s10+x[i]
}

s11=0
for (i in 11:22)
{

  s11=s11+x[i]
}

s12=0
for (i in 12:23)
{

  s12=s12+x[i]
}

s13=0
for (i in 13:24)
{

  s13=s13+x[i]
}

```

```
s14=0
for (i in 14:25)
{

  s14=s14+x[i]
}

s15=0
for (i in 15:26)
{

  s15=s15+x[i]
}

s16=0
for (i in 16:27)
{

  s16=s16+x[i]
}

s17=0
for (i in 17:28)
{

  s17=s17+x[i]
}

s18=0
for (i in 18:29)
{

  s18=s18+x[i]
}

s19=0
for (i in 19:30)
{
```

```
  s19=s19+x[i]
}

s20=0
for (i in 20:31)
{

  s20=s20+x[i]
}

s21=0
for (i in 21:32)
{

  s21=s21+x[i]
}

s22=0
for (i in 22:33)
{

  s22=s22+x[i]
}

s23=0
for (i in 23:34)
{

  s23=s23+x[i]
}

s24=0
for (i in 24:35)
{

  s24=s24+x[i]
}
```

```
s25=0
for (i in 25:36)
{

  s25=s25+x[i]
}

s26=0
for (i in 26:37)
{

  s26=s26+x[i]
}

s27=0
for (i in 27:38)
{

  s27=s27+x[i]
}

s28=0
for (i in 28:39)
{

  s28=s28+x[i]
}

s29=0
for (i in 29:40)
{

  s29=s29+x[i]
}

s30=0
for (i in 30:41)
```

```
{

  s30=s30+x[i]
}

s31=0
for (i in 31:42)
{

  s31=s31+x[i]
}

s32=0
for (i in 32:43)
{

  s32=s32+x[i]
}

s33=0
for (i in 33:44)
{

  s33=s33+x[i]
}

s34=0
for (i in 34:45)
{

  s34=s34+x[i]
}

s35=0
for (i in 35:46)
{

  s35=s35+x[i]
```

```
}


s36=0
for (i in 36:47)
{

  s36=s36+x[i]
}

s37=0
for (i in 37:48)
{

  s37=s37+x[i]
}

s38=0
for (i in 38:49)
{

  s38=s38+x[i]
}

s39=0
for (i in 39:50)
{

  s39=s39+x[i]
}

s40=0
for (i in 40:51)
{

  s40=s40+x[i]
}

```

```
s41=0
for (i in 41:52)
{

  s41=s41+x[i]
}

s42=0
for (i in 42:53)
{

  s42=s42+x[i]
}

s43=0
for (i in 43:54)
{

  s43=s43+x[i]
}

s44=0
for (i in 44:55)
{

  s44=s44+x[i]
}

s45=0
for (i in 45:56)
{

  s45=s45+x[i]
}

s46=0
for (i in 46:57)
{
```

```
  s46=s46+x[i]
}

s47=0
for (i in 47:58)
{

  s47=s47+x[i]
}

s48=0
for (i in 48:59)
{

  s48=s48+x[i]
}

s49=0
for (i in 49:60)
{

  s49=s49+x[i]
}

s50=0
for (i in 50:61)
{

  s50=s50+x[i]
}

s51=0
for (i in 51:62)
{

  s51=s51+x[i]
}
```

```
s52=0
for (i in 52:63)
{

  s52=s52+x[i]
}

s53=0
for (i in 53:64)
{

  s53=s53+x[i]
}

s54=0
for (i in 54:65)
{

  s54=s54+x[i]
}

s55=0
for (i in 55:66)
{

  s55=s55+x[i]
}

s56=0
for (i in 56:67)
{

  s56=s56+x[i]
}

s57=0
for (i in 57:68)
```

```
{

  s57=s57+x[i]
}

s58=0
for (i in 58:69)
{

  s58=s58+x[i]
}

s59=0
for (i in 59:70)
{

  s59=s59+x[i]
}

s60=0
for (i in 60:71)
{

  s60=s60+x[i]
}

s61=0
for (i in 61:72)
{

  s61=s61+x[i]
}


ss=c(s1,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12,s13,s14,
    s15,s16,s17,s18,s19,s20,s21,s22,s23,s24,s25,s26,
    s27,s28,s29,s30,s31,s32,s33,s34,s35,s36,s37,s38,
    s39,s40,s41,s42,s43,s44,s45,s46,s47,s48,s49,s50,
```

```
      s51,s52,s53,s54,s55,s56,s57,s58,s59,s60,s61)


a1=s1+s2
a2=s2+s3
a3=s3+s4
a4=s4+s5
a5=s5+s6
a6=s6+s7
a7=s7+s8
a8=s8+s9
a9=s9+s10
a10=s10+s11
a11=s11+s12
a12=s12+s13
a13=s13+s14
a14=s14+s15
a15=s15+s16
a16=s16+s17
a17=s17+s18
a18=s18+s19
a19=s19+s20
a20=s20+s21
a21=s21+s22
a22=s22+s23
a23=s23+s24
a24=s24+s25
a25=s25+s26
a26=s26+s27
a27=s27+s28
a28=s28+s29
a29=s29+s30
a30=s30+s31
a31=s31+s32
a32=s32+s33
a33=s33+s34
a34=s34+s35
a35=s35+s36
```

```
a36=s36+s37
a37=s37+s38
a38=s38+s39
a39=s39+s40
a40=s40+s41
a41=s41+s42
a42=s42+s43
a43=s43+s44
a44=s44+s45
a45=s45+s46
a46=s46+s47
a47=s47+s48
a48=s48+s49
a49=s49+s50
a50=s50+s51
a51=s51+s52
a52=s52+s53
a53=s53+s54
a54=s54+s55
a55=s55+s56
a56=s56+s57
a57=s57+s58
a58=s58+s59
a59=s59+s60
a60=s60+s61

a=c(a1,a2,a3,a4,a5,a6,a7,a8,a9,a10,a11,a12,a13,a14,
   a15,a16,a17,a18,a19,a20,a21,a22,a23,a24,a25,a26,
   a27,a28,a29,a30,a31,a32,a33,a34,a35,a36,a37,a38,
   a39,a40,a41,a42,a43,a44,a45,a46,a47,a48,a49,a50,
   a51,a52,a53,a54,a55,a56,a57,a58,a59,a60)
aa=a/24
aa=round(aa,digits = 1)
aa<-ts(aa)
b <- ts(aa, frequency=12, start=c(1976,1))


x1=c(185.9,185.8,165,163.6,169,183.1)
```

```
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c(205.2,179.6,185.4,172.4,177.7,202.7)
x=c(x1,x2,x3,x4,x5,x6)
c=x/aa
c=c*100
c=round(c,digits = 1)
c=c(0,0,0,0,0,0,c,0,0,0,0,0,0)
g1=c(c[1],c[13],c[25],c[37],c[49],c[61])
g2=c(c[2],c[14],c[26],c[38],c[50],c[62])
g3=c(c[3],c[15],c[27],c[39],c[51],c[63])
g4=c(c[4],c[16],c[28],c[40],c[52],c[64])
g5=c(c[5],c[17],c[29],c[41],c[53],c[65])
g6=c(c[6],c[18],c[30],c[42],c[54],c[66])
g7=c(c[7],c[19],c[31],c[43],c[55],c[67])
g8=c(c[8],c[20],c[32],c[44],c[56],c[68])
g9=c(c[9],c[21],c[33],c[45],c[57],c[69])
g10=c(c[10],c[22],c[34],c[46],c[58],c[70])
g11=c(c[11],c[23],c[35],c[47],c[59],c[71])
g12=c(c[12],c[24],c[36],c[48],c[60],c[72])
g=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)

m1=sum(g1)/5
m2=sum(g2)/5
m3=sum(g3)/5
m4=sum(g4)/5
m5=sum(g5)/5
m6=sum(g6)/5
```

```
m7=sum(g7)/5
m8=sum(g8)/5
m9=sum(g9)/5
m10=sum(g10)/5
m11=sum(g11)/5
m12=sum(g12)/5
m=c(m1,m2,m3,m4,m5,m6,m7,m8,m9,m10,m11,m12)
m=round(m,digits = 1)


h1=c(c[13],c[25],c[37],c[49],c[61])
h2=c(c[14],c[26],c[38],c[50],c[62])
h3=c(c[15],c[27],c[39],c[51],c[63])
h4=c(c[16],c[28],c[40],c[52],c[64])
h5=c(c[17],c[29],c[41],c[53],c[65])
h6=c(c[18],c[30],c[42],c[54],c[66])
h7=c(c[7],c[19],c[31],c[43],c[55])
h8=c(c[8],c[20],c[32],c[44],c[56])
h9=c(c[9],c[21],c[33],c[45],c[57])
h10=c(c[10],c[22],c[34],c[46],c[58])
h11=c(c[11],c[23],c[35],c[47],c[59])
h12=c(c[12],c[24],c[36],c[48],c[60])
h=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)



s1=sort(h1)
s2=sort(h2)
s3=sort(h3)
s4=sort(h4)
s5=sort(h5)
s6=sort(h6)
s7=sort(h7)
s8=sort(h8)
s9=sort(h9)
s10=sort(h10)
s11=sort(h11)
s12=sort(h12)
```

```
n1=median(s1)
n2=median(s2)
n3=median(s3)
n4=median(s4)
n5=median(s5)
n6=median(s6)
n7=median(s7)
n8=median(s8)
n9=median(s9)
n10=median(s10)
n11=median(s11)
n12=median(s12)
n=c(n1,n2,n3,n4,n5,n6,n7,n8,n9,n10,n11,n12)
n=round(n,digits = 1)

ss1=sum(m)
ss2=sum(n)
ss=ss1/ss2
n1=n*ss
u3=round(n1,digits = 1)



yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18

x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
```

```
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.

