

R Textbook Companion for
Business Statistics for Contemporary Decision
Making
by Ken Black¹

Created by
Vibha Mehta
B.Tech.
Computer Science and Engineering
Techno India NJR Institute of Technology
Cross-Checked by
R TBC Team

May 20, 2021

¹Funded by a grant from the National Mission on Education through ICT - <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and R codes written in it can be downloaded from the "Textbook Companion Project" section at the website - <https://r.fossee.in>.

Book Description

Title: Business Statistics for Contemporary Decision Making

Author: Ken Black

Publisher: Wiley, USA

Edition: 6

Year: 2010

ISBN: 978-0470-40901-5

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	4
2 Charts and Graphs	5
3 Descriptive Statistics	12
4 Probability	20
5 Discrete Distributions	28
6 Continuous Distributions	36
7 Sampling and Sampling Distributions	44
8 Statistical Inference Estimation for Single Populations	47
9 Statistical Inference Hypothesis Testing for Single Populations	52
10 Statistical Inferences About Two Populations	58
11 Analysis of Variance and Design of Experiments	65
12 Simple Regression Analysis and Correlation	70
13 Multiple Regression Analysis	78
14 Building Multiple Regression Models	81
15 Time Series Forecasting and Index Numbers	83

16 Analysis of Categorical Data	93
17 Nonparametric Statistics	97

List of R Codes

Exa 2.1.a	Class Midpoints	5
Exa 2.1.b	Relative Frequency	6
Exa 2.1.c	Cumulative Frequency	7
Exa 2.2	Steam and leaf plot	8
Exa 2.3.a	Bar Graph	9
Exa 2.3.b	Bar Graph	10
Exa 2.4	Scatter Plot	11
Exa 3.1.a	Mode	12
Exa 3.1.b	Median	13
Exa 3.1.c	Mean	13
Exa 3.2	Determine the 30th percentile of the following eight numbers	14
Exa 3.3	Quartiles	14
Exa 3.5	Chebyshevs Theorem	15
Exa 3.6.a	Mean Absolute Deviation	16
Exa 3.6.b	Variance and Standard deviation	17
Exa 3.7	Mean Median Mode Variance and Standard deviation	17
Exa 4.1	Addition Law	20
Exa 4.3	Special Law of Addition	21
Exa 4.5	Multiplication Law	22
Exa 4.6	General Law of Multiplication	23
Exa 4.8	Special Law of Multiplication	24
Exa 4.9	Conditional Probability	25
Exa 4.11	Independent Event	26
Exa 4.12	Bayes Rule	26
Exa 5.1	Variance and standard deviation of a Discrete Distribution	28
Exa 5.2	Binomial Distribution	29

Exa 5.3	Binomial Distribution ex 2	30
Exa 5.5	Using Binomial Table	30
Exa 5.6	Mean and standard deviation in Binomial distribution	31
Exa 5.7	Poissons formula	31
Exa 5.8	Poisson distribution Example	33
Exa 5.9	Using poissions table	33
Exa 5.10	Probability Example	34
Exa 5.11	Hypergeometrics distribution	34
Exa 6.1	Uniform Distribution	36
Exa 6.2	MEAN AND STANDARD DEVIATION OF A UNIFORM DISTRIBUTION	37
Exa 6.3	Normal Curve distribution	37
Exa 6.4	PROBABILITY OF A UNIFORM DISTRIBUTION	38
Exa 6.5	Probability of Normal Curve DISTRIBUTION	38
Exa 6.6	PROBABILITY OF A UNIFORM DISTRIBUTION	39
Exa 6.7	MEAN OF A UNIFORM DISTRIBUTION	39
Exa 6.8	Normal distribution using z value	40
Exa 6.9	Binomial distribution problem by using the normal distribution	40
Exa 6.10	Binomial distribution by using the normal distribution	41
Exa 6.11	Exponential Distribution	42
Exa 7.1	Z formula for sample means	44
Exa 7.2	Z formula for Sample mean of a finite population	45
Exa 7.3	Z formula for Sample Proportion	45
Exa 8.1	Confidence interval to Estimate Population mean	47
Exa 8.2	Confidence interval to Estimate Population mean using Finite Correction	47
Exa 8.3	Confidence Interval to Estimate population mean Population standard deviation unknown and population normally distributed	48
Exa 8.4	Confidence Interval to estimate Population Proportion	49
Exa 8.5	Confidence Interval to estimate Population Proportion	49
Exa 8.6	Confidence to estimate the Population Variance	50
Exa 8.7	Sample Size when Estimating Population mean	50
Exa 8.8	Sample size when estimating population proportion	51
Exa 9.1	Test Hypothesis about population mean	52
Exa 9.2	t test for population mean	53
Exa 9.3	z test of a population proportion	53

Exa 9.4	Test Hypothesis about a population variance	54
Exa 9.5	Z value for Type II error	55
Exa 9.6	Z value for Type II error	56
Exa 10.1	Z formula for the difference in Two Sample Means . .	58
Exa 10.2	Confidence Interval to estimate difference in two popu- lation means	59
Exa 10.3	t formula to test the difference in means assuming the standard deviations are equal	60
Exa 10.4	CONFIDENCE INTERVAL TO ESTIMATE difference in means ASSUMING THE POPULATION VARIANCES ARE UNKNOWN AND EQUAL	61
Exa 10.5	t formula to test the Difference in Two Dependent Pop- ulation	62
Exa 10.6	Z formula to test the difference in Population Proportion	63
Exa 10.7	F test for two Population Variance	63
Exa 11.1	One Way ANOVA	65
Exa 11.2	TUKEYs HSD Test	66
Exa 11.3	Randomized Block Design	67
Exa 11.4	Two Way ANOVA	68
Exa 12.1	Slope of Regression line	70
Exa 12.2	Residual Analysis	70
Exa 12.3	Standard Error of Estimation	72
Exa 12.4	Coefficient of Determination	73
Exa 12.5	t test for slope	75
Exa 12.6	CONFIDENCE INTERVAL TO ESTIMATE THE SIN- GAL VALUE FOR A GIVEN VALUE OF x	75
Exa 12.7	Regression Analysis Example	76
Exa 13.1	Multiple Regression Model	78
Exa 13.2	Multiple Regression Analysis Model	79
Exa 14.1	Model Transformation	81
Exa 15.1.a	Moving average	83
Exa 15.1.b	Moving average	84
Exa 15.2	Weighted Moving Average	87
Exa 15.3	EXPONENTIAL SMOOTHING	88
Exa 15.4	Regression Trend Analysis Using Quadratic Models . .	89
Exa 15.5	LASPEYRES PRICE INDEX and PAASCHE PRICE INDEX	90
Exa 16.1	CHI SQUARE GOODNESS OF FIT TEST	93

Exa 16.2	Test data is whether in Poisson distributed	94
Exa 16.3	CHI SQUARE GOODNESS OF FIT TEST example 2	95
Exa 16.4	CHI SQUARE TEST OF INDEPENDENCE	96
Exa 17.1	Mann Whitney U test	97
Exa 17.2	LARGE SAMPLE FORMULAS MANN WHITNEY U TEST	98
Exa 17.3	WILCOXON MATCHED PAIRS SIGNED RANK TEST	99
Exa 17.4	KRUSKAL WALLIS TEST	101
Exa 17.5	FRIEDMAN TEST	102
Exa 17.6	SPEARMANS RANK CORRELATION	102

Chapter 2

Charts and Graphs

R code Exa 2.1.a Class Midpoints

```
1 # Class midpoints.  
2  
3 Interest_rate <- c  
  (7.29,7.23,7.11,6.78,7.47,6.69,6.77,6.57,6.80,6.88,6.98,7.16,  
4  
  7.30,7.24,7.16,7.03,6.90,7.16,7.40,7.05,7.28,7.31  
5  
  7.03,7.17,6.78,7.08,7.12,7.31,7.40,6.35,6.96,7.29  
6  
  6.96,7.02,7.13,6.84)  
7  
8 summary(Interest_rate)  
9  
10 low_val<- 6.30  
11 high_val <-7.70  
12 step_val <- 0.20  
13 x_breaks <- seq(low_val,high_val,step_val)  
14 x_breaks  
15 x_mid <- seq(low_val+step_val/2,high_val-step_val/2,  
  step_val)  
16 x_mid
```

```

17 x<-cut(Interest_rate,breaks = x_breaks,right=FALSE)
18 x
19 y<-table(x)
20 y
21
22 df <- data.frame(y)
23 df
24
25 # Class Mid point :
26 df$midpoint <- x_mid
27 View(df)

```

R code Exa 2.1.b Relative Frequency

```

1 # Relative Frequency .
2
3 Interest_rate <- c
4 (7.29 ,7.23 ,7.11 ,6.78 ,7.47 ,6.69 ,6.77 ,6.57 ,6.80 ,6.88 ,6.98 ,7.16 ,
5
6 7.30 ,7.24 ,7.16 ,7.03 ,6.90 ,7.16 ,7.40 ,7.05 ,7.28 ,7.31
7
8 summary(Interest_rate)
9
10 low_val<- 6.30
11 high_val <-7.70
12 step_val <- 0.20
13 x_breaks <- seq(low_val,high_val,step_val)
14 x_breaks
15 x_mid <- seq(low_val+step_val/2,high_val-step_val/2,
16 step_val)
16 x_mid

```

```

17 x<-cut(Interest_rate,breaks = x_breaks,right=FALSE)
18 x
19 y<-table(x)
20 y
21
22 df <- data.frame(y)
23 df
24
25 # Class Mid point :
26 df$midpoint <- x_mid
27 df
28
29 # Relative Frequency :
30 rf <- df$Freq/sum(df$Freq)
31 rf
32 df$relative_frequency <- rf
33 View(df)

```

R code Exa 2.1.c Cumulative Frequency

```

1 # Cumulative Frequency .
2
3 Interest_rate <- c
4 (7.29,7.23,7.11,6.78,7.47,6.69,6.77,6.57,6.80,6.88,6.98,7.16,
5
6 7.30,7.24,7.16,7.03,6.90,7.16,7.40,7.05,7.28,7.31
7
8 7.03,7.17,6.78,7.08,7.12,7.31,7.40,6.35,6.96,7.29
9
10 6.96,7.02,7.13,6.84)
11
12 summary(Interest_rate)
13
14 low_val<- 6.30
15 high_val <-7.70

```

```

12 step_val <- 0.20
13 x_breaks <- seq(low_val,high_val,step_val)
14 x_breaks
15 x_mid <- seq(low_val+step_val/2,high_val-step_val/2,
16   step_val)
17 x<-cut(Interest_rate,breaks = x_breaks,right=FALSE)
18 x
19 y<-table(x)
20 y
21
22 df <- data.frame(y)
23 df
24
25 # Class Mid point :
26 df$midpoint <- x_mid
27 df
28
29 # Relative Frequency :
30 rf <- df$Freq/sum(df$Freq)
31 rf
32 df$relative_frequency <- rf
33 View(df)
34
35 # Cumulative Frequency :
36 c<-cumsum(df$Freq)
37 df$cumulative_frequency <- c
38 n <- sum(df$Freq)
39 crf <- c/n
40 df$cumul <- crf
41 df$pie <- round(360*rf,1)
42 View(df)

```

R code Exa 2.2 Steam and leaf plot

```

1 # Stem-and-leaf plot
2
3 costs <- c
  (3.67, 2.75, 9.15, 5.11, 3.32, 2.09, 1.83, 10.94, 1.93, 3.89,
4           7.20, 2.78, 6.72, 7.80, 5.47, 4.15, 3.55, 3.53, 3.34, 4.95,
5           5.42, 8.64, 4.84, 4.10, 5.10, 6.45, 4.65, 1.97, 2.84, 3.21
6           )
7
8 stem(costs, scale = 1, width = 80, atom = 1e-08)

```

R code Exa 2.3.a Bar Graph

```

1 # Bar Graph :
2
3 Inventory_shrinkage <- c("Employee theft", "
4   Shoplifting", "Administrative error", "Vendor fraud"
5   ")
6
7 data <- data.frame(Inventory_shrinkage, Annual_amount
8   )
9 Proportion <- data$Annual_amount/sum(data$Annual_
10  amount)
11 Percent <- Proportion*100
12
13 data <- cbind(data,Proportion,Percent)
14
15 Degree <- data$Proportion*360
16

```

```
17 data<-cbind(data ,Degree)
18
19 library(ggplot2)
20
21 ggplot(data ,aes(x=data$Inventory_shrinkage ,y=data$Annual_amount))+geom_bar(stat = "identity")
```

R code Exa 2.3.b Bar Graph

```
1 # Pie Chart :
2
3 Inventory_shrinkage <- c("Employee theft" ,
4                               "Shoplifting" , "Administrative error" , "Vendor fraud")
5 Annual_amount <- c(17918.6 , 15191.9 , 7617.6 , 2553.6)
6
7 data <- data.frame(Inventory_shrinkage ,Annual_amount)
8
9 Proportion <- data$Annual_amount/sum(data$Annual_amount)
10
11 Percent <- Proportion*100
12
13 data <- cbind(data ,Proportion ,Percent)
14
15 Degree <- data$Proportion*360
16
17 data<-cbind(data ,Degree)
18
19 labs <- paste(data$Inventory_shrinkage ,data$Percent
20 ,sep = "      ")
21 labs <- paste(labs ,"%",sep="")
```

```
22  
23 pie(data$Percent, labels = labls)
```

R code Exa 2.4 Scatter Plot

```
1 # Scatter Plot :  
2 Residential <- c  
  (169635,155113,149410,175822,162706,134605,195028,231396,234955,  
3  
  266481,267063,263385,252745,228943,197526,232134,24  
4  
  251937,281229,280748,297886,315757)  
5  
6 Non_residential <- c  
  (96497,115372,96407,129275,140569,145054,131289,155261,178925,  
7  
  163740,160363,164191,169173,167896,135389,12092  
8  
  139711,153866,166754,177639,175048)  
9  
10 home <- cbind(Residential,Non_residential)  
11 View(home)  
12  
13 # Scatter plot :  
14 plot(Residential, Non_residential,xlab="Residential"  
  ,ylab="Non-Residential")
```

Chapter 3

Descriptive Statistics

R code Exa 3.1.a Mode

```
1 # Mode Example :
2
3 getmode <- function(v) {
4   uniqv <- unique(v)
5   uniqv[which.max(tabulate(match(v, uniqv)))]
6 }
7
8 Company <- c("Enterprise", "Hertz", "Natioanl/Alamo",
9             "Avis", "Dollar", "Budget", "Advantage",
9             "U-save", "Payless", "ACE", "Fox", "Rent-A-
Wreck", "Triangle")
10
11 Number_of_Cars_in_Service <- c(
12   643000, 327000, 233000, 204000, 167000, 144000, 20000, 12000, 10000,
13
14   9000, 9000, 7000, 6000)
15
16 sort_data <- data1[order(-Number_of_Cars_in_Service)]
```

```
    ) ,]  
17  
18 result <- getmode(sort_data$Number_of_Cars_in_  
    Service)  
19 print(result)
```

R code Exa 3.1.b Median

```
1 # Median :  
2  
3 Company <- c("Enterprise", "Hertz", "Natioanl/Alamo", "  
    Avis", "Dollar", "Budget", "Advantage",  
    "U-save", "Payless", "ACE", "Fox", "Rent-A-  
    Wreck", "Traingle")  
5  
6 Number_of_Cars_in_Service <- c  
    (643000, 327000, 233000, 204000, 167000, 144000, 20000, 12000, 10000,  
7  
    9000, 9000, 7000, 6000)  
8  
9 data1 <- data.frame(Company, Number_of_Cars_in_  
    Service)  
10  
11 sort_data <- data1[order(-Number_of_Cars_in_Service  
    ),]  
12  
13 median(sort_data$Number_of_Cars_in_Service)
```

R code Exa 3.1.c Mean

```
1 # Mean Example :  
2
```

```

3 Company <- c("Enterprise", "Hertz", "Natioanl/Alamo", "
Avis", "Dollar", "Budget", "Advantage",
4 "U-save", "Payless", "ACE", "Fox", "Rent-A-
Wreck", "Triangle")
5
6 Number_of_Cars_in_Service <- c
(643000, 327000, 233000, 204000, 167000, 144000, 20000, 12000, 10000,
7 9000, 9000, 7000, 6000)
8
9 data1 <- data.frame(Company, Number_of_Cars_in_
Service)
10
11 sort_data <- data1[order(-Number_of_Cars_in_Service
),]
12
13 mean(sort_data$Number_of_Cars_in_Service)

```

R code Exa 3.2 Determine the 30th percentile of the following eight numbers

```

1 # Determine the 30th percentile of the following
   eight numbers :
2 data3 <- c(5, 12, 13, 14, 17, 19, 23, 28)
3 N = 8
4 P = 30
5
6 # 30th percentile value is :
7 a <- quantile(data3, c(.30))
8 cat("30th percentile value is : ", a)

```

R code Exa 3.3 Quartiles

```

1 # Quartiles :
2
3 Category <- c("Automotive", "Personal Care", "
4 Entertainment & Media",
5 "Food", "Drugs", "Electronics", "Soft
6 Drinks", "Retail", "Cleaners",
7 "Restaurants", "Computers", "Telephone",
8 "Financial",
9 "Beer Wine & Liquor", "Candy", "Toys")
10
11 Ad_spending <- c
12 (22195, 19526, 9538, 7793, 7707, 4023, 3916, 3576, 3571, 3553, 3247, 2488,
13
14 2433, 2050, 1137, 699)
15
16 advertise_age <- cbind(Category, Ad_spending)
17 View(advertise_age)
18
19 N=16
20
21 # Q1 = P25 is found by :
22 i = 25/100*N
23 i
24
25 # Quantile :
26 quantile(Ad_spending)

```

R code Exa 3.5 Chebyshevs Theorem

```

1 # Chebyshev's Theorem :
2

```

```

3 avg_age = 28
4 sd = 6
5
6 # Chebyshev's theorem states that at least  $(1 - 1/k^2)$  proportion of the values are within
7 #(mean+k*sd). Because 80% of the values are within
     this range, let
8
9 # $1 - (1/k^2) = .80$ 
10
11 k = sqrt(1/(1-0.80))
12 k
13
14 # now for :
15 mean = 28
16 sd = 6
17
18 # values are within
19 r1 = mean + k * sd
20 r1 #41.41
21 r2 = mean - k * sd
22 r2 # 14.58
23
24 # Years of age or between 14.6 and 41.4 years old.

```

R code Exa 3.6.a Mean Absolute Deviation

```

1 # Mean absolute deviation :
2
3 x<- c(55,100,125,140,60)
4 n = 5
5
6 # a = abs(x - x_bar), where x_bar = sum(x)/n
7 a <- c(41,4,29,44,36)
8

```

```
9 x <- cbind(x,a)
10 View(x)
11
12 # MAD :
13 mean_dev <- sum(a)/n
14 mean_dev
```

R code Exa 3.6.b Variance and Standard deviation

```
1 # Variance and stanadard deviation :
2
3 x<- c(55,100,125,140,60)
4 n = 5
5
6 # a = abs(x - x_bar) , where x_bar = sum(x)/n
7 a <- c(41,4,29,44,36)
8
9 # b = (x - x_bar)^2
10 b <- c(1681,16,841,1936,1296)
11
12 y <- cbind(x,a,b)
13 View(y)
14
15 # Variance :
16 var(x)
17
18 # standard deviation :
19 sd(x)
```

R code Exa 3.7 Mean Median Mode Variance and Standard deviation

```
1 # Mean, Median, Mode, Variance, and Standard
  deviation :
```

```

2
3 class <- c("10-under-15", "15-under-20", "20-under-25"
 , "25-under-30", "30-under-35",
4           "35-under-40", "40-under-45", "45-under-50"
 )
5 freq <- c(6,22,35,29,16,8,4,2)
6 class <-data.frame(class,freq)
7 class
8
9 # Mean of each intervals :
10 a <- mean(10:15)
11 b<-mean(15:20)
12 c<-mean(20:25)
13 d<-mean(25:30)
14 e<-mean(30:35)
15 f<-mean(35:40)
16 g<-mean(40:45)
17 h<-mean(45:50)
18 Mean <- rbind(a,b,c,d,e,f,g,h)
19 Mean
20
21 # fM :
22 for(i in 1:8)
23 {
24   fM <- freq * Mean
25 }
26 fM
27
28 # group mean :
29 Group_mean <- sum(fM) / sum(freq)
30 Group_mean
31
32 # Mean - group mean :
33 for(i in 1:8)
34 {
35   Mean_grpmean <- Mean - Group_mean
36 }
37 Mean_grpmean