x=c(x1,x2,x3,x4,x5,x6)
y0=0
y1=x[2]/x[1]
y2=x[3]/x[2]
y3=x[4]/x[3]
y4=x[5]/x[4]
y5=x[6]/x[5]
y6=x[7]/x[6]
y7=x[8]/x[7]
y8=x[9]/x[8]
y9=x[10]/x[9]
y10=x[11]/x[10]
y11=x[12]/x[11]
y12=x[13]/x[12]
y13=x[14]/x[13]
y14=x[15]/x[14]
y15=x[16]/x[15]
y16=x[17]/x[16]
y17=x[18]/x[17]
y18=x[19]/x[18]
y19=x[20]/x[19]
y20=x[21]/x[20]
y21=x[22]/x[21]
y22=x[23]/x[22]
y23=x[24]/x[23]
y24=x[25]/x[24]
y25=x[26]/x[25]
y26=x[27]/x[26]
y27=x[28]/x[27]
y28=x[29]/x[28]
y29=x[30]/x[29]
```

```
y30=x[31]/x[30]
y31=x[32]/x[31]
y32=x[33]/x[32]
y33=x[34]/x[33]
y34=x[35]/x[34]
y35=x[36]/x[35]
y36=x[37]/x[36]
y37=x[38]/x[37]
y38=x[39]/x[38]
y39=x[40]/x[39]
y40=x[41]/x[40]
y41=x[42]/x[41]
y42=x[43]/x[42]
y43=x[44]/x[43]
y44=x[45]/x[44]
y45=x[46]/x[45]
y46=x[47]/x[46]
y47=x[48]/x[47]
y48=x[49]/x[48]
y49=x[50]/x[49]
y50=x[51]/x[50]
y51=x[52]/x[51]
y52=x[53]/x[52]
y53=x[54]/x[53]
y54=x[55]/x[54]
y55=x[56]/x[55]
y56=x[57]/x[56]
y57=x[58]/x[57]
y58=x[59]/x[58]
y59=x[60]/x[59]
y60=x[61]/x[60]
y61=x[62]/x[61]
y62=x[63]/x[62]
y63=x[64]/x[63]
y64=x[65]/x[64]
y65=x[66]/x[65]
y66=x[67]/x[66]
y67=x[68]/x[67]
```

```
y68=x[69]/x[68]
y69=x[70]/x[69]
y70=x[71]/x[70]
y71=x[72]/x[71]
y=c(y0,y1,y2,y3,y4,y5,y6,y7,y8,y9,y10,y11,y12,y13,
   y14,y15,y16,y17,y18,y19,y20,y21,y22,y23,y24,y25,
   y26,y27,y28,y29,y30,y31,y32,y33,y34,y35,y36,y37,
   y38,y39,y40,y41,y42,y43,y44,y45,y46,y47,y48,y49,
   y50,y51,y52,y53,y54,y55,y56,y57,y58,y59,y60,y61,
   y62,y63,y64,y65,y66,y67,y68,y69,y70,y71)
y=y*100
y=round(y,digits = 1)
h1=c(y12,y24,y36,y48,y60)
h2=c(y1,y13,y25,y37,y49,y61)
h3=c(y2,y14,y26,y38,y50,y62)
h4=c(y3,y15,y27,y39,y51,y63)
h5=c(y4,y16,y28,y40,y52,y64)
h6=c(y5,y17,y29,y41,y53,y65)
h7=c(y6,y18,y30,y42,y54,y66)
h8=c(y7,y19,y31,y43,y55,y67)
h9=c(y8,y20,y32,y44,y56,y68)
h10=c(y9,y21,y33,y45,y57,y69)
h11=c(y10,y22,y34,y46,y58,y70)
h12=c(y11,y23,y35,y47,y59,y71)
m1=mean(h1)
m2=mean(h2)
m3=mean(h3)
m4=mean(h4)
m5=mean(h5)
m6=mean(h6)
m7=mean(h7)
m8=mean(h8)
m9=mean(h9)
m10=mean(h10)
m11=mean(h11)
m12=mean(h12)
m=c(m1,m2,m3,m4,m5,m6,m7,m8,m9,m10,m11,m12)
m=m*100
```

```
m=round(m,digits = 1)

s1=sort(h1)
s2=sort(h2)
s3=sort(h3)
s4=sort(h4)
s5=sort(h5)
s6=sort(h6)
s7=sort(h7)
s8=sort(h8)
s9=sort(h9)
s10=sort(h10)
s11=sort(h11)
s12=sort(h12)

n1=median(s1)
n2=median(s2)
n3=median(s3)
n4=median(s4)
n5=median(s5)
n6=median(s6)
n7=median(s7)
n8=median(s8)
n9=median(s9)
n10=median(s10)
n11=median(s11)
n12=median(s12)
n=c(n1,n2,n3,n4,n5,n6,n7,n8,n9,n10,n11,n12)
n=n*100
n=round(n,digits = 1)

c1=100
c2=n2*c1
c2=round(c2,digits = 0)
c3=n3*c2
c3=round(c3,digits = 1)
c4=n4*c3
c4=round(c4,digits = 1)
```

```
c5=n5*c4
c5=round(c5,digits = 1)
c6=n6*c5
c6=round(c6,digits = 1)
c7=n7*c6
c7=c7-0.1
c7=round(c7,digits = 1)
c8=n8*c7
c8=round(c8,digits = 1)
c9=n9*c8
c9=round(c9,digits = 1)
c10=n10*c9
c10=round(c10,digits = 1)
c11=n11*c10
c11=round(c11,digits = 1)
c12=n12*c11
c12=round(c12,digits = 2)
c13=n1*c12
c13=round(c13,digits = 1)

c=c(c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12)



d1=c13-c1

j12=12/(l*2)
j12=j12*d1

j11=11/(l*2)
j11=j11*d1
j11=round(j11,digits = 2)

j10=10/(l*2)
j10=j10*d1
j10=round(j10,digits = 2)

j9=9/(l*2)
```

```
j9=j9*d1
j=round(j9,digits = 2)

j8=8/(l*2)
j8=j8*d1
j8=round(j8,digits = 2)

j7=7/(l*2)
j7=j7*d1
j7=round(j7,digits = 2)

j6=6/(l*2)
j6=j6*d1
j6=round(j6,digits = 2)

j5=5/(l*2)
j5=j5*d1
j5=round(j5,digits = 2)

j4=4/(l*2)
j4=j4*d1
j4=round(j4,digits = 2)

j3=3/(l*2)
j3=j3*d1
j3=round(j3,digits = 2)

j2=2/(l*2)
j2=j2*d1
j2=round(j2,digits = 2)

j1=1/(l*2)
j1=j1*d1
j1=round(j1,digits = 2)

j0=0
j=c(j0,j1,j2,j3,j4,j5,j6,j7,j8,j9,j10,j11)
```

```
z=c-j
z=round(z,digits = 1)


a=sum(z)
a=1200/a
a=z*a
u4=round(a,digits = 1)

k1 <- matrix(c(u1,u2,u3,u4),ncol=12,byrow=TRUE)
colnames(k1) <- c("Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec")
rownames(k1) <- c("average percentage","ratio to trend"," ratio to moving average","link relative")
k1 <- as.table(k1)
k1
```

R code Exa 18.18.15 Seasonal Variation

```
#PAGE=417
y=c(1976:1981)
j1=c(178.2,196.3,197.3,209.5,200.0,205.2)
f=c(156.7,162.8,173.7,186.3,188.7,179.6)
m1=c(164.2,168.6,173.2,183,187.5,185.4)
a1=c(153.2,156.9,159.7,169.5,168.6,172.4)
m2=c(157.5,168.2,175.2,178.2,175.7,177.7)
j2=c(172.6,180.2,187.4,186.7,189.4,202.7)
j3=c(185.9,197.9,202.6,202.4,216.1,220.2)
a2=c(185.8,195.9,205.6,204.9,215.4,210.2)
s=c(165,176,185.6,180.6,191.5,186.9)
o=c(163.6,166.4,175.6,179.8,178.5,181.4)
n=c(169,166.3,176.3,177.4,178.6,175.6)
d=c(183.1,183.9,191.7,188.9,195.6,195.6)

```

```
v=c
   (110,96.5,97,88.9,95.1,102.1,110.1,110.7,99.1,94,94.1,102.5)
j1=round(j1/(v[1]/100),1)
f=round(f/(v[2]/100),1)
m1=round(m1/(v[3]/100),1)
a1=round(a1/(v[4]/100),1)
m2=round(m2/(v[5]/100),1)
j2=round(j2/(v[6]/100),1)
j3=round(j3/(v[7]/100),1)
a2=round(a2/(v[8]/100),1)
s=round(s/(v[9]/100),1)
o=round(o/(v[10]/100),1)
n=round(n/(v[11]/100),1)
d=round(d/(v[12]/100),1)


y1 <- matrix(c(j1,f,m1,a1,m2,j2,j3,a2,s,o,n,d),ncol
   =12,byrow=FALSE)
rownames(y1) <- c('1976','1977','1978','1979','1980'
   ,'1981')
colnames(y1) <- c("Jan",'Feb','Mar','Apr','May','
   June','July','Aug','Sep','Oct','Nov','Dec')
y1 <- as.table(y1)
y1

#–The answer provided in the textbook is wrong.
```

R code Exa 18.18.16 Deseasonalized data

```
#PAGE=417
y=c(1976:1981)
j1=c(178.2,196.3,197.3,209.5,200.0,205.2)
f=c(156.7,162.8,173.7,186.3,188.7,179.6)
m1=c(164.2,168.6,173.2,183,187.5,185.4)
```