```

```
38
39 # Square of Mean_grpmean :
40 Mean_grpmean_sq <- Mean_grpmean^2
41 Mean_grpmean_sq
42
43 # freq * Mean_grpmean_sq :
44 freq_Mean_grpmean_sq <- freq * Mean_grpmean_sq
45 freq_Mean_grpmean_sq
46
47
48 var <- sum(freq_Mean_grpmean_sq)/(sum(freq)-1)
49 var
50 sd <- sqrt(var)
51 sd
```

Chapter 4

Probability

R code Exa 4.1 Addition Law

```
1 # Addition Law : P(F and P) = P(F) + P(P) - P(F or P)
2
3 Type_of_position <- c("Managerial", "Professional", "Technical", "Clerical")
4 Sex_male <- c(8,31,52,9)
5 Sex_female <- c(3,13,17,22)
6 total_r <- c(11,44,69,31)
7 total_c <- c(" ",100,55,55)
8 Compy_HR_data <- cbind(Type_of_position,Sex_male,
                           Sex_female,total_r)
9 Compy_HR_data <- rbind(Compy_HR_data,total_c)
10 View(Compy_HR_data)
11
12 # F denote the event of female and P denote the
   event of professional worker
13
14 # Probability of event of female :
15 Pb_F = sum(Sex_female)/sum(sum(Sex_female),sum(Sex_
   male))
16 Pb_F
```

```

17
18 # Probability of event of professional worker :
19 Pb_P = sum(Sex_male[2],Sex_female[2])/sum(sum(Sex_
    female),sum(Sex_male))
20 Pb_P
21
22 # Probability of female or Professional worker :
23 Pb_F_P = Sex_female[2]/sum(sum(Sex_female),sum(Sex_
    male))
24 Pb_F_P
25
26 # probability that the employee is female or a
    professional worker :
27 Pb_F_a_P <- Pb_F + Pb_P - Pb_F_P
28 Pb_F_a_P

```

R code Exa 4.3 Special Law of Addition

```

1 # Special Law of Addition : P (T and C) = P (T) + P
    (C)
2
3 Type_of_position <- c("Managerial", "Professional","
    Technical", "Clerical")
4 Sex_male <- c(8,31,52,9)
5 Sex_female <- c(3,13,17,22)
6 total_r <- c(11,44,69,31)
7 total_c <- c(" ",100,55,55)
8 Compy_HR_data <- cbind(Type_of_position,Sex_male,
    Sex_female,total_r)
9 Compy_HR_data <- rbind(Compy_HR_data,total_c)
10 View(Compy_HR_data)
11
12 # T denote technical , C denote clerical , and P
    denote professional .
13

```

```

14 # Probability of Technical position :
15 Pb_T = sum(Sex_male[3],Sex_female[3])/sum(sum(Sex_
    female),sum(Sex_male))
16 Pb_T
17
18 # Probability of Clerical position :
19 Pb_C = sum(Sex_male[4],Sex_female[4])/sum(sum(Sex_
    female),sum(Sex_male))
20 Pb_C
21
22 # Probability of professional position :
23 Pb_P = sum(Sex_male[2],Sex_female[2])/sum(sum(Sex_
    female),sum(Sex_male))
24 Pb_P
25
26 # probability that a worker is either technical or
    clerical is :
27 Pb_T_C = Pb_T + Pb_C
28 Pb_T_C
29
30 # probability that a worker is either professional
    or clerical is :
31 Pb_P_C = Pb_P + Pb_C
32 Pb_P_C

```

R code Exa 4.5 Multiplication Law

```

1 # General Law of Multiplication : P (X or Y) = P(X)*
    P(Y|X) = P(Y)*P(X|Y)
2
3 Total_emp = 140
4 supervisor = 30
5 Married_emp = 80
6 Pb_S_M = .20 # P(S|M) i.e. married employees are
    supervisors

```

```

7
8 # probability that the employee is married :
9 Pb_M = Married_emp/Total_emp
10 Pb_M
11
12 # probability that the employee is married and is a
13 supervisor :
13 Pb_M_s <- Pb_M * Pb_S_M
14 Pb_M_s
15
16 # 11.43% of the 140 employees are married and are
16 supervisors

```

R code Exa 4.6 General Law of Multiplication

```

1 # General Law of Multiplication :
2
3 Industry_type <- c("Finance_A", "Manufacturing_B",
4 Communication_C")
5 Northeast_D <- c(.12,.15,.14)
6 Southeast_E <- c(.05,.03,.09)
7 Midwest_F <- c(.04,.11,.06)
8 West_G <- c(.07,.06,.08)
9 total_r <- c(.28,.35,.37)
10 total_c <- c(" ",.41,.17,.21,.21,1.00)
11 Industry_type <- cbind(Industry_type,Northeast_D,
12 Southeast_E,Midwest_F,West_G,total_r)
12 View(Industry_type)
13
14 # a.) P(Manufacturing_B and Southeast_E) :
15 P_B_E <- total_r[2] *(Southeast_E[2]/total_r[2])
16 P_B_E
17
18 # b.) P(West_G and Finance_A) :

```

```

19 P_G_A <- sum(Midwest_F) *(West_G[1] /sum(Midwest_F))
20 P_G_A
21
22 # c.) P(Manufacturing_B and Communication_C) :
23 P_B_C <- .0
24 P_B_C # The matrix shows no intersection for these
      two events.
25 # Thus B and C are mutually exclusive.

```

R code Exa 4.8 Special Law of Multiplication

```

1 # Special law of Mulyiplication : If X, Y are
  independent , P (X or Y) = P (X) * P (Y)
2
3
4 T1 <- c("A" , "B" , "C")
5 D <- c(8,20,6)
6 E <- c(12,30,9)
7 total_r <- c(20,50,15)
8 total_c <- c(" " ,34,51,85)
9 T1 <- cbind(T1,D,E,total_r)
10 T1 <- rbind(T1,total_c)
11 View(T1)
12
13 # Probability of B :
14 Pb_B = sum(D[2] ,E[2]) /sum(total_r)
15 Pb_B
16
17 # Probability of D :
18 Pb_D = sum(D) /sum(total_r)
19 Pb_D
20
21 # Probability of B and D is :
22 Pb_B_D = Pb_B * Pb_D
23 Pb_B_D

```

R code Exa 4.9 Conditional Probability

```
1 # Conditional Probability : P (X|Y) = P(X or Y)/P(Y)
2 # = (P(X)*P(Y|X))/P(Y)
3 Industry_type <- c("Finance_A", "Manufacturing_B", "
4 Communication_C")
5 Northeast_D <- c(.12,.15,.14)
6 Southeast_E <- c(.05,.03,.09)
7 Midwest_F <- c(.04,.11,.06)
8 West_G <- c(.07,.06,.08)
9 total_r <- c(.28,.35,.37)
10 total_c <- c(" ",.41,.17,.21,.21,1.00)
11 Industry_type <- cbind(Industry_type,Northeast_D,
12 Southeast_E,Midwest_F,West_G,total_r)
12 Industry_type <- rbind(Industry_type,total_c)
13 View(Industry_type)
14 #a.) P(Manufacturing_B | Midwest_F) = P(
15 Manufacturing_B and Midwest_F)/P(Midwest_F)
16 Pb_B_F = Midwest_F[2]/sum(Midwest_F)
17 Pb_B_F
18 #b.) P(West_G | Communication_C) = P(West_G and
19 Communication_C)/P(Communication_C)
20 Pb_G_C = West_G[3]/sum(Northeast_D[3],Southeast_E
21 [3],Midwest_F[3],West_G[3])
22 Pb_G_C
23 #c.) P(Northeast_D | Midwest_F) = P(Northeast_D and
24 Midwest_F)/P(Midwest_F)
25 Pb_D_F = .00/sum(Midwest_F)
26 Pb_D_F
```

R code Exa 4.11 Independent Event

```
1 # Independent Event : P(X|Y) = P(X) and P(Y|X) = P(Y)
2
3 T1 <- c("A", "B", "C")
4 D <- c(8, 20, 6)
5 E <- c(12, 30, 9)
6 total_r <- c(20, 50, 15)
7 total_c <- c(" ", 34, 51, 85)
8 T1 <- cbind(T1, D, E, total_r)
9 T1 <- rbind(T1, total_c)
10 View(T1)
11
12 # Check the ???rst cell in the matrix to ???nd
   whether P(A|D) = P(A)
13 Pb_A_D <- D[1]/sum(D) # P(A|D)
14 Pb_A_D
15
16 P_A <- sum(D[1], E[1])/sum(total_r)
17 P_A # P(A)
```

R code Exa 4.12 Bayes Rule

```
1 # Bayes 's Rule : P (Xi|Y) = P(Xi)*P(Y|Xi) / P(X1)*P(
   Y|X1)+P(X2)*P(Y|X2)+...+P(Xn)*P(Y|Xn)
2
3 Event <- c("A", "B", "C")
4 Prior <- c(.60, .30, .10) # P(Ei)
5 Conditional <- c(.40, .50, .70) # P(x | Ei)
6 Joint <- c(.24, .15, .07) # P(X and Ei) = P(Ei)*P(x |
   Ei)
```

```
7 Posterior <- c(.52,.33,.15) # P(X and Ei)/sum(P(X  
and Ei))  
8  
9 machine <- cbind(Event,Prior,Conditional,Joint,  
Posterior)  
10 machine  
11  
12 # Revised Probabilities :  
13 machine_A <- Prior[1]* Conditional[1]/sum(Joint)  
14 machine_A  
15  
16 machine_B <- Prior[2]* Conditional[2]/sum(Joint)  
17 machine_B  
18  
19 machine_C <- Prior[3]* Conditional[3]/sum(Joint)  
20 machine_C
```

Chapter 5

Discrete Distributions

R code Exa 5.1 Variance and standard deviation of a Discrete Distribution

```
1 # Variance and standard deviation of a Discrete  
2 # Distribution :  
3 Prize <- c(1000,100,20,10,4,2,1,0) # x  
4 Probability <- c  
  (.00002,.00063,.00400,.00601,.02403,.08877,.10479,.77175)  
  # P(x)  
5  
6 # x * P(x) :  
7 for(i in 1:8){  
8   x_Pb <- Prize*Probability  # x * P(x)  
9 }  
10 print(x_Pb)  
11  
12 # sum Of x * P(x) :  
13 x_Pb_s <- sum(x_Pb)  
14 x_Pb_s  
15  
16  
17 # (x - x_Pb_s)^2  
18 for(j in 1:8){
```

```

19   x_mean_sq <- (Prize - x_Pb_s)^2
20 }
21 print(x_mean_sq)
22
23
24 # (x - x_Pb_s)^2 * P(x) :
25 for(j in 1:8){
26   x_mean_sq_Pb <- (Prize - x_Pb_s)^2 * Probability
27 }
28 print(x_mean_sq_Pb)
29
30 # sum of (x - x_Pb_s)^2 * P(x) :
31 x_mean_sq_Pb_s <- sum(x_mean_sq_Pb)
32 x_mean_sq_Pb_s
33
34 Prize <- cbind(Prize,Probability,x_mean_sq,x_mean_sq
35 _Pb)
36 View(Prize)
37
38 # Variance and Standard deviation :
39 var
40 sd <- sqrt(var)
41 sd

```

R code Exa 5.2 Binomial Distribution

```

1 # Binomial Distribution : P(x) = nCx*p^x*q^(n-x) = n! /
2           x!(n - x)! * p^x*q^(n-x)
3
4 p = .65
5 q = 1-p
6 n = 25
7 x = 19
7 x1 = 0:19

```

```
8
9 # Binomial Distribution through inbuild function in
  r :
10 bd <- dbinom(x,n,p)
11 bd
12
13 # Binomial Distribution through formula :
14 bd <- (factorial(n)/(factorial(x)*factorial(n-x))) *
  (p^x) * (q^(n-x))
15 bd
```

R code Exa 5.3 Binomial Distribution ex 2

```
1 # Binomial Disribution ex 2 :
2
3 p = .06
4 q = .94
5 n = 20
6
7 x <- c(0,1,2)
8 c<-choose(n,x)*(p^x) * (q^(n-x))
9 c
10 sum(c)
```

R code Exa 5.5 Using Binomial Table

```
1 # using Binomial Table :
2
3 n = 20
4 p = .10
5 q = 1-p
6
7 x <- c(0,1,2,3)
```

```

8 c<-choose(n,x)*(p^x) * (q^(n-x))
9 c
10
11 # Probability that fewer than four purchasers
   choose Oreos i.e. x<4 :
12 sum(c) # about 86.7% of the time fewer than four of
   the 20 will select Oreos

```

R code Exa 5.6 Mean and standard deviation in Binomial distribution

```

1 # Mean and standard deviation in Binomial
   distribution :
2 # mean = n * p and sd = sqrt(n*p*q)
3
4 n = 10
5 p<-c(.10,.20,.30,.40)
6 q = 1-p
7
8 # mean <- n*p
9 for(p1 in 1:4){
10   mean = n*p
11 }
12 print(mean)
13
14 pd<-pbinom(2,n,p)
15
16
17 p<-cbind(p,mean,pd)
18 p

```

R code Exa 5.7 Poissons formula

```

1 # Poission formula : P(x) =lamda^x*e^-lamda/x!

```

```

2
3 l <- 3.2 # lamda
4 # x>7 customers/4 minutes
5
6 # through in build function of poission in r:
7 dpois(8,lambda = 3.2) # x=8
8
9 # x = 8 through formula :
10 x = 8
11 pd_8 <- (l^x*exp(-l))/factorial(x)
12 pd_8
13
14 # x = 9 through formula :
15 x = 9
16 pd_9 <- (l^x*exp(-l))/factorial(x)
17 pd_9
18
19 # x = 10 through formula :
20 x = 10
21 pd_10 <- (l^x*exp(-l))/factorial(x)
22 pd_10
23
24 # x = 11 through formula :
25 x = 11
26 pd_11 <- (l^x*exp(-l))/factorial(x)
27 pd_11
28
29 # x = 12 through formula :
30 x = 12
31 pd_12 <- (l^x*exp(-l))/factorial(x)
32 pd_12
33
34 # x = 13 through formula :
35 x = 13
36 pd_13 <- (l^x*exp(-l))/factorial(x)
37 pd_13
38
39 # Poission distribution for x>=8

```

```
40 sum(pd_8,pd_9,pd_10,pd_11,pd_12,pd_13)
```

R code Exa 5.8 Poisson distribution Example

```
1 # Poisson distribution Example :  
2 # Poission formula : P(x) =lamda^x*e^-lamda/x!  
3  
4 l=3.2  
5 x = 10  
6 pd <- dpois(x,l,log=FALSE)  
7 pd  
8  
9 # probability of getting exactly 10 customers during  
# an 8-minute interval  
10 l1=6.4  
11 x1 = 10  
12 pd1 <- dpois(x1,l1,log=FALSE)  
13 pd1
```

R code Exa 5.9 Using poissions table

```
1 # using poission table :  
2  
3 l <- 1.6  
4 x<- c(6,7,8,9)  
5  
6  
7 # Poission probability for x>5 :  
8 p<-dpois(x,l)  
9 p  
10 sum(p)
```

R code Exa 5.10 Probability Example

```
1 # Probability Example :
2
3 p = .0003
4 n= 10000
5 l <- n*p
6 l
7 x<- c(7,8,9,10,11,12)
8
9 # Binomial probability for x>5 :
10 b<-dbinom(x,n,p)
11 b
12 sum(b)
13
14
15 # Poission probability for x>5 :
16 p<-dpois(x,1)
17 p
18 sum(p)
```

R code Exa 5.11 Hypergeometrics distribution

```
1 # Hypergeometric distribution : P(x) = ACx*(N-A)C(n-
x)/NCn
2
3 # N = size of the population , n = sample size , A =
   number of successes in the population , x = number
   of successes in the sample; sampling is done
   without replacement
4
5 N = 18
```

```
6 n = 3
7 A = 12
8
9 # Using choose function :
10
11 1 - ((choose(A,0)*choose((N-A),n))/choose(N,n))
```

Chapter 6

Continuous Distributions

R code Exa 6.1 Uniform Distribution

```
1 # Probabilities in Uniform Distribution : P(x) = x2-
  x1 / b-a where: a<=x1<=x2<=b
2
3 b = 39
4 a = 27
5
6 f_x = 1/(b-a) # f(x)
7 f_x
8
9 u <- (a+b)/2 #mean
10 u
11
12 sd <- (b-a)/sqrt(b-a) # standard deviation
13 sd
14
15 # P(30 <= x <= 35) :
16 P = (35-30)/(39-27)
17 P
18
19 # P(x<30) :
20 P1 = (30-27)/(39-27)
```

R code Exa 6.2 MEAN AND STANDARD DEVIATION OF A UNIFORM DISTRIBUTION

```
1 # MEAN AND STANDARD DEVIATION OF A UNIFORM  
# DISTRIBUTION :  
2  
3 u = 691 # mean  
4 a = 200  
5 b = 1182  
6 x1 = 410  
7 x2 = 825  
8 sd <- (b-a)/sqrt(12) # standard deviation  
9 sd  
10  
11 # height of distribution :  
12 f_x = 1/(b-a) # f(x)  
13 f_x  
14  
15 # probability that a randomly selected person pays  
# between $410 and $825 annually for automobile  
# insurance in the US:  
16 p_x = (x2-x1)/(b-a)  
17 p_x
```

R code Exa 6.3 Normal Curve distribution

```
1 # Normal Curve distribution :  
2  
3 mean = 494  
4 sd=100  
5 x =700
```

```
6  
7 # probability of x greater than 700 :  
8 pnorm(x, mean, sd, lower.tail=FALSE)
```

R code Exa 6.4 PROBABILITY OF A UNIFORM DISTRIBUTION

```
1 # PROBABILITY OF A UNIFORM DISTRIBUTION  
2  
3 x = 550  
4 mean = 494  
5 sd = 100  
6 lb = .2123 # probability of values between 550 and  
the mean  
7 ub = .5000 # probability of values less than the  
mean  
8  
9  
10 # using r function :  
11 pnorm(x, mean, sd)  
12  
13 # Or using normal formula :  
14 z=(x-mean)/sd  
15 z  
16  
17 ub+lb # probability of values 550
```

R code Exa 6.5 Probability of Normal Curve DISTRIBUTION

```
1 # Probability of Normal Curve DISTRIBUTION :  
2  
3 x = 600  
4 mean = 494  
5 sd = 100
```

```
6 x1 = 300
7
8 a <- pnorm(x1, mean, sd, lower.tail=FALSE)
9 a
10 b <- pnorm(x, mean, sd, lower.tail=FALSE)
11 b
12
13 # probability of a value between 300 and 600 :
14 a - b
```

R code Exa 6.6 PROBABILITY OF A UNIFORM DISTRIBUTION

```
1 # PROBABILITY OF A UNIFORM DISTRIBUTION
2
3 x = 350
4 mean = 494
5 sd = 100
6 x1 = 450
7
8 a <- pnorm(x, mean, sd, lower.tail=FALSE)
9 a
10 b <- pnorm(x1, mean, sd, lower.tail=FALSE)
11 b
12
13 # probability of a value between 350 and 450 :
14 a-b
```

R code Exa 6.7 MEAN OF A UNIFORM DISTRIBUTION

```
1 # MEAN OF A UNIFORM DISTRIBUTION
2
3 x = 449
4 z = 1.11 # value taken from z table
```

```
5 sd = 36
6 # z = (x - mean) / sd
7
8 mean = x - (z*sd)
9 mean
```

R code Exa 6.8 Normal distribution using z value

```
1 # Normal distribution using z value :
2
3 mean = 3.58
4 z = -0.46 # value taken from z table
5 sd = 1.04
6 # z = (x - mean) / sd
7
8 x = (z*sd) + mean
9 x
10
11 # 67.72% of the daily average amount of solid waste
     per person weighs more than 3.10 pound.
```

R code Exa 6.9 Binomial distribution problem by using the normal distribution

```
1 # binomial distribution problem by using the normal
   distribution :
2
3 x = 12
4 n = 25
5 p = .40
6 q = 1 - p
7
8 mean = n * p
```

```

9 mean
10
11 sd = sqrt(n*p*q)
12 sd
13
14 # test : mean +/- 3sd
15 test1 <- mean + 3*sd
16 test2 <- mean - 3*sd
17 test1
18 test2
19
20 # test : 2.65 to 17.35
21
22 # z value at x = 12.5
23 x = 12.5
24 z = (x-mean)/sd
25 z
26
27 # z value at x = 11.5
28 x = 11.5
29 z = (x-mean)/sd
30 z
31
32 #z = 1.02 produces a probability of .3461.
33 # z = 0.61 produces a probability of .2291.
34
35 # The difference in areas yields the following
   answer:
36 0.3461 - .2291