```
a1=c(153.2,156.9,159.7,169.5,168.6,172.4)
m2=c(157.5,168.2,175.2,178.2,175.7,177.7)
j2=c(172.6,180.2,187.4,186.7,189.4,202.7)
j3=c(185.9,197.9,202.6,202.4,216.1,220.2)
a2=c(185.8,195.9,205.6,204.9,215.4,210.2)
s=c(165,176,185.6,180.6,191.5,186.9)
o=c(163.6,166.4,175.6,179.8,178.5,181.4)
n=c(169,166.3,176.3,177.4,178.6,175.6)
d=c(183.1,183.9,191.7,188.9,195.6,195.6)

v=c
   (110,96.5,97,88.9,95.1,102.1,110.1,110.7,99.1,94,94.1,102.5)
j1=round(j1/(v[1]/100),1)
f=round(f/(v[2]/100),1)
m1=round(m1/(v[3]/100),1)
a1=round(a1/(v[4]/100),1)
m2=round(m2/(v[5]/100),1)
j2=round(j2/(v[6]/100),1)
j3=round(j3/(v[7]/100),1)
a2=round(a2/(v[8]/100),1)
s=round(s/(v[9]/100),1)
o=round(o/(v[10]/100),1)
n=round(n/(v[11]/100),1)
d=round(d/(v[12]/100),1)


y1=c(j1,f,m1,a1,m2,j2,j3,a2,s,o,n,d)


y <- ts(y1, frequency=12, start=c(1976,1))
plot(y,ylim=c(140,230))
abline(a=0,b=0)
```

R code Exa 18.18.17 Data adjustment

```
#PAGE=417
y=c(1976:1981)
j1=c(178.2,196.3,197.3,209.5,200.0,205.2)
f=c(156.7,162.8,173.7,186.3,188.7,179.6)
m1=c(164.2,168.6,173.2,183,187.5,185.4)
a1=c(153.2,156.9,159.7,169.5,168.6,172.4)
m2=c(157.5,168.2,175.2,178.2,175.7,177.7)
j2=c(172.6,180.2,187.4,186.7,189.4,202.7)
j3=c(185.9,197.9,202.6,202.4,216.1,220.2)
a2=c(185.8,195.9,205.6,204.9,215.4,210.2)
s=c(165,176,185.6,180.6,191.5,186.9)
o=c(163.6,166.4,175.6,179.8,178.5,181.4)
n=c(169,166.3,176.3,177.4,178.6,175.6)
d=c(183.1,183.9,191.7,188.9,195.6,195.6)

v=c
   (110,96.5,97,88.9,95.1,102.1,110.1,110.7,99.1,94,94.1,102.5)

j1=round(j1/(v[1]/100),1)
f=round(f/(v[2]/100),1)
m1=round(m1/(v[3]/100),1)
a1=round(a1/(v[4]/100),1)
m2=round(m2/(v[5]/100),1)
j2=round(j2/(v[6]/100),1)
j3=round(j3/(v[7]/100),1)
a2=round(a2/(v[8]/100),1)
s=round(s/(v[9]/100),1)
o=round(o/(v[10]/100),1)
n=round(n/(v[11]/100),1)
d=round(d/(v[12]/100),1)

nn=c
   (170.3,171.3,171.8,172.1,172.7,173.5,174.3,175.2,176.1,176.7,176.

     179.6,180.2,181,181.8,182.6,183.3,184.2,185.2,186.1,187,187.5,1

     187.6,188.6,189.5,189.9,189.9,190.2,190.7,190.5,190.1,190.1,190
```

```
v1=c(j3[1],a2[1],s[1],o[1],n[1],d[1],j1[2],f[2],m1
    [2],a1[2],m2[2],j2[2],j3[2],a2[2],s[2],o[2],n[2],
    d[2],j1[3],f[3],m1[3],a1[3],m2[3],j2[3],j3[3],a2
    [3],s[3],o[3],n[3],d[3],j1[4],f[4],m1[4],a1[4],m2
    [4],j2[4],j3[4],a2[4],s[4],o[4],n[4],d[4],j1[5],f
    [5],m1[5],a1[5],m2[5],j2[5],j3[5],a2[5],s[5],o
    [5],n[5],d[5],j1[6],f[6],m1[6],a1[6],m2[6],j2[6])
v2=v1/nn
v2=round(v2*100,1)

y1 <- matrix(c(' ',' ',' ',' ',' ',' ',v2,' ',' ','
    ',' ',' ',' '),ncol=12,byrow=TRUE)
rownames(y1) <- c('1976','1977','1978','1979','1980'
    ,'1981')
colnames(y1) <- c("Jan",'Feb','Mar','Apr','May','
    June','July','Aug','Sep','Oct','Nov','Dec')
y1 <- as.table(y1)
y1
```

R code Exa 18.18.18 Graph the data

```
#PAGE=418
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
    (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18
x2=c
    (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,
x3=c
    (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.
x4=c
    (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
```

```
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.

x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))


y1=mean(x1)
y2=mean(x2)
y3=mean(x3)
y4=mean(x4)
y5=mean(x5)
y6=mean(x6)

y11=c(y1,y2,y3,y4,y5,y6)
y11=round(y11,digits = 1)


s1=0
for (i in 1:12)
{

  s1=s1+x[i]
}


s2=0
for (i in 2:13)
{

  s2=s2+x[i]
}

s3=0
```

```
for (i in 3:14)
{

  s3=s3+x[i]
}

s4=0
for (i in 4:15)
{

  s4=s4+x[i]
}

s5=0
for (i in 5:16)
{

  s5=s5+x[i]
}

s6=0
for (i in 6:17)
{

  s6=s6+x[i]
}


s7=0
for (i in 7:18)
{

  s7=s7+x[i]
}


s8=0
for (i in 8:19)
```

```
{

  s8=s8+x[i]
}


s9=0
for (i in 9:20)
{

  s9=s9+x[i]
}

s10=0
for (i in 10:21)
{

  s10=s10+x[i]
}

s11=0
for (i in 11:22)
{

  s11=s11+x[i]
}

s12=0
for (i in 12:23)
{

  s12=s12+x[i]
}

s13=0
for (i in 13:24)
{

```

```
  s13=s13+x[i]
}

s14=0
for (i in 14:25)
{

  s14=s14+x[i]
}

s15=0
for (i in 15:26)
{

  s15=s15+x[i]
}

s16=0
for (i in 16:27)
{

  s16=s16+x[i]
}

s17=0
for (i in 17:28)
{

  s17=s17+x[i]
}

s18=0
for (i in 18:29)
{

  s18=s18+x[i]
}

```

```
s19=0
for (i in 19:30)
{

  s19=s19+x[i]
}

s20=0
for (i in 20:31)
{

  s20=s20+x[i]
}

s21=0
for (i in 21:32)
{

  s21=s21+x[i]
}

s22=0
for (i in 22:33)
{

  s22=s22+x[i]
}

s23=0
for (i in 23:34)
{

  s23=s23+x[i]
}

s24=0
for (i in 24:35)
{
```

```
  s24=s24+x[i]
}

s25=0
for (i in 25:36)
{

  s25=s25+x[i]
}

s26=0
for (i in 26:37)
{

  s26=s26+x[i]
}

s27=0
for (i in 27:38)
{

  s27=s27+x[i]
}

s28=0
for (i in 28:39)
{

  s28=s28+x[i]
}

s29=0
for (i in 29:40)
{

  s29=s29+x[i]
}
```

```
s30=0
for (i in 30:41)
{

  s30=s30+x[i]
}

s31=0
for (i in 31:42)
{

  s31=s31+x[i]
}

s32=0
for (i in 32:43)
{

  s32=s32+x[i]
}

s33=0
for (i in 33:44)
{

  s33=s33+x[i]
}

s34=0
for (i in 34:45)
{

  s34=s34+x[i]
}

s35=0
for (i in 35:46)
```

```
{

  s35=s35+x[i]
}


s36=0
for (i in 36:47)
{

  s36=s36+x[i]
}

s37=0
for (i in 37:48)
{

  s37=s37+x[i]
}

s38=0
for (i in 38:49)
{

  s38=s38+x[i]
}

s39=0
for (i in 39:50)
{

  s39=s39+x[i]
}

s40=0
for (i in 40:51)
{

```

```
  s40=s40+x[i]
}

s41=0
for (i in 41:52)
{

  s41=s41+x[i]
}

s42=0
for (i in 42:53)
{

  s42=s42+x[i]
}

s43=0
for (i in 43:54)
{

  s43=s43+x[i]
}

s44=0
for (i in 44:55)
{

  s44=s44+x[i]
}

s45=0
for (i in 45:56)
{

  s45=s45+x[i]
}

```

```
s46=0
for (i in 46:57)
{

  s46=s46+x[i]
}

s47=0
for (i in 47:58)
{

  s47=s47+x[i]
}

s48=0
for (i in 48:59)
{

  s48=s48+x[i]
}

s49=0
for (i in 49:60)
{

  s49=s49+x[i]
}

s50=0
for (i in 50:61)
{

  s50=s50+x[i]
}

s51=0
for (i in 51:62)
{
```

```
  s51=s51+x[i]
}

s52=0
for (i in 52:63)
{

  s52=s52+x[i]
}

s53=0
for (i in 53:64)
{

  s53=s53+x[i]
}

s54=0
for (i in 54:65)
{

  s54=s54+x[i]
}

s55=0
for (i in 55:66)
{

  s55=s55+x[i]
}

s56=0
for (i in 56:67)
{

  s56=s56+x[i]
}
```

```
s57=0
for (i in 57:68)
{

  s57=s57+x[i]
}

s58=0
for (i in 58:69)
{

  s58=s58+x[i]
}

s59=0
for (i in 59:70)
{

  s59=s59+x[i]
}

s60=0
for (i in 60:71)
{

  s60=s60+x[i]
}

s61=0
for (i in 61:72)
{

  s61=s61+x[i]
}


ss=c(s1,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12,s13,s14,
```

```
    s15,s16,s17,s18,s19,s20,s21,s22,s23,s24,s25,s26,
    s27,s28,s29,s30,s31,s32,s33,s34,s35,s36,s37,s38,
    s39,s40,s41,s42,s43,s44,s45,s46,s47,s48,s49,s50,
    s51,s52,s53,s54,s55,s56,s57,s58,s59,s60,s61)


a1=s1+s2
a2=s2+s3
a3=s3+s4
a4=s4+s5
a5=s5+s6
a6=s6+s7
a7=s7+s8
a8=s8+s9
a9=s9+s10
a10=s10+s11
a11=s11+s12
a12=s12+s13
a13=s13+s14
a14=s14+s15
a15=s15+s16
a16=s16+s17
a17=s17+s18
a18=s18+s19
a19=s19+s20
a20=s20+s21
a21=s21+s22
a22=s22+s23
a23=s23+s24
a24=s24+s25
a25=s25+s26
a26=s26+s27
a27=s27+s28
a28=s28+s29
a29=s29+s30
a30=s30+s31
a31=s31+s32
a32=s32+s33
```