```

R code Exa 6.10 Binomial distribution by using the normal distribution

```

1 # Binomial distribution by using the normal
   distribution :
2

```

```

3 p = .37
4 n = 100
5 q=1-p
6 mean1 = n*p
7 mean1
8 sd = sqrt(n*p*q)
9 sd
10
11 # range :
12 u = mean +3*(sd)
13 u
14 l = mean - 3*(sd)
15 l
16
17 x = 26.5
18 z=(x-mean)/sd
19 z
20
21 # tail of the distribution :
22 .5000-.4850
23
24 x1 <- c(26:20)
25 b<-dbinom(x1,n,p)
26 b
27 sum(b)

```

R code Exa 6.11 Exponential Distribution

```

1 # Exponential Distribution : f(x) = lambda * e^-lambda*x
2
3 # Probability of right tail exponential distribution
# : P(x>=x0) = e^-lambda*x0
4
5 l = 1.38 # lambda

```

```
6 mean = 1/1
7 mean
8 x0 = .75
9
10 # P(x>=x0) :
11 P <- exp(-1*x0)
12 P
13
14 # for x0 = 0.75, Probability < x0 :
15 Prob = 1-P
16 Prob
```

Chapter 7

Sampling and Sampling Distributions

R code Exa 7.1 Z formula for sample means

```
1 # Z formula for sample means : z = (sample_mean -  
2 # average)/(standard_dev/sqrt(sample_size))  
3 mean = 448  
4 sd = 21/sqrt(49)  
5 n = 49 # sample size  
6 # sample mean : 441 <= x_bar <= 446  
7 samplemean_l = 441  
8 samplemean_u = 446  
9  
10 a <-pnorm(samplemean_l, mean, sd, lower.tail=FALSE)  
11 a  
12 b <-pnorm(samplemean_u, mean, sd, lower.tail=FALSE)  
13 b  
14  
15  
16 # probability of a value being between z = -2.33  
# and -0.67 is :  
17 prob = a - b
```

```
18 prob
19
20 # The probability of a value being between z=2.33
   and -0.67 is .2426; that is ,
21 # there is a 24.26% chance of randomly selecting 49
   hourly periods for
22 # which the sample mean is between 441 and 446
   shoppers.
```

R code Exa 7.2 Z formula for Sample mean of a finite population

```
1 # Z formula for Sample mean of a finite population :
2 # z = (samplemean - population_mean)/(sd/sqrt(n))*( 
3   sqrt((N-n)/(N-1)))
4
5 pop_mean = 37.6 # avg
6 pop_sd = 8.3 # sd
7 n = 45 # sample size
8 N = 360 # finite population
9 sample_mean = 40
10
11 sd = (pop_sd/sqrt(n))*(sqrt((N-n)/(N-1)))
12 pnorm(sample_mean, pop_mean, sd, lower.tail=TRUE)
```

R code Exa 7.3 Z formula for Sample Proportion

```
1 # Z formula for Sample Proportion :
2 # z = (sample_proportion - population_prop)/sqrt((
3   population_prop*q)/sample_size)
4
5 p = 0.10 # population_prop
6 sample_prop = 12/80
```

```
6 n = 80
7 q = 1-p
8
9 sd = sqrt(p*q/n)
10
11 # P(sample_prop >= .15) :
12 pnorm(sample_prop,p, sd, lower.tail=FALSE)
```

Chapter 8

Statistical Inference Estimation for Single Populations

R code Exa 8.1 Confidence interval to Estimate Population mean

```
1 # Confidence interval to Estimate Population mean :  
2 # pop_mean +/- z*(sd/sqrt(n))  
3  
4 n = 44  
5 sample_mean = 10.455  
6 sd = 7.7  
7 z = 1.645  
8  
9 pop_mean_1 = sample_mean - (z*(sd/sqrt(n)))  
10 pop_mean_1  
11  
12 pop_mean_2 = sample_mean + (z*(sd/sqrt(n)))  
13 pop_mean_2
```

R code Exa 8.2 Confidence interval to Estimate Population mean using Finite Correction

```

1 # Confidence interval to Estimate Population mean
  using finite correction :
2 # (pop_mean) +/- (z*(sd/sqrt(n))*sqrt(N-n/N-1))
3
4 n = 50
5 N = 800
6 sample_mean = 34.30
7 sd = 8
8 z = 2.33
9
10 pop_mean_1 = sample_mean - (z*(sd/sqrt(n))*sqrt((N-n
    )/(N-1)))
11 pop_mean_1
12
13 pop_mean_2 = sample_mean + (z*(sd/sqrt(n))*sqrt((N-n
    )/(N-1)))
14 pop_mean_2

```

R code Exa 8.3 Confidence Interval to Estimate population mean Population standard deviation unknown and population normally distributed

```

1 # Confidence Interval to Estimate population mean :
  Population standard devition unknown and
  population normally distributed
2 # pop_mean +/- t*(sd/sqrt(n)) , df = n-1
3 a<- c(3,1,3,2,5,1,2,1,4,2,1,3,1,1)
4 n = 14
5 df = n-1
6 t = 3.012
7 sd = 1.29
8 sample_mean = 2.14
9
10 pop_mean_1 = sample_mean - (t*(sd/sqrt(n)))
11 pop_mean_1
12

```

```
13 pop_mean_2 = sample_mean + (t*(sd/sqrt(n)))
14 pop_mean_2
```

R code Exa 8.4 Confidence Interval to estimate Population Proportion

```
1 # Confidence Interval to estimate Population
  Proportion :
2 # p = samp_prop +/- (z*sqrt(samp_prop*q/sample_size))
3
4 samp_prop = 0.51
5 q = 1-samp_prop
6 z = 1.75
7 n = 210 # sample size
8
9 p_1 = samp_prop - (z*sqrt(samp_prop*q/n))
10 p_1
11
12 p_2 = samp_prop + (z*sqrt(samp_prop*q/n))
13 p_2
```

R code Exa 8.5 Confidence Interval to estimate Population Proportion

```
1 # Confidence Interval to estimate Population
  Proportion :
2 # p = samp_prop +/- (z*sqrt(samp_prop*q/sample_size))
3
4 samp_prop = 34/212 # sample size =212 and no. of
  jeans = 34
5 q = 1-samp_prop
6 z = 1.645
7 n = 212 # sample size
8
9 p_1 = samp_prop - (z*sqrt(samp_prop*q/n))
```

```
10 p_1
11
12 p_2 = samp_prop + (z*sqrt(samp_prop*q/n))
13 p_2
```

R code Exa 8.6 Confidence to estimate the Population Variance

```
1
2 # Confidence to estimate the Population Variance :
3 # var = ((n-1)*s^2)/(X(a/2))^2 or ((n-1)*s^2)/(X(1-a/2))^2 , df = n-1
4
5 s = 1.12
6 n = 25
7 df = n-1
8
9 a = qchisq(0.975, df=24)
10 a
11 b = qchisq(.025, df=24)
12 b
13
14 var_1 = ((n-1)*s^2)/a
15 var_1
16
17 var_2 = ((n-1)*s^2)/b
18 var_2
```

R code Exa 8.7 Sample Size when Estimating Population mean

```
1 # Sample Size when Estimating Population mean :
2 # n = (z*sd/E)^2
3
4 E = 1 # error in estimating
```

```
5 z = 1.96
6 sd = 5
7
8 n = (z*sd/E)^2
9 n
```

R code Exa 8.8 Sample size when estimating population proportion

```
1 # Sample size when estimating population proportion
  :
2 # n = z^2*p*q/E^2
3
4 E = .03
5 p = .40
6 z = 2.33
7 q = 1-p
8
9 n = z^2*p*q/E^2
10 n
```

Chapter 9

Statistical Inference Hypothesis Testing for Single Populations

R code Exa 9.1 Test Hypothesis about population mean

```
1 # Formula to test Hypoyhesis about population mean
  :
2 # z = sample_mean - pop_mean/(sd/sqrt(n))
3
4 pop_mean = 4.30
5 sample_mean = 4.156
6 sd = .574
7 n = 32
8 a = .05 # alpha value
9
10 # Calculated value of test statistic :
11 z1 = (sample_mean - pop_mean)/(sd/sqrt(n))
12 z1
13
14 # Critical Z value associated with alpha = 0.05 :
15 z = qnorm(.05,lower.tail=TRUE)
16 z
17
18 # critical sample mean :
```

```
19 sample_mean_c = (z * (sd/sqrt(n))) + pop_mean  
20 sample_mean_c
```

R code Exa 9.2 t test for population mean

```
1 # t test for population mean :  
2 # t = (sample_mean - pop_mean) / (sd/sqrt(n)) , df =  
    n-1  
3  
4 pop_mean = 471  
5 sample_mean = 498.78  
6 sd = 46.94  
7 n = 23  
8 alpha = 0.05  
9 df = n-1  
10  
11 # t-distribution function to calculate critical t-  
    value using alpha and df:  
12 qt(alpha, df, lower.tail = FALSE, log.p = FALSE)  
13  
14 # Observed t value using sample mean and standard  
    deviation :  
15 t = (sample_mean - pop_mean) / (sd/sqrt(n))  
16 t  
17  
18 # The observed t value of 2.84 is greater than the  
    table t value of 1.717,  
19 # so the business researcher rejects the null  
    hypothesis.
```

R code Exa 9.3 z test of a population proportion

```
1 # z test of a population proportion :
```

```

2 # z = sample_prop - population_prop/sqrt(population_
   prop*q/n)
3
4 n = 550
5 x = 115
6 sample_prop = 115/550
7 population_prop = .17
8 q = 1- population_prop
9
10 # test statistic value of z :
11 z1 = (sample_prop - population_prop)/sqrt((
   population_prop*q)/n)
12 z1
13
14 # critical value of z :
15 z = qnorm(.05,lower.tail=FALSE)
16 z
17
18 # critical sample proportion :
19 sample_prop_c = z * sqrt(population_prop*q/n) +
   population_prop
20 sample_prop_c

```

R code Exa 9.4 Test Hypothesis about a population variance

```

1 # Test Hypothesis about a population variance :
2 # X^2 = (n-1)*s^2/var , df = n-1
3
4 var = 25
5 n = 16
6 s_sq = 28.0625 # sample variance
7 df = n-1
8
9 # Two tailed test and alpha = .10 it will be divided
   by 2 :

```

```

10 a <- .10/2
11
12 # we have two critical values of chi square :
13
14 # 1st chi-sq value is a :
15 qchisq(a, df=15)
16
17 # 2nd chi-sq is 1-a :
18 qchisq(1-a, df=15)
19
20 # The decision rule is to reject the null hypothesis
   if the observed value
21 # of the test statistic is less than 7.26093 or
   greater than 24.9958.
22
23 X_sq = ((n-1)*s_sq)/var
24 X_sq
25
26 # This observed chi-square value is in the
   nonrejection region because
27 # chi_sq(.05)=7.26 < chi_sq(observed) = 16.83 < chi_
   sq(.95) = 24.9958.
28 # The company fails to reject the null hypothesis .
   The population variance
29 # of overtime hours per week is 25.

```

R code Exa 9.5 Z value for Type II error

```

1 # Z value for Type II error : z = sample_mean_c -
   pop_mean_1/(sd/sqrt(n))
2
3 sample_mean_c = 11.979
4 pop_mean_1 = 11.96
5 sd = .10
6 n = 60

```

```

7
8 z = (sample_mean_c - pop_mean_1)/(sd/sqrt(n))
9 z

```

R code Exa 9.6 Z value for Type II error

```

1 # Z value for Type II error
2
3 z_c = 1.96
4 p = .40
5 q = 1-p
6 n = 250
7 # z_c = (p_c-p)/sqrt(p*q/n)
8 p_c = z_c*sqrt((p*q)/n)+p
9 p_c
10 p_c1 = z_c*sqrt((p*q)/n)-p
11 p_c1
12
13 # z value on taking p_c = .46 and p = .36 :
14 p_c = .46
15 p = .36
16 z_c = (p_c-p)/sqrt(p*q/n)
17 z_c
18
19 # z value on taking p_c = .34 and p = .36 :
20 p_c = .34
21 p = .36
22 z_c = (p_c-p)/sqrt(p*q/n)
23 z_c
24
25 # The area associated with z = 3.29 is .4995.
    Combining this value with the .2454 obtained from
    the left side of the distribution in graph (b)
    yields the total probability of committing a Type
    II error:

```

26 . 2454+.4994

Chapter 10

Statistical Inferences About Two Populations

R code Exa 10.1 Z formula for the difference in Two Sample Means

```
1 # z formula for the difference in two sample means :
2 # z = (samp_mean_1-samp_mean_2)-(pop_mean_1-pop_mean
3 # _2)/sqrt((sd1^2/n1)+(sd2^2/n2))
4 samp_mean_1 = 3352
5 samp_mean_2 = 5727
6 sd1 = 1100
7 sd2 = 1700
8 n1 = 87
9 n2 = 76
10
11 # Observed value of Z :
12 z1 = ((samp_mean_1-samp_mean_2)-(0))/sqrt((sd1^2/n1)
13 # +(sd2^2/n2))
14 z1
15 # Critical value of Z :
16 z = qnorm(.001, mean = 0, sd = 1, lower.tail = TRUE,
log.p = FALSE)
```

```

17 z
18
19 # sample critical :
20 s_c = (0)-(z*sqrt((sd1^2/n1)+(sd2^2/n2)))
21 s_c
22
23 # The difference in sample means would need to be at
   least 704.23
24 # to reject the null hypothesis.
25
26 # The actual sample difference in this problem :
27 s_c = samp_mean_1-samp_mean_2
28 s_c # which is considerably larger than the critical
      value of difference
29
30 # Thus, with the critical value method also , the
   null hypothesis is rejected.

```

R code Exa 10.2 Confidence Interval to estimate difference in two population means

```

1 # Confidence Interval to estimate difference in two
   population means :
2 # pop_mean_1-pop_mean_2 = (samp_mean_1-samp_mean_2)
   +/- (z*sqrt((sd1^2/n1)+(sd2^2/n2)))
3
4 n1 = 50
5 n2 = 50
6 samp_mean_1 = 21.45
7 samp_mean_2 = 24.6
8 sd1 = 3.46
9 sd2 = 2.99
10 z = 1.96
11 pmean_diff_1 = (samp_mean_1-samp_mean_2) + (z*sqrt((
   sd1^2/n1)+(sd2^2/n2)))

```

```

12 pmean_diff_1
13
14 pmean_diff_2 = (samp_mean_1-samp_mean_2) - (z*sqrt((
    sd1^2/n1)+(sd2^2/n2)))
15 pmean_diff_2

```

R code Exa 10.3 t formula to test the difference in means assuming the standard deviations are equal

```

1 # t formula to test the difference in means assuming
  sd1, sd2 are equal :
2 #t = (samp_mean_1-samp_mean_2)-(pop_mean_1-pop_mean_
  2)/(sqrt((s1^2(n1-1))+(s2^2(n2-1))/n1+n2-2))*sqrt(
  ((1/n1)+(1/n2)))
3
4 n1 = 46
5 n2 = 26
6 samp_mean_1 = 5.42
7 samp_mean_2 = 5.04
8 s1 = .58
9 s2 = .49
10 df = n1+n2-2
11
12 # Critical t value :
13 qt(.005, df, lower.tail = FALSE, log.p = FALSE)
14
15 # Observed t value :
16 t = ((samp_mean_1-samp_mean_2)-0)/(sqrt(((s1^2*(n1-
  1))+(s2^2*(n2-1)))/(n1+n2-2))*sqrt((1/n1)+(1/n2)))
17 t
18
19 # Because the observed value of is greater than the
  critical table value of the decision is to reject
20 # the null hypothesis

```

R code Exa 10.4 CONFIDENCE INTERVAL TO ESTIMATE difference in means ASSUMING THE POPULATION VARIANCES ARE UNKNOWN AND EQUAL

```
1 # CONFIDENCE INTERVAL TO ESTIMATE difference in  
means ASSUMING THE POPULATION VARIANCES ARE  
UNKNOWN AND EQUAL :  
2 n1 = 13  
3 n2 = 15  
4 samp_mean_1 = 4.35  
5 samp_mean_2 = 6.84  
6 s1 = 1.20  
7 s2 = 1.42  
8  
9 alpha = .025  
10 df = 26  
11  
12 t = qt(alpha, df, lower.tail = FALSE, log.p = FALSE)  
13 t  
14  
15 # p_m_diff = pop_mean_1 - pop_mean_2  
16 s_diff = samp_mean_1 - samp_mean_2  
17 b = sqrt(((s1^2 * (n1 - 1)) + (s2^2 * (n2 - 1))) / (n1 + n2 - 2))  
18 c = sqrt((1/n1) + (1/n2))  
19  
20  
21 p_m_diff_1 = s_diff - (t * b * c)  
22 p_m_diff_1  
23  
24 p_m_diff_2 = s_diff + (t * b * c)  
25 p_m_diff_2
```

R code Exa 10.5 t formula to test the Difference in Two Dependent Population

```
1 # t formula to test the Difference in Two Dependent
  Population :
2 # t = (mean_samp_diff - D) / (sd / sqrt(n))
3 # df = n-1
4 # D = mean_pop_diff , sd = sd_samp_diff , n = num_of_
  pairs , d= samp_diff_pair
5
6
7 Individual <- c(1,2,3,4,5,6,7)
8 Before <- c(32,11,21,17,30,38,14)
9 After <- c(39,15,35,13,41,39,22)
10 n = 7
11
12 for(i in 1:7){
13   d = Before - After
14 }
15 print(d)
16 Individual <- cbind(Individual,Before,After,d)
17 Individual
18
19 mean_samp_diff = sum(d)/n
20 mean_samp_diff
21 d1 = sum(d)/7
22
23 sd = sqrt((sum((d-mean_samp_diff)^2))/(n-1))
24 sd
25
26 D = 0
27 t = (mean_samp_diff - D) / (sd / sqrt(n))
28 t
29
30 # Because the observed value of -2.54 is less than
  the critical , table value of -1.943 and the
31 # p-value (0.022) is less than alpha (.05) , the
  decision is to reject the null hypothesis.
```

R code Exa 10.6 Z formula to test the difference in Population Proportion

```
1 # Z formula to test the difference in Population  
Proportion :  
2 # z = ((p1_c - p2_c)-(p1-p2)) / sqrt((p_c*q_c)*((1/  
n1)+(1/n2)))  
3 # p_c =((n1*p1_c)+(n2*p2_c))/(n1+n2)  
4 # q_c = 1 - p_c  
5  
6 n1 = 100  
7 n2 = 95  
8 p1_c = .24  
9 p2_c = .41  
10  
11 p_c =((n1*p1_c)+(n2*p2_c))/(n1+n2)  
12 p_c  
13 q_c = 1 - p_c  
14 q_c  
15 # p1 - p2 = 0  
16  
17 z = ( (p1_c - p2_c) - (0) ) / sqrt( (p_c*q_c) * ( (1/  
n1) + (1/n2) ) )  
18 z  
19  
20 # If a one-tailed test had been used ,zc would have  
been z.01 = 2.33 ,  
21 # and the null hypothesis would have been rejected .  
# If alpha had been .05 ,  
22 # zc would have been z. 025 = , and the null  
hypothesis would have been rejected .
```

R code Exa 10.7 F test for two Population Variance

```

1 # F test for two Population Variance :
2 # F = s1^2/s2^2
3 # df_num = v1 = n1-1 and df_deno = v2 = n2-1
4
5 # from given table we computed :
6 s1_sq = 5961428.6
7 s2_sq = 737142.9
8 n1 = 7
9 n2 = 8
10
11 # critical F-value :
12 qf(.01, df1=n1-1, df2=n2-1, lower.tail = FALSE, log.
    p = FALSE)
13
14 # Observed F- value :
15 F = s1_sq/s2_sq
16 F
17
18 # Because the observed value of F = 8.09 is greater
    than the table
19 # critical F value of 7.19, the decision is to
    reject the null hypothesis.