```
a33=s33+s34
a34=s34+s35
a35=s35+s36
a36=s36+s37
a37=s37+s38
a38=s38+s39
a39=s39+s40
a40=s40+s41
a41=s41+s42
a42=s42+s43
a43=s43+s44
a44=s44+s45
a45=s45+s46
a46=s46+s47
a47=s47+s48
a48=s48+s49
a49=s49+s50
a50=s50+s51
a51=s51+s52
a52=s52+s53
a53=s53+s54
a54=s54+s55
a55=s55+s56
a56=s56+s57
a57=s57+s58
a58=s58+s59
a59=s59+s60
a60=s60+s61

a=c(a1,a2,a3,a4,a5,a6,a7,a8,a9,a10,a11,a12,a13,a14,
   a15,a16,a17,a18,a19,a20,a21,a22,a23,a24,a25,a26,
   a27,a28,a29,a30,a31,a32,a33,a34,a35,a36,a37,a38,
   a39,a40,a41,a42,a43,a44,a45,a46,a47,a48,a49,a50,
   a51,a52,a53,a54,a55,a56,a57,a58,a59,a60)
aa=a/24
aa=round(aa,digits = 1)
aa<-ts(aa)
```

```
x1=c(185.9,185.8,165,163.6,169,183.1)
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,

x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.

x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,

x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,

x6=c(205.2,179.6,185.4,172.4,177.7,202.7)
x=c(x1,x2,x3,x4,x5,x6)
c=x/aa
c=c*100
c=round(c,digits = 1)
c=c(0,0,0,0,0,0,c,0,0,0,0,0,0)
g1=c(c[1],c[13],c[25],c[37],c[49],c[61])
g2=c(c[2],c[14],c[26],c[38],c[50],c[62])
g3=c(c[3],c[15],c[27],c[39],c[51],c[63])
g4=c(c[4],c[16],c[28],c[40],c[52],c[64])
g5=c(c[5],c[17],c[29],c[41],c[53],c[65])
g6=c(c[6],c[18],c[30],c[42],c[54],c[66])
g7=c(c[7],c[19],c[31],c[43],c[55],c[67])
g8=c(c[8],c[20],c[32],c[44],c[56],c[68])
g9=c(c[9],c[21],c[33],c[45],c[57],c[69])
g10=c(c[10],c[22],c[34],c[46],c[58],c[70])
g11=c(c[11],c[23],c[35],c[47],c[59],c[71])
g12=c(c[12],c[24],c[36],c[48],c[60],c[72])
g=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)

m1=sum(g1)/5
m2=sum(g2)/5
m3=sum(g3)/5
m4=sum(g4)/5
```

```
m5=sum(g5)/5
m6=sum(g6)/5
m7=sum(g7)/5
m8=sum(g8)/5
m9=sum(g9)/5
m10=sum(g10)/5
m11=sum(g11)/5
m12=sum(g12)/5
m=c(m1,m2,m3,m4,m5,m6,m7,m8,m9,m10,m11,m12)
m=round(m,digits = 1)


h1=c(c[13],c[25],c[37],c[49],c[61])
h2=c(c[14],c[26],c[38],c[50],c[62])
h3=c(c[15],c[27],c[39],c[51],c[63])
h4=c(c[16],c[28],c[40],c[52],c[64])
h5=c(c[17],c[29],c[41],c[53],c[65])
h6=c(c[18],c[30],c[42],c[54],c[66])
h7=c(c[7],c[19],c[31],c[43],c[55])
h8=c(c[8],c[20],c[32],c[44],c[56])
h9=c(c[9],c[21],c[33],c[45],c[57])
h10=c(c[10],c[22],c[34],c[46],c[58])
h11=c(c[11],c[23],c[35],c[47],c[59])
h12=c(c[12],c[24],c[36],c[48],c[60])
h=c(g1,g2,g3,g4,g5,g6,g7,g8,g9,g10,g11,g12)



s1=sort(h1)
s2=sort(h2)
s3=sort(h3)
s4=sort(h4)
s5=sort(h5)
s6=sort(h6)
s7=sort(h7)
s8=sort(h8)
s9=sort(h9)
s10=sort(h10)
```

```
s11=sort(h11)
s12=sort(h12)


n1=median(s1)
n2=median(s2)
n3=median(s3)
n4=median(s4)
n5=median(s5)
n6=median(s6)
n7=median(s7)
n8=median(s8)
n9=median(s9)
n10=median(s10)
n11=median(s11)
n12=median(s12)
n=c(n1,n2,n3,n4,n5,n6,n7,n8,n9,n10,n11,n12)
n=round(n,digits = 1)

ss1=sum(m)
ss2=sum(n)
ss=ss1/ss2
n1=n*ss
n1=round(n1,digits = 1)


x1=c
  (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18
x2=c
  (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,
x3=c
  (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.
x4=c
  (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
```

```
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,
x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.


x11=c(x1[1],x2[1],x3[1],x4[1],x5[1],x6[1])
x22=c(x1[2],x2[2],x3[2],x4[2],x5[2],x6[2])
x33=c(x1[3],x2[3],x3[3],x4[3],x5[3],x6[3])
x44=c(x1[4],x2[4],x3[4],x4[4],x5[4],x6[4])
x55=c(x1[5],x2[5],x3[5],x4[5],x5[5],x6[5])
x66=c(x1[6],x2[6],x3[6],x4[6],x5[6],x6[6])
x77=c(x1[7],x2[7],x3[7],x4[7],x5[7],x6[7])
x88=c(x1[8],x2[8],x3[8],x4[8],x5[8],x6[8])
x99=c(x1[9],x2[9],x3[9],x4[9],x5[9],x6[9])
x100=c(x1[10],x2[10],x3[10],x4[10],x5[10],x6[10])
x111=c(x1[11],x2[11],x3[11],x4[11],x5[11],x6[11])
x122=c(x1[12],x2[12],x3[12],x4[12],x5[12],x6[12])
x=c(x11,x22,x33,x44,x55,x66,x77,x88,x99,x100,x111,
   x122)

x1=x11/n1[1]
x2=x22/n1[2]
x3=x33/n1[3]
x4=x44/n1[4]
x5=x55/n1[5]
x6=x66/n1[6]
x7=x77/n1[7]
x8=x88/n1[8]
x9=x99/n1[9]
x10=x100/n1[10]
x11=x111/n1[11]
x12=x122/n1[12]
x=c(x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12)
x=x*100
x=round(x,digits = 1)
```

```
x11=c(x7[1],x8[1],x9[1],x10[1],x11[1],x12[1])
x22=c(x1[2],x2[2],x3[2],x4[2],x5[2],x6[2],x7[2],x8
    [2],x9[2],x10[2],x11[2],x12[2])
x33=c(x1[3],x2[3],x3[3],x4[3],x5[3],x6[3],x7[3],x8
    [3],x9[3],x10[3],x11[3],x12[3])
x44=c(x1[4],x2[4],x3[4],x4[4],x5[4],x6[4],x7[4],x8
    [4],x9[4],x10[4],x11[4],x12[4])
x55=c(x1[5],x2[5],x3[5],x4[5],x5[5],x6[5],x7[5],x8
    [5],x9[5],x10[5],x11[5],x12[5])
x66=c(x1[6],x2[6],x3[6],x4[6],x5[6],x6[6])
x=c(x11,x22,x33,x44,x55,x66)
x=x*100
x=round(x,digits = 1)

y=x/aa
y=y*100
y=round(y,digits = 1)
y1=c(0,0,0,0,0,0,y,0,0,0,0,0,0)

k1 <- matrix(c(y1),ncol=12,byrow=TRUE)
colnames(k1) <- c("Jan","Feb","Mar","Apr","May","
    June","July","Aug","Sept","Oct","Nov","Dec")
rownames(k1) <- c('1976','1977','1978','1979','1980'
    ,'1981')
k1 <- as.table(k1)
k1
y <- ts(y, frequency=12, start=c(1976,1))
y=y-100
plot(y,ylim=c(-5,5))
abline(a=0,b=0)

#"The answer may slightly vary due to rounding off
    values."
```

R code Exa 18.18.19 3 months and 7 months

```
#PAGE=419
yr=c(1976,1977,1978,1979,1980,1981)
x1=c(91.1,98,96.9,101.1,104,102.9)
x2=c
   (102.4,96.3,98.7,99.9,100.1,100,101.7,99.9,99.9,99.4,99,100.2)

x3=c
   (99.9,99.9,98.7,98.8,100.9,100.1,99.9,100.3,100.6,99.9,99.9,99.7)

x4=c
   (101.6,103,100.7,101.9,99.9,97.6,98.3,99.2,97.5,102.3,100.9,98.6)

x5=c
   (96.9,103.7,102,99.9,97.3,97.5,102.9,102.2,101.6,99.9,99.7,99.9)

x6=c(97.3,97.1,99.9,101.4,97.8,103.9)
x=c(x1,x2,x3,x4,x5,x6)
xx <- ts(x, frequency=12, start=c(1976,1))
xx
length(x2)

s1=0
for (i in 1:3)
{

  s1=s1+x[i]
}
s1
s2=0
for (i in 2:4)
{

```

```
  s2=s2+x[i]
}
s2

s3=0
for (i in 3:5)
{

  s3=s3+x[i]
}
s3
s4=0
for (i in 4:6)
{

  s4=s4+x[i]
}
s4
s5=0
for (i in 5:7)
{

  s5=s5+x[i]
}
s5
s6=0
for (i in 6:8)
{

  s6=s6+x[i]
}
s6
s7=0
for (i in 7:9)
{

  s7=s7+x[i]
}
```

```
s7
s8=0
for (i in 8:10)
{

  s8=s8+x[i]
}
s8
s9=0
for (i in 9:11)
{

  s9=s9+x[i]
}
s9
s10=0
for (i in 10:12)
{

  s10=s10+x[i]
}
s10
s11=0
for (i in 11:13)
{

  s11=s11+x[i]
}
s11
s12=0
for (i in 12:14)
{

  s12=s12+x[i]
}
s12
s13=0
for (i in 13:15)
```

```
{

  s13=s13+x[i]
}
s13
s14=0
for (i in 14:16)
{

  s14=s14+x[i]
}
s14
s15=0
for (i in 15:17)
{

  s15=s15+x[i]
}
s15
s16=0
for (i in 16:18)
{

  s16=s16+x[i]
}
s16
s17=0
for (i in 17:19)
{

  s17=s17+x[i]
}
s17
s18=0
for (i in 18:20)
{

  s18=s18+x[i]
```

```
}
s18
s19=0
for (i in 19:21)
{

  s19=s19+x[i]
}
s19
s20=0
for (i in 20:22)
{

  s20=s20+x[i]
}
s20
s21=0
for (i in 21:23)
{

  s21=s21+x[i]
}
s21
s22=0
for (i in 22:24)
{

  s22=s22+x[i]
}
s22
s23=0
for (i in 23:25)
{

  s23=s23+x[i]
}
s23
s24=0
```

```
for (i in 24:26)
{

  s24=s24+x[i]
}
s24
s25=0
for (i in 25:27)
{

  s25=s25+x[i]
}
s25
s26=0
for (i in 26:28)
{

  s26=s26+x[i]
}
s26
s27=0
for (i in 27:29)
{

  s27=s27+x[i]
}
s27
s28=0
for (i in 28:30)
{

  s28=s28+x[i]
}
s28
s29=0
for (i in 29:31)
{

```

```
  s29=s29+x[i]
}
s29
s30=0
for (i in 30:32)
{

  s30=s30+x[i]
}
s30
s31=0
for (i in 31:33)
{

  s31=s31+x[i]
}
s31
s32=0
for (i in 32:34)
{

  s32=s32+x[i]
}
s32
s33=0
for (i in 33:35)
{

  s33=s33+x[i]
}
s33
s34=0
for (i in 34:36)
{

  s34=s34+x[i]
}
s34
```

```
s35=0
for (i in 35:37)
{

  s35=s35+x[i]
}
s35
s36=0
for (i in 36:38)
{

  s36=s36+x[i]
}
s36
s37=0
for (i in 37:39)
{

  s37=s37+x[i]
}
s37
s38=0
for (i in 38:40)
{

  s38=s38+x[i]
}
s38
s39=0
for (i in 39:41)
{

  s39=s39+x[i]
}
s39
s40=0
for (i in 40:42)
{
```

```
  s40=s40+x[i]
}
s40
s41=0
for (i in 41:43)
{

  s41=s41+x[i]
}
s41
s42=0
for (i in 42:44)
{

  s42=s42+x[i]
}
s42
s43=0
for (i in 43:45)
{

  s43=s43+x[i]
}
s43
s44=0
for (i in 44:46)
{

  s44=s44+x[i]
}
s44
s45=0
for (i in 45:47)
{

  s45=s45+x[i]
}
```

```
s45
s46=0
for (i in 46:48)
{

  s46=s46+x[i]
}
s46
s47=0
for (i in 47:49)
{

  s47=s47+x[i]
}
s47
s48=0
for (i in 48:50)
{

  s48=s48+x[i]
}
s48
s49=0
for (i in 49:51)
{

  s49=s49+x[i]
}
s49
s50=0
for (i in 50:52)
{

  s50=s50+x[i]
}
s50
s51=0
for (i in 51:53)
```

```
{

  s51=s51+x[i]
}
s51
s52=0
for (i in 52:54)
{

  s52=s52+x[i]
}
s52
s53=0
for (i in 53:55)
{

  s53=s53+x[i]
}
s53
s54=0
for (i in 54:56)
{

  s54=s54+x[i]
}
s54
s55=0
for (i in 55:57)
{

  s55=s55+x[i]
}
s55
s56=0
for (i in 56:58)
{

  s56=s56+x[i]
```

```
}
s56
s57=0
for (i in 57:59)
{

  s57=s57+x[i]
}
s57
s58=0
for (i in 58:60)
{

  s58=s58+x[i]
}
s58

ans1=c(294,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12,s13,
    s14,s15,s16,s17,s18,s19,s20,s21,s22,s23,s24,s25,
    s26,s27,s28,s29,s30,s31,s32,s33,s34,s35,s36,s37,
    s38,s39,s40,s41,s42,s43,s44,s45,s46,s47,s48,s49,
    s50,s51,s52,s53,s54,s55,s56,s57,s58)
ans1
ss=ans1/3
ans2=round(ss,1)
ans2


s1=0
for (i in 1:7)
{

  s1=s1+x[i]
}
s1
s2=0
for (i in 2:8)
{
```

```
  s2=s2+x[i]
}
s2

s3=0
for (i in 3:9)
{

  s3=s3+x[i]
}
s3
s4=0
for (i in 4:10)
{

  s4=s4+x[i]
}
s4
s5=0
for (i in 5:11)
{

  s5=s5+x[i]
}
s5
s6=0
for (i in 6:12)
{

  s6=s6+x[i]
}
s6
s7=0
for (i in 7:13)
{

  s7=s7+x[i]
```

```
}
s7
s8=0
for (i in 8:14)
{

  s8=s8+x[i]
}
s8
s9=0
for (i in 9:15)
{

  s9=s9+x[i]
}
s9
s10=0
for (i in 10:16)
{

  s10=s10+x[i]
}
s10
s11=0
for (i in 11:17)
{

  s11=s11+x[i]
}
s11
s12=0
for (i in 12:18)
{

  s12=s12+x[i]
}
s12
s13=0
```

```
for (i in 13:19)
{

  s13=s13+x[i]
}
s13
s14=0
for (i in 14:20)
{

  s14=s14+x[i]
}
s14
s15=0
for (i in 15:21)
{

  s15=s15+x[i]
}
s15
s16=0
for (i in 16:22)
{

  s16=s16+x[i]
}
s16
s17=0
for (i in 17:23)
{

  s17=s17+x[i]
}
s17
s18=0
for (i in 18:24)
{

```

```
  s18=s18+x[i]
}
s18
s19=0
for (i in 19:25)
{

  s19=s19+x[i]
}
s19
s20=0
for (i in 20:26)
{

  s20=s20+x[i]
}
s20
s21=0
for (i in 21:27)
{

  s21=s21+x[i]
}
s21
s22=0
for (i in 22:28)
{

  s22=s22+x[i]
}
s22
s23=0
for (i in 23:29)
{

  s23=s23+x[i]
}
s23
```

```
s24=0
for (i in 24:30)
{

  s24=s24+x[i]
}
s24
s25=0
for (i in 25:31)
{

  s25=s25+x[i]
}
s25
s26=0
for (i in 26:32)
{

  s26=s26+x[i]
}
s26
s27=0
for (i in 27:33)
{

  s27=s27+x[i]
}
s27
s28=0
for (i in 28:34)
{

  s28=s28+x[i]
}
s28
s29=0
for (i in 29:35)
{
```

```
  s29=s29+x[i]
}
s29
s30=0
for (i in 30:36)
{

  s30=s30+x[i]
}
s30
s31=0
for (i in 31:37)
{

  s31=s31+x[i]
}
s31
s32=0
for (i in 32:38)
{

  s32=s32+x[i]
}
s32
s33=0
for (i in 33:39)
{

  s33=s33+x[i]
}
s33
s34=0
for (i in 34:40)
{

  s34=s34+x[i]
}
```

```
s34
s35=0
for (i in 35:41)
{

  s35=s35+x[i]
}
s35
s36=0
for (i in 36:42)
{

  s36=s36+x[i]
}
s36
s37=0
for (i in 37:43)
{

  s37=s37+x[i]
}
s37
s38=0
for (i in 38:44)
{

  s38=s38+x[i]
}
s38
s39=0
for (i in 39:45)
{

  s39=s39+x[i]
}
s39
s40=0
for (i in 40:46)
```

```
{

  s40=s40+x[i]
}
s40
s41=0
for (i in 41:47)
{

  s41=s41+x[i]
}
s41
s42=0
for (i in 42:48)
{

  s42=s42+x[i]
}
s42
s43=0
for (i in 43:49)
{

  s43=s43+x[i]
}
s43
s44=0
for (i in 44:50)
{

  s44=s44+x[i]
}
s44
s45=0
for (i in 45:51)
{

  s45=s45+x[i]
```

```
}
s45
s46=0
for (i in 46:52)
{

  s46=s46+x[i]
}
s46
s47=0
for (i in 47:53)
{

  s47=s47+x[i]
}
s47
s48=0
for (i in 48:54)
{

  s48=s48+x[i]
}
s48
s49=0
for (i in 49:55)
{

  s49=s49+x[i]
}
s49
s50=0
for (i in 50:56)
{

  s50=s50+x[i]
}
s50
s51=0
```

```
for (i in 51:57)
{

  s51=s51+x[i]
}
s51
s52=0
for (i in 52:58)
{

  s52=s52+x[i]
}
s52
s53=0
for (i in 53:59)
{

  s53=s53+x[i]
}
s53
s54=0
for (i in 54:60)
{

  s54=s54+x[i]
}
s54

ans3=c(704.4,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12,s13
    ,s14,s15,s16,s17,s18,s19,s20,s21,s22,s23,s24,s25,
    s26,s27,s28,s29,s30,s31,s32,s33,s34,s35,s36,s37,
    s38,s39,s40,s41,s42,s43,s44,s45,s46,s47,s48,s49,
    s50,s51,s52,s53,696.8)
ans3
ss=ans3/7
ans4=round(ss,1)
ans4
```