```

Chapter 11

Analysis of Variance and Design of Experiments

R code Exa 11.1 One Way ANOVA

```
1 # One Way ANOVA SSE, SSc, SST values :
2 # SSc = sum( nj*( xj_b-x_b) ^2)
3 # SSE = sum( sum(( xij-xj_b) ^2) )
4 # SST = sum( sum(( xij-x_b) ^2) )
5
6 a <- c(29,27,30,27,28)
7 b <- c(32,33,31,34,30)
8 c <- c(25,24,24,25,26)
9 df <- data.frame(a,b,c)
10 df
11
12 r = c(t(as.matrix(df))) # response data
13 r
14 f = c("a", "b", "c")      # treatment levels
15 k = 3                      # number of treatment
16 levels
17 n = 5
18 tm = gl(k, 1, n*k, factor(f)) # matching
```

```

    treatments
19 tm
20
21 av = aov(r ~ tm)
22 av
23 summary(av)

```

R code Exa 11.2 TUKEYs HSD Test

```

1 # TUKEYs HSD Test : HSD = q*sqrt(MSE/n) # q =
   critical value
2
3 a <- c(2.46,2.41,2.43,2.47,2.46)
4 b <- c(2.38,2.34,2.31,2.40,2.32)
5 c <- c(2.51,2.48,2.46,2.49,2.44)
6 d <- c(2.49,2.47,2.48,2.46,2.44)
7 e <- c(2.56,2.57,2.53,2.55,2.55)
8 df <- data.frame(a,b,c,d,e)
9 df
10
11
12 r = c(t(as.matrix(df))) # response data
13 r
14 f = c("a", "b", "c", "d", "e") # treatment levels
15 k = 5                         # number of treatment
   levels
16 n = 5
17
18 tm = gl(k, 1, n*k, factor(f)) # matching
   treatments
19 tm
20
21 av = aov(r ~ tm)
22 av
23 b <- summary(av)

```

```

24 b
25
26 # From above anova analysis we get MSE value :
27 MSE = 0.000618
28 q = 5.29
29 n = 5
30 HSD = q*sqrt(MSE/n)
31 HSD

```

R code Exa 11.3 Randomized Block Design

```

1 # Formula for computing Randomized Block Design for
  SSE, SSC, SSR, SST
2 # SSC = n*sum((xj_b-x_b)^2)
3 # SSR = C*sum((xi_b-x_b)^2)
4 # SSE = sum(sum((xij-xj_b-xi_b+x_b)^2))
5 # SST = sum(sum((xij-x_b)^2))
6
7 a <- c(3.47,3.43,3.44,3.46,3.46,3.44)
8 b <- c(3.40,3.41,3.41,3.45,3.40,3.43)
9 c <- c(3.38,3.42,3.43,3.40,3.39,3.42)
10 d <- c(3.32,3.35,3.36,3.30,3.39,3.39)
11 e <- c(3.50,3.44,3.45,3.45,3.48,3.49)
12 df <- data.frame(a,b,c,d,e)
13 df
14
15
16 r = c(t(as.matrix(df))) # response data
17 r
18 f = c("a", "b", "c", "d", "e") # treatment levels
19 k = 5 # number of treatment
  levels
20 n = 6
21
22 blk = gl(n, k, k*n) # blocking factor

```

```

23 blk
24
25 tm = gl(k, 1, n*k, factor(f)) # matching
   treatments
26 tm
27
28 av = aov(r ~ tm + blk)
29 av
30 b <- summary(av)
31 b

```

R code Exa 11.4 Two Way ANOVA

```

1 # Two-Way ANOVA :
2
3 Types_of_warehouses <- c("GM", "GM", "GM", "GM", "GM", "
4                                     "GM", "GM", "GM",
4                                     "Com", "Com", "Com", "Com", "
4                                     Com", "Com", "Com", "Com", "
4                                     Com",
5                                     "BS", "BS", "BS", "BS", "BS", "
5                                     BS", "BS", "BS", "BS",
6                                     "CS", "CS", "CS", "CS", "
6                                     CS", "CS", "CS", "CS", "
6                                     CS")
7
8
9 Training_sessions <- c("A", "A", "A", "B", "B", "B", "C",
10                            "C", "C", "A", "A", "A",
10                            "B", "B", "B", "C", "C", "C", "A",
10                            "A", "A", "B", "B", "B",
11                            "C", "C", "C", "A", "A", "A", "B",
11                            "B", "B", "C", "C", "C")
12
13 Values <- c(3, 4.5, 4, 2, 2.5, 2, 2.5,

```

```
1 ,1 .5 ,5 ,4 .5 ,4 ,1 ,3 ,2 .5 ,0 ,1 .5 ,2 ,2 .5 ,3 ,3 .5 ,1 ,3 , 1 .5 ,
14           3 .5 ,3 .5 , 4 ,2 ,2 ,3 ,5 , 4 .5 ,2 .5 ,4 , 4 .5 , 5 )
15
16 df <- data.frame(Types_of_warehouses ,Training_
17 sessions ,Values)
18 df
19 av <- aov(Values~as.factor(Types_of_warehouses)*as.
20 factor(Training_sessions) ,data= df)
21 summary(av)
```

Chapter 12

Simple Regression Analysis and Correlation

R code Exa 12.1 Slope of Regression line

```
1 # Slope of Regression line :  
2  
3 no_of_beds <- c(23,29,29,35,42,46,50,54,64,66,76,78)  
4 FTEs <- c  
      (69,95,102,118,126,125,138,178,156,184,176,225)  
5 Hospitals<-data.frame(no_of_beds,FTEs)  
6 Hospitals  
7  
8 # least squares equation of the regression line is :  
9 lm( FTEs ~ no_of_beds, data=Hospitals)  
10  
11 # y_c = 30.91 + 2.23 * x
```

R code Exa 12.2 Residual Analysis

```
1 # Residual Analysis :
```

```

2
3 Hospitals <- c(1,2,3,4,5,6,7,8,9,10,11,12)
4 x <- c(23,29,29,35,42,46,50,54,64,66,76,78)
5 y <- c
       (69,95,102,118,126,125,138,178,156,184,176,225)
6 for(i in 1:12){
7   x_sq <- x*x
8 }
9 print(x_sq)
10
11 for(i in 1:12){
12   xy <- x*y
13 }
14 print(xy)
15
16 x1 <- cbind(x,y,x_sq,xy)
17
18 n = 12
19
20 b1 = ((sum(x*y))-((sum(x)*sum(y))/n))/((sum(x^2))-
      sum(x)^2/n))
21 b1
22
23 b0 = (sum(y)/n)-b1*(sum(x)/n)
24 b0
25
26 # y_c = 30.91 + 2.23 * x
27 y_c = b0 + b1*x
28 y_c
29 x1 <- cbind(x1,y_c)
30
31 Residual <- y-y_c
32 Residual
33
34 x1 <- cbind(x1,Residual)
35 View(x1)
36
37 sum(Residual)

```

```
38  
39 hist(Residual)
```

R code Exa 12.3 Standard Error of Estimation

```
1 # Standard Error of Estimation : Se = sqrt(SSE/(n-2))  
2 # SSE = sum((y-y_c)^2)  
3  
4 Hospitals <- c(1,2,3,4,5,6,7,8,9,10,11,12)  
5 x <- c(23,29,29,35,42,46,50,54,64,66,76,78)  
6 y <- c(69,95,102,118,126,125,138,178,156,184,176,225)  
7 for(i in 1:12){  
8   x_sq <- x*x  
9 }  
10 print(x_sq)  
11  
12 for(i in 1:12){  
13   xy <- x*y  
14 }  
15 print(xy)  
16  
17 x1 <- cbind(x,y,x_sq,xy)  
18  
19 n = 12  
20  
21 b1 = ((sum(x*y))-((sum(x)*sum(y))/n))/((sum(x^2))-(  
22   sum(x)^2/n))  
23 b1  
24 b0 = (sum(y)/n)-b1*(sum(x)/n)  
25 b0  
26  
27 # y_c = 30.91 + 2.23 * x
```

```

28 y_c = b0 + b1*x
29 y_c
30 x1 <- cbind(x1,y_c)
31
32 Residual <- y-y_c
33 Residual
34
35 x1 <- cbind(x1,Residual)
36
37 for(i in 1:12){
38   Residual_sq = Residual^2
39 }
40 print(Residual_sq)
41
42 x1 <- cbind(x1,Residual_sq)
43 View(x1)
44
45 SSE = sum(Residual_sq)
46 SSE
47
48 Se = sqrt(SSE/(n-2))
49 Se

```

R code Exa 12.4 Coeficient of Determination

```

1 # Coeficient of Determination : r_sq = 1 - (SSE/SS_yy)
2 # SS_yy = sum(y_sq)-(sum(y)^2/n)
3
4 Hospitals <- c(1,2,3,4,5,6,7,8,9,10,11,12)
5 x <- c(23,29,29,35,42,46,50,54,64,66,76,78)
6 y <- c
       (69,95,102,118,126,125,138,178,156,184,176,225)
7 for(i in 1:12){
8   x_sq <- x*x

```

```

9  }
10 print(x_sq)
11
12 for(i in 1:12){
13   xy <- x*y
14 }
15 print(xy)
16
17 x1 <- cbind(x,y,x_sq,xy)
18
19 n = 12
20
21 b1 = ((sum(x*y))-((sum(x)*sum(y))/n))/((sum(x^2))-
22   sum(x)^2/n))
23 b1
24 b0 = (sum(y)/n)-b1*(sum(x)/n)
25 b0
26
27 # y_c = 30.91 + 2.23 * x
28 y_c = b0 + b1*x
29 y_c
30 x1 <- cbind(x1,y_c)
31
32 Residual <- y-y_c
33 Residual
34
35 x1 <- cbind(x1,Residual)
36
37 for(i in 1:12){
38   Residual_sq = Residual^2
39 }
40 print(Residual_sq)
41
42 x1 <- cbind(x1,Residual_sq)
43 View(x1)
44
45 SSE = sum(Residual_sq)

```

```

46 SSE
47
48 SS_yy = sum(y^2) - (sum(y)^2/n)
49 SS_yy
50
51 r_sq = 1 - (SSE/SS_yy)
52 r_sq
53
54 # Or r_sq = (b1^2 * SS_xx)/SS_yy

```

R code Exa 12.5 t test for slope

```

1 # t test for slope :
2
3 no_of_beds <- c(23,29,29,35,42,46,50,54,64,66,76,78)
4 FTEs <- c
      (69,95,102,118,126,125,138,178,156,184,176,225)
5 Hospitals<-data.frame(no_of_beds,FTEs)
6 Hospitals
7
8 # critical t value :
9 qchisq(.01,df = 10)
10
11 # least squares equation of the regression line is :
12 a <- lm(FTEs ~ no_of_beds, data=Hospitals)
13 a
      # y_c = 30.91 + 2.23 * x
14 b <- summary(a)
15 b
16
17 # observed t value :
18 b$coefficients[6]