```
ans1
ans22=ans2-100
ans3
ans44=ans4-100

x=c(x)
ans1=c(' ',ans1,' ')
ans2=c(' ',ans2,' ')
ans3=c(' ',' ',' ',ans3,' ',' ',' ')
ans4=c(' ',' ',' ',ans4,' ',' ',' ')


k1 <- matrix(c(x,ans1,ans2,ans3,ans4),ncol=5,byrow=FALSE)
rownames(k1) <- c("July","Aug","Sept","Oct","Nov","Dec","Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec","Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec","Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec","Jan","Feb","Mar","Apr","May","June","July","Aug","Sept","Oct","Nov","Dec","Jan","Feb","Mar","Apr","May","June")
colnames(k1) <- c("Data","3-Month Moving Total","3-Month Moving Average","7-Month Moving Total","7-Month Moving Average")
k1 <- as.table(k1)
k1

y <- ts(ans22, frequency=12, start=c(1976,1))
plot(y,ylim=c(-5,5),type='l',xlab='3-Month Moving Average',ylab='Percent deviation from 100%')
abline(a=0,b=0)

y <- ts(ans44, frequency=12, start=c(1976,1))
plot(y,ylim=c(-5,5),type='l',xlab='7-Month Moving Average',ylab='Percent deviation from 100%')
abline(a=0,b=0)
```

R code Exa 18.18.20 Data modification

```
#PAGE=422
yr=c(1976,1977,1978,1979,1980,1981)
y=c(169.6,176.6,183.7,187.3,190.5,191.1)
x1=c
   (178.2,156.7,164.2,153.2,157.5,172.6,185.9,185.8,165,163.6,169,18
x2=c
   (196.3,162.8,168.6,156.9,168.2,180.2,197.9,195.9,176,166.4,166.3,
x3=c
   (197.3,173.7,173.2,159.7,175.2,187.4,202.6,205.6,185.6,175.6,176.
x4=c
   (209.5,186.3,183,169.5,178.2,186.7,202.4,204.9,180.6,179.8,177.4,
x5=c
   (200,188.7,187.5,168.6,175.7,189.4,216.1,215.4,191.5,178.5,178.6,
x6=c
   (205.2,179.6,185.4,172.4,177.7,202.7,220.2,210.2,186.9,181.4,175.
x=c(x1,x2,x3,x4,x5,x6)
x <- ts(x, frequency=12, start=c(1976,1))

a=28/29
x[2]=x[2]*a
x[2]=round(x[2],digits = 1)
x[50]=x[50]*a
x[50]=round(x[50],digits = 1)

k1 <- matrix(c(x),ncol=12,byrow=TRUE)
colnames(k1) <- c("Jan","Feb","Mar","Apr","May","
```

```
    June","July","Aug","Sept","Oct","Nov","Dec")
rownames(k1) <- c('1976','1977','1978','1979','1980'
    ,'1981')
k1 <- as.table(k1)
k1
```

R code Exa 18.18.21 Electric Energy Production

```
#PAGE=422
y=c(1976:1981)
j1=c(178.2,196.3,197.3,209.5,200.0,205.2)
f=c(156.7,162.8,173.7,186.3,188.7,179.6)
m1=c(164.2,168.6,173.2,183,187.5,185.4)
a1=c(153.2,156.9,159.7,169.5,168.6,172.4)
m2=c(157.5,168.2,175.2,178.2,175.7,177.7)
j2=c(172.6,180.2,187.4,186.7,189.4,202.7)
j3=c(185.9,197.9,202.6,202.4,216.1,220.2)
a2=c(185.8,195.9,205.6,204.9,215.4,210.2)
s=c(165,176,185.6,180.6,191.5,186.9)
o=c(163.6,166.4,175.6,179.8,178.5,181.4)
n=c(169,166.3,176.3,177.4,178.6,175.6)
d=c(183.1,183.9,191.7,188.9,195.6,195.6)

c1=c
    (186.9,186.6,186.9,187,186.9,186.9,187.6,188.6,189.5,189.9,189.9,

t1=sum(c1)
m1=mean(c1)
c2=c
    (190.7,190.5,190.1,190.1,190.4,191,191.7,191.7,191.3,191.2,191.2,

t2=sum(c2)
m2=mean(c2)
m=m2-m1
m=round(m,1)
```

```
m=m/12
m=round(m,2)
c4=0
c3=c2[length(c2)]
for (i in 1:18)
{
  c3=c3+m
  c4=append(c4,c3)
}
c4=round(c4,1)
c4=c4[2:19]
c4=c(c2[length(c2)],c4)


s=c(110,96.5,97,88.9,95.1,102.1,110.1,110.7,99.1,94,94.1,102.5)

c5=c4[7:19]
c6=c5*s/100
c6=round(c6,1)
c6=c6[1:12]

c4=c(' ',' ',' ',' ',' ',c4)

y1 <- matrix(c(c4,s,c6),ncol=12,byrow=TRUE)
rownames(y1) <- c('1981 trend value (T)','1982 trend value (T)','Seasonal insex(S%)','1982 predicted energy(TS)')
colnames(y1) <- c("Jan",'Feb','Mar','Apr','May','June','July','Aug','Sep','Oct','Nov','Dec')
y1 <- as.table(y1)
y1

#"The answer may slightly vary due to rounding off values."
```

Chapter 19

Index Numbers

R code Exa 19.1 consumer prices of a litre of milk

```
#PAGE=434
y=c(1970,1980)
c=c(45,54)
p1=c[2]/c[1]
p1=p1*100
cat(p1,'%')
```

R code Exa 19.2 milk prices

```
#PAGE=435
y=c(1970,1980)
c=c(45,54)
p1=c[1]/c[2]
p1=p1*100
cat(p1,'%')
```

R code Exa 19.3 Prices of a commodity

```
#PAGE=436
t=c(1983,1984,1985,1986)
p=c(8,12,15,18)

p1=p[2]/p[1]
p1=p1*100
cat(p1,'%')

p2=p[3]/p[2]
p2=p2*100
cat(p2,'%')

p3=p[4]/p[3]
p3=p3*100
cat(p3,'%')
```

R code Exa 19.4 Price Relative

```
#PAGE=436
t=c(1983,1984,1985,1986)
p=c(8,12,15,18)

p1=p[2]/p[1]
p2=p[3]/p[2]
p3=p[4]/p[3]

p=p1*p2*p3
p=p*100
cat(p,'%')
```

R code Exa 19.5 Collection of chain relatives

```
#PAGE=436
t=c(1983,1984,1985,1986)
p=c(8,12,15,18)

p1=p[2]/p[1]
p1=p1*100
cat(p1,'%')


p2=(p[3]/p[2])*(p[2]/p[1])
p2=p2*100
cat(p2,'%')

p3=(p[4]/p[3])*(p[3]/p[2])*(p[2]/p[1])
p3=p3*100
cat(p3,'%')
```

R code Exa 19.19.1 Average retail prices

```
#PAGE=441
yr=c(1978,1979,1980,1981,1982,1983,1984)
x=c(68.2,82.1,82.3,98.1,84.7,91.1,106.9)

a=which(yr==1978)
y=x[a]
b=which(yr==1982)
y1=x[b]
y1=y1/y
y1=y1*100
y1=round(y1,digits = 1)
cat(y1,'%')

b1=which(yr==1984)
y2=x[b1]
y2=y2/y
```

```
y2=y2*100
y2=round(y2,digits = 1)
cat(y2,'%')


c1=which(yr==1980)
y3=x[c1]
y4=x/y3
y4=y4*100
y4=round(y4,digits =1 )


smoke <- matrix(c(yr,y4),ncol=7,byrow=TRUE)
colnames(smoke) <- c(" "," "," "," "," "," "," ")
rownames(smoke) <- c("Year"," Price relative")
smoke <- as.table(smoke)
smoke

d1=which(yr==1978)
y5=x[d1]
d2=which(yr==1979)
y6=x[d2]
d3=which(yr==1980)
y7=x[d3]
d=(y5+y6+y7)/3
d=round(d,digits = 1)

y8=x/d
y8=y8*100
y8=round(y8,digits = 1)

smoke <- matrix(c(yr,y8),ncol=7,byrow=TRUE)
colnames(smoke) <- c(" "," "," "," "," "," "," ")
rownames(smoke) <- c("Year"," Price relative")
smoke <- as.table(smoke)
smoke
```

R code Exa 19.19.3 Price relatives

```
#PAGE=442
y=c(1978,1979,1980,1981,1982,1983,1984)
p=c(88,105.9,106.2,126.6,109.3,117.5,137.9)
a=which(y==1980)
p1=p[a]
p2=p/p1
p2=p2*100
p2=round(p2,1)
sm <- matrix(c(y,p2),ncol=7,byrow=TRUE)
colnames(sm) <- c(" "," "," "," "," "," "," ")
rownames(sm) <- c("Year","Price  Relative(1980=100)")
sm <- as.table(sm)
sm
```

R code Exa 19.19.4 Average price of commodity

```
#PAGE=442
y1=1986
c1=0.2
y2=1985
c2=0.2
y3=1984
c3=0.5
a=100
y4=1987
x1=a*c1
x1=x1+a
x1

x2=a*c2
```

```
x2=a-x2
x2=x2/100
x2=1/x2
x3=x2*100

a1=x2*x1
a1

x4=c3*a
x4=a+x4
x4=x4/100

x5=1/x4
a2=x1*x5
a2

y=c(y3,y2,y1,y4)
x=c(a1,a,x1,a2)
k <- matrix(c(y,x),ncol=4,byrow=TRUE)
colnames(k) <- c(" "," "," "," ")
rownames(k) <- c("Year"," Price relative")
smoke <- as.table(k)
k

g=which(y==1986)
g1=x[g]
g1

g2=x/g1
g2=g2*100
g2=round(g2,digits = 1)

l <- matrix(c(y,g2),ncol=4,byrow=TRUE)
colnames(l) <- c(" "," "," "," ")
rownames(l) <- c("Year"," Price relative")
l <- as.table(l)
l
```

```
g3=which(y==1984)
g3=x[g3]

g4=which(y==1985)
g4=x[g4]

g5=(g3+g4)/2
g5=x/g5
g5=g5*100

l1 <- matrix(c(y,g5),ncol=4,byrow=TRUE)
colnames(l1) <- c(" "," "," "," ")
rownames(l1) <- c("Year"," Price relative")
l1 <- as.table(l1)
l1
```

R code Exa 19.19.5 wheat production of the country

```
#PAGE=443
y=c(1977,1978,1979,1980,1981,1982,1983,1984,1985)
p=c(2046,1776,2134,2380,2785,2765,2420,2595,2425)

a=which(y==1982)
g=p[a]
g1=p/g
g1=g1*100
g1=round(g1,digits = 1)

l <- matrix(c(y,g1),ncol=9,byrow=TRUE)
colnames(l) <- c(" "," "," "," "," "," "," "," "," "
  )
rownames(l) <- c("Year"," Price relative")
l <- as.table(l)
l

```

```
a1=which(y==1977)
g2=p[a1]

a2=which(y==1978)
g3=p[a2]

a3=which(y==1979)
g4=p[a3]

a4=which(y==1980)
g5=p[a4]

g6=(g2+g3+g4+g5)/4
g7=p/g6
g7=g7*100
g7=round(g7,digits = 1)

l1 <- matrix(c(y,g7),ncol=9,byrow=TRUE)
colnames(l1) <- c(" "," "," "," "," "," "," "," ","
  ")
rownames(l1) <- c("Year"," Price relative")
l1 <- as.table(l1)
l1
```

R code Exa 19.19.6 quantity relative for the base year

```
#PAGE=444
y1=1986
a1=105
y2=1977
a2=140
y3=1980
a1=a1/100
a2=a2/100
b1=1/a2
```

```
b2=b1*a1
b2=b2*100
cat(b2,'%')
```

R code Exa 19.19.7 factory pay and employees

```
#PAGE=445
y1=1980
a1=80000
e1=120
a2=30
e2=e1+a2
b1=12000

a=e2/e1
a=a*100
a

b=(a1+b1)/a1
b=b*100
b

c=b/a
c=c*100
c
```

R code Exa 19.19.8 sales of commodity

```
#PAGE=445
a=150
b=200
c=b/a
c=c-1
```

```
c=round(c,digits = 2)
cat(c,'%')
#"The answer may vary due to difference in
   representation."
```

R code Exa 19.19.9 link relatives

```
#PAGE=445
y=c(1981,1982,1983,1984,1985)
x=c(125,120,135,150,175)

g1=which(y==1981)
g1=x[g1]

g2=which(y==1982)
g2=x[g2]

g3=which(y==1983)
g3=x[g3]

g4=which(y==1984)
g4=x[g4]

g5=which(y==1985)
g5=x[g5]

g1=g1/100
g2=g2/100
g3=g3/100
g4=g4/100
g5=g5/100

a=g1*g2
a=a*100
cat(a,'%')
```

```
p1=1/g1
p1=p1*100
cat(p1,'%')

p2=1.2/g2
p2=p2*100
cat(p2,'%')

p3=g2*100
cat(p3,'%')

p4=g2*g3
p4=p4*100
cat(p4,'%')

p5=g2*g3*g4
p5=p5*100
cat(p5,'%')

p6=g2*g3*g4*g5
p6=p6*100
p6=round(p6,digits = 0)
cat(p6,'%')
```

R code Exa 19.19.10 Milk butter and cheese

```
#PAGE=446
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
y5=c(60360,558,1211)
y6=c(65320,567,1297)
```

```
a=sum(y3)/sum(y1)
a=a*100
a=round(a,digits = 1)
cat(a,'%')

b1=(y1[1]+y2[1])/2
b1
b2=(y1[2]+y2[2])/2
b2=round(b2,digits = 0)
b2
b3=(y1[3]+y2[3])/2
b3

s=sum(y3)/(b1+b2+b3)
s=s*100
s=round(s,digits = 1)
cat(s,'%')
```

R code Exa 19.19.12 Average US prices and production of cotton and wheat

```
#PAGE=447
y<-c(1980,1986)
p1<-c(163.7,125)
p2<-c(143,116)
q1<-c(2.427,13.947)
q2<-c(2.931,13.285)
p1=p1/100
a1=(p1[2]+p2[2])/(p1[1]+p2[1])
a1=a1*100
a1=round(a1,1)
cat(a1,'%')
p2<-p2/10
p1<-p1*100
a2=(p1[2]+p2[2])/(p1[1]+p2[1])
```

```
a2=a2*100
a2=round(a2,1)
cat(a2,'%')
```

R code Exa 19.19.13 Wholesale price index of dairy products

```
#PAGE=447
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
y5=c(60360,558,1211)
y6=c(65320,567,1297)

a1=y3[1]/y1[1]
a1=a1*100
a1=round(a1,digits = 1)
cat(a1,'%')
a2=y3[2]/y1[2]
a2=a2*100
a2=round(a2,digits = 1)
cat(a2,'%')
a3=y3[3]/y1[3]
a3=a3*100
a3=round(a3,digits = 1)
cat(a3,'%')
m=(a1+a2+a3)/3
m=round(m,digits = 1)
cat(m,'%')
```

R code Exa 19.19.14 Median instead mean

```
#PAGE=448
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
y5=c(60360,558,1211)
y6=c(65320,567,1297)

a1=y3[1]/y1[1]
a1=a1*100
a1=round(a1,digits = 1)
a2=y3[2]/y1[2]
a2=a2*100
a2=round(a2,digits = 1)
a3=y3[3]/y1[3]
a3=a3*100
a3=round(a3,digits = 1)

a=c(a1,a2,a3)
a=median(a)
a

a1=(y1[1]+y2[1])/2
a1=y3[1]/a1
a1=a1*100
a1=round(a1,digits = 1)
a2=(y1[2]+y2[2])/2
a2=y3[2]/a2
a2=a2*100
a2=round(a2,digits = 1)
a3=(y1[3]+y2[3])/2
a3=y3[3]/a3
a3=a3*100
a3=round(a3,digits = 1)

a=c(a1,a2,a3)
a=median(a)
```

```
a
```

R code Exa 19.19.15 Geometric mean instead of mean

```
#PAGE=448
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
y5=c(60360,558,1211)
y6=c(65320,567,1297)

a1=y3[1]/y1[1]
a1=a1*100
a1=round(a1,digits = 1)
a2=y3[2]/y1[2]
a2=a2*100
a2=round(a2,digits = 1)
a3=y3[3]/y1[3]
a3=a3*100
a3=round(a3,digits = 1)

a=c(a1,a2,a3)
l=length(a)
a=(a1*a2*a3)**(1/l)
a=round(a,digits = 1)
a

a1=(y1[1]+y2[1])/2
a1=y3[1]/a1
a1=a1*100
a1=round(a1,digits = 1)
a2=(y1[2]+y2[2])/2
a2=y3[2]/a2
```

```
a2=a2*100
a2=round(a2,digits = 1)
a3=(y1[3]+y2[3])/2
a3=y3[3]/a3
a3=a3*100
a3=round(a3,digits = 1)

a=c(a1,a2,a3)
l=length(a)
a=(a1*a2*a3)**(1/l)
a=round(a,digits = 1)
a
```

R code Exa 19.19.16 price relatives index for commodities

```
#PAGE=448
y1=1980
y2=1986
a1=163.7
a2=125
b1=143
b2=116
c1=a2/a1
c1=c1*100
c1=round(c1,digits = 1)
cat(c1,'%')

c2=b2/b1
c2=c2*100
c2=round(c2,digits = 1)
cat(c2,'%')

c=(c1+c2)/2
c=round(c,digits = 1)
cat(c,'%')
```

R code Exa 19.19.17 Using geometric mean

```
#PAGE=448
y1=1980
y2=1986
a1=163.7
a2=125
b1=143
b2=116
c1=a2/a1
c1=c1*100
c1=round(c1,digits = 1)

c2=b2/b1
c2=c2*100
c2=round(c2,digits = 1)

c=c(c1,c2)
l=length(c)
c=(c1*c2)**(1/l)
c=round(c,digits = 1)
cat(c,'%')
```

R code Exa 19.19.18 Laspeyres price index

```
#PAGE=448
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
```

```
y5=c(60360,558,1211)
y6=c(65320,567,1297)
a1=sum(y3*y4)
a2=sum(y1*y4)
a=a1/a2
a=a*100
a=round(a,digits = 1)
cat(a,'%')

c1=(y4+y5)/2
c3=(y1+y2)/2
c4=sum(c1*y3)
c5=sum(c3*c1)
c6=c4/c5
c6=c6*100
c6=round(c6,digits = 1)
cat(c6,'%')
```

R code Exa 19.19.19 Paasche

```
#PAGE=449
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
y5=c(60360,558,1211)
y6=c(65320,567,1297)
a1=sum(y3*y6)
a2=sum(y1*y6)
a=a1/a2
a=a*100
a=round(a,digits = 1)
cat(a,'%')
```

```
c3=(y1+y2)/2
c4=sum(y6*y3)
c5=sum(c3*y6)
c6=c4/c5
c6=c6*100
c6=round(c6,digits = 1)
cat(c6,'%')
```

R code Exa 19.19.20 Laspeyres price index and Paasche price index

```
#PAGE=449
y1=1980
y2=1986
a1=163.7/100
a2=125/100
b1=143
b2=116
c1=2.427
c2=2.931
d1=13.947
d2=13.285

a=((a2*c1*1000)+(b2*d1))/((a1*c1*1000)+(b1*d1))
a=a*100
a=round(a,digits = 1)
cat(a,'%')

b=((a2*c2*1000)+(b2*d2))/((a1*c2*1000)+(b1*d2))
b=b*100
b=round(b,digits = 1)
cat(b,'%')
```

R code Exa 19.19.26 Fishers ideal price index for the dairy products

```
#PAGE=451
l1=0.988
p1=0.9885
l2=0.9607
p2=0.9608
f1=sqrt(l1*p1)
f2=sqrt(l2*p2)
f1=f1*100
f1=round(f1,1)
f2=f2*100
f2=round(f2,1)
cat(f1,'%')
cat(f2,'%')
```

R code Exa 19.19.27 Fishers ideal price index

```
#PAGE=451
y1=1980
y2=1986
a1=163.7/100
a2=125/100
b1=143
b2=116
c1=2.427
c2=2.931
d1=13.947
d2=13.285

a=((a2*c1*1000)+(b2*d1))/((a1*c1*1000)+(b1*d1))
a=a*100
a=round(a,digits = 1)
a=a/100

b=((a2*c2*1000)+(b2*d2))/((a1*c2*1000)+(b1*d2))
b=b*100
```

```r
b=round(b,digits = 1)
b=b/100

c=sqrt(a*b)
c=c*100
c=round(c,digits = 1)
cat(c,'%')
```

R code Exa 19.19.29 Marshall Edgeworth

```r
#PAGE=452
y=c(1980,1981,1985)
y1=c(29.11,306.5,343.6)
y2=c(30.69,325.6,367.8)
y3=c(28.38,310.4,356.4)
y4=c(58410,520,1082)
y5=c(60360,558,1211)
y6=c(65320,567,1297)
y=(y4+y6)
a1=sum(y*y3)/sum(y*y1)
a1=a1*100
a1=round(a1,digits = 1)
cat(a1,'%')
```

R code Exa 19.19.31 Weighted arithmetic mean

```r
#PAGE=453
p0=c(163.7,143)
pn=c(125,116)
qn=c(2931,13.285)
c1=pn/p0
c1=round(c1,digits = 4)
c2=pn*qn
```

```
g1=c2[1]/100
g2=c2[2]
g2=round(g2,digits = 1)
g=c(g1,g2)
c3=c1*g
c3=round(c3,digits = 1)
s1=sum(g)
s2=sum(c3)
s1=round(s1,digits = 1)

a=s2/s1
a=a*100
a=round(a,digits = 1)
cat(a,'%')

q0=c(2.427,13.947)
p0=c(163.7/100,143)
pn=c(125/100,116)
qn=c(2.931*1000,13.285)

y1=1980
y2=1986
p01=163.7/100
pn1=125/100
p02=143
pn2=116
q01=2.427*1000
qn1=2.931
q02=13.947
qn2=13.285

c=(pn1*q01+pn2*q02)/(p01*q01+p02*q02)
c=c*100
c=round(c,digits = 1)
cat(c,'%')
```

R code Exa 19.19.32 Computing the volume index

```
#PAGE=454
y1=1980
y2=1986
p01=163.7*10
pn1=125
p02=143
pn2=116
q01=2.427
qn1=2.931
q02=13.947
qn2=13.285
p0=c(p01,p02)
pn=c(pn1,pn2)
q0=c(q01,q02)
qn=c(qn1,qn2)

a=(qn1/q01+qn2/q02)/2
a=a*100
a=round(a,digits = 0)
cat(a,'%')

b=(qn1*p01+qn2*p02)/(q01*p01+q02*p02)
b=b*100
b=round(b,digits = 1)
cat(b,'%')

c=(qn1*pn1*10+qn2*pn2)/(q01*pn1*10+q02*pn2)
c=c*100
c=round(c,digits = 1)
cat(c,'%')
```

R code Exa 19.19.33 Fishers ideal volume index number

```
#PAGE=454
y1=1980
y2=1986
p01=163.7*10
pn1=125
p02=143
pn2=116
q01=2.427
qn1=2.931
q02=13.947
qn2=13.285
p0=c(p01,p02)
pn=c(pn1,pn2)
q0=c(q01,q02)
qn=c(qn1,qn2)

a=(qn1/q01+qn2/q02)/2
a=a*100
a=round(a,digits = 0)

b=(qn1*p01+qn2*p02)/(q01*p01+q02*p02)
b=b*100
b=round(b,digits = 1)

c=(qn1*pn1*10+qn2*pn2)/(q01*pn1*10+q02*pn2)
c=c*100
c=round(c,digits = 1)

d=sqrt(b*c)
d=round(d,digits = 0)
cat(d,'%')
```

R code Exa 19.19.35 Value Index

```
#PAGE=455
y1=1980
y2=1986
p01=163.7*10
pn1=125
p02=143
pn2=116
q01=2.427
qn1=2.931
q02=13.947
qn2=13.285
p0=c(p01,p02)
pn=c(pn1,pn2)
q0=c(q01,q02)
qn=c(qn1,qn2)

a=(qn1/q01+qn2/q02)/2
a=a*100
a=round(a,digits = 0)

b=(qn1*p01+qn2*p02)/(q01*p01+q02*p02)
b=b*100
b=round(b,digits = 1)

c=(qn1*pn1*10+qn2*pn2)/(q01*pn1*10+q02*pn2)
c=c*100
c=round(c,digits = 1)

d=sqrt(b*c)
d=round(d,digits = 0)

y1=1980
```

```
y2=1986
a1=163.7/100
a2=125/100
b1=143
b2=116
c1=2.427
c2=2.931
d1=13.947
d2=13.285

a=((a2*c1*1000)+(b2*d1))/((a1*c1*1000)+(b1*d1))
a=a*100
a=round(a,digits = 1)
a=a/100

b=((a2*c2*1000)+(b2*d2))/((a1*c2*1000)+(b1*d2))
b=b*100
b=round(b,digits = 1)
b=b/100

c=sqrt(a*b)
c=c*100
c=round(c,digits = 1)

vi=d*c
vi=vi/100
vi=round(vi,digits = 1)
cat(vi,'%')
```

R code Exa 19.19.38 Industrial production

```
#PAGE=456
yr=c
  (1974,1975,1976,1977,1978,1979,1980,1981,1982,1983,1984,1985)
```

```r
x=c(93,85,93,100,107,111,109,111,103,109,122,125)

a=which(yr==1979)
a=x[a]
x1=x/a*100
x1=round(x1,digits = 0)

z<- matrix(c(yr,x1),ncol=12,byrow=TRUE)
colnames(z) <- c(" "," "," "," "," "," "," "," "," "," "," "," ")
rownames(z) <- c("year","index")
z <- as.table(z)
z

b=which(yr==1974)
b=x[b]
c=which(yr==1975)
c=x[c]
d=which(yr==1976)
d=x[d]

e=(b+c+d)/3
x2=x/e*100
x2=round(x2,digits = 0)
x2

z1<- matrix(c(yr,x2),ncol=12,byrow=TRUE)
colnames(z1) <- c(" "," "," "," "," "," "," "," "," "," "," "," ")
rownames(z1) <- c("year","index")
z1 <- as.table(z1)
z1
```

R code Exa 19.19.39 Weekly wage of workers in US

```
#PAGE=457
yr=c
   (1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)
x=c
   (96.32,102.68,108.86,114.6,121.66,130.2,138.62,147.38,158.03,163.
y=c
   (106.2,117.9,128.7,136.1,144.9,155.9,173.5,197,217.4,230.7,238.1)

a=which(yr==1973)
b=y[a]
c=y/b
c=c*100
c=round(c,digits = 1)

e=x/c
e=e*100
e=round(e,digits = 2)

y <- matrix(c(yr,c,e),ncol=11,byrow=TRUE)
colnames(y) <- c(" "," "," "," "," "," "," "," "," "
   ," "," ")
rownames(y) <- c("year","consumer price","real
   weekly wage")
y <- as.table(y)
y
```

R code Exa 19.19.40 Consumer price index

```
#PAGE=457
yr=c
   (1973,1974,1975,1976,1977,1978,1979,1980,1981,1982,1983)
```

```
x=c
  (96.32,102.68,108.86,114.6,121.66,130.2,138.62,147.38,158.03,163.8
y=c
  (106.2,117.9,128.7,136.1,144.9,155.9,173.5,197,217.4,230.7,238.1)

a=which(yr==1973)
b=y[a]
c=y/b
c=c*100
c=round(c,digits = 1)

e=x/c
e=e*100
e=round(e,digits = 2)

d=1
d=d/c
d=d*100
d=round(d,digits = 2)

y <- matrix(c(yr,d),ncol=11,byrow=TRUE)
colnames(y) <- c(" "," "," "," "," "," "," "," "," "
  ," "," ")
rownames(y) <- c("year","purchasing powerr")
y <- as.table(y)
y
```