```

R code Exa 12.6 CONFIDENCE INTERVAL TO ESTIMATE THE SINGLE VALUE FOR A GIVEN VALUE OF x

```
1 # CONFIDENCE INTERVAL TO ESTIMATE E (yx) FOR A GIVEN  
  VALUE OF x :  
2 # y_c +/- t*Se*sqrt ((1/n)+((x0-x_b)^2)/SS_xx)  
3 # SS_xx = sum(x^2)-(sum(x)^2/n)  
4  
5 no_of_beds <- c(23,29,29,35,42,46,50,54,64,66,76,78)  
6 FTEs <- c  
  (69,95,102,118,126,125,138,178,156,184,176,225)  
7 Hospitals<-data.frame(no_of_beds,FTEs)  
8 Hospitals  
9  
10 a <- lm( FTEs ~ no_of_beds , data=Hospitals)  
11 a  
12  
13 data = data.frame(no_of_beds=40)  
14 data  
15  
16 predict(a, data, interval="confidence")  
17  
18 predict(a, data, interval="predict")
```

R code Exa 12.7 Regression Analysis Example

```
1 # Regression Analysis Example :  
2  
3 Month <- c("January","Feburary","March","April","May"  
  ,"June","July","August")  
4 Sales <- c  
  (32569,32274,32583,32304,32149,32077,31989,31977)  
5 Month_number <- c(1,2,3,4,5,6,7,8)  
6 df <- data.frame(Month,Sales,Month_number)  
7 df
```

```
8
9 library("ggplot2")
10 ggplot(df, aes(x=Month, y=Sales)) + geom_point(size
11 =1)
12 # Regression Analysis: Sales versus Month
13 a <- lm(Sales~Month_number, data= df)
14 a
15 summary(a)
16
17 # y_cap = 32,628.2 - 86.21*x :
18 x =10
19 y_cap = 32628.2 - 86.21*x
20 y_cap
```

Chapter 13

Multiple Regression Analysis

R code Exa 13.1 Multiple Regression Model

```
1 # Multiple Regression Model:  
2  
3 Year <- c  
      (1980,1982,1984,1986,1988,1990,1992,1994,1996,1998,2000,2002,2004  
4 Prime_Interest_rate <- c  
      (15.26,14.85,12.04,8.33,9.32,10.01,6.25,7.15,8.27,8.35,9.23,4.67,  
5 Unemp_rate <- c  
      (7.1,9.7,7.5,7.0,5.5,5.6,7.5,6.1,5.4,4.5,4.0,5.8,5.5,4.6,5.8)  
6 Personal_saving <- c  
      (10.0,11.2,10.8,8.2,7.3,7.0,7.7,4.8,4.0,4.3,2.3,2.4,2.1,0.7,1.8)  
7 df <- data.frame(Year,Prime_Interest_rate,Unemp_rate  
,Personal_saving)  
8 df  
9  
10 a <- lm(Prime_Interest_rate ~ Unemp_rate+Personal_  
saving,data=df)  
11 a
```

```

12 summary(a)
13 anova(a)
14
15 # y_cap = 7.4904 - 0.6725x1 + 0.9500x2
16 # If the unemployment rate is 6.5 and the personal
   saving rate is 5.0,
17 # the predicted prime interest rate is 7.869%:
18 x1 = 6.5
19 x2 = 5.0
20 y_cap = 7.4904 - (0.6725)*(x1) + (0.9500)*(x2)
21 y_cap

```

R code Exa 13.2 Multiple Regression Analysis Model

```

1 # Multiple Regression Model:
2
3 Year <- c
   (1980,1982,1984,1986,1988,1990,1992,1994,1996,1998,2000,2002,2004)

4 Prime_Interest_rate <- c
   (15.26,14.85,12.04,8.33,9.32,10.01,6.25,7.15,8.27,8.35,9.23,4.67,)

5 Unemp_rate <- c
   (7.1,9.7,7.5,7.0,5.5,5.6,7.5,6.1,5.4,4.5,4.0,5.8,5.5,4.6,5.8)

6 Personal_saving <- c
   (10.0,11.2,10.8,8.2,7.3,7.0,7.7,4.8,4.0,4.3,2.3,2.4,2.1,0.7,1.8)

7 df <- data.frame(Year,Prime_Interest_rate,Unemp_rate
   ,Personal_saving)
8 View(df)
9
10 a <- lm(Prime_Interest_rate ~ Unemp_rate+Personal_
   saving,data=df)
11 a

```

```
12 s <- summary(a)
13 s
14 anova(a)
15
16 pred <- predict(a)
17 resd <- s$residuals
18 data <- data.frame(pred, resd)
19 View(data)
```

Chapter 14

Building Multiple Regression Models

R code Exa 14.1 Model Transformation

```
1 # Model Transformation : y = B0*x_B1 + E
2
3 y_cost <- c(1.2,9.0,4.5,3.2,13.0,0.6,1.8,2.7)
4 x_weight <- c
      (450,20200,9060,3500,75600,175,800,2100)
5 y_cost <- data.frame(y_cost,x_weight)
6 y_cost
7
8 # logy = log_B0 + B1*logx + E
9 log_xy <- log10(y_cost)
10 log_xy
11
12 a <- lm(y_cost~x_weight,data=log_xy)
13 a
14 b <- summary(a)
15 b
16
17 b0 <- b$coefficients[1]
18 b0
```

```
19 b1 <- b$coefficients [2]
20 b1
21
22 logy_c = b0 + b1 * (sum(log_xy$x_weight)/8)
23 logy_c
24
25 # antilog = 2.9644
26 # y = (.055857)*x^.49606
```

Chapter 15

Time Series Forecasting and Index Numbers

R code Exa 15.1.a Moving average

```
1 # Moving average :
2
3 Month <- c("January", "February", "March", "April", "May",
4           "June", "July", "August", "September", "October",
5           "November", "December")
6 Shipments <- c
7 (1056, 1345, 1381, 1191, 1259, 1361, 1110, 1334, 1416, 1282, 1341, 1382)
8
9 Month <- cbind(Month, Shipments)
10 Month
11
12 # The ???rst moving average is
13 first_four_Month_Moving_Average = sum(Shipments[1],
14                               Shipments[2], Shipments[3], Shipments[4])/4
15 first_four_Month_Moving_Average
16 Second_four_Month_Moving_Average = sum(Shipments[5],
17                               Shipments[2], Shipments[3], Shipments[4])/4
18 Second_four_Month_Moving_Average
19 Third_four_Month_Moving_Average = sum(Shipments[5],
```

```

            Shipments [6] , Shipments [3] , Shipments [4]) /4
14 Third _four _Month _Moving _Average
15 fourth _four _Month _Moving _Average = sum(Shipments [5] ,
      Shipments [6] , Shipments [7] , Shipments [4]) /4
16 fourth _four _Month _Moving _Average
17 fifth _four _Month _Moving _Average = sum(Shipments [5] ,
      Shipments [6] , Shipments [7] , Shipments [8]) /4
18 fifth _four _Month _Moving _Average
19 sixth _four _Month _Moving _Average = sum(Shipments [9] ,
      Shipments [6] , Shipments [7] , Shipments [8]) /4
20 sixth _four _Month _Moving _Average
21 seventh _four _Month _Moving _Average = sum(Shipments
      [9] , Shipments [10] , Shipments [7] , Shipments [8]) /4
22 seventh _four _Month _Moving _Average
23 eight _four _Month _Moving _Average = sum(Shipments [9] ,
      Shipments [10] , Shipments [11] , Shipments [8]) /4
24 eight _four _Month _Moving _Average
25
26 a = " "
27 b= " "
28 c = " "
29 d = " "
30 Average = rbind(a,b,c,d,first _four _Month _Moving _
      Average ,Second _four _Month _Moving _Average ,Third _four _Month _Moving _Average ,
31           fourth _four _Month _Moving _Average ,fifth _four _Month _Moving _Average ,sixth _four _Month _Moving _Average ,
32           seventh _four _Month _Moving _Average ,eight _four _Month _Moving _Average )
33 Average

```

R code Exa 15.1.b Moving average

```
1 # Error in Moving Average :
```

```

2 # Moving average :
3
4 Month <- c("January", "February", "March", "April", "May",
5           "June", "July", "August", "September", "October", "November",
6           "December")
7 Shipments <- c
8   (1056, 1345, 1381, 1191, 1259, 1361, 1110, 1334, 1416, 1282, 1341, 1382)
9
10 Month <- cbind(Month, Shipments)
11 Month
12
13 # The ???rst moving average is
14 first_four_Month_Moving_Average = sum(Shipments[1],
15                                         Shipments[2], Shipments[3], Shipments[4])/4
16 first_four_Month_Moving_Average
17 Second_four_Month_Moving_Average = sum(Shipments[5],
18                                         Shipments[2], Shipments[3], Shipments[4])/4
19 Second_four_Month_Moving_Average
20 Third_four_Month_Moving_Average = sum(Shipments[5],
21                                         Shipments[6], Shipments[3], Shipments[4])/4
22 Third_four_Month_Moving_Average
23 fourth_four_Month_Moving_Average = sum(Shipments[5],
24                                         Shipments[6], Shipments[7], Shipments[4])/4
25 fourth_four_Month_Moving_Average
26 fifth_four_Month_Moving_Average = sum(Shipments[5],
27                                         Shipments[6], Shipments[7], Shipments[8])/4
28 fifth_four_Month_Moving_Average
29 sixth_four_Month_Moving_Average = sum(Shipments[9],
30                                         Shipments[6], Shipments[7], Shipments[8])/4
31 sixth_four_Month_Moving_Average
32 seventh_four_Month_Moving_Average = sum(Shipments
33                                         [9], Shipments[10], Shipments[7], Shipments[8])/4
34 seventh_four_Month_Moving_Average
35 eight_four_Month_Moving_Average = sum(Shipments[9],
36                                         Shipments[10], Shipments[11], Shipments[8])/4
37 eight_four_Month_Moving_Average
38
39 a = " "

```

```

28 b= " "
29 c = " "
30 d = " "
31 Average = rbind(a,b,c,d,first_four_Month_Moving_
    Average,Second_four_Month_Moving_Average,Third_
    four_Month_Moving_Average,
32                      fourth_four_Month_Moving_Average,
                      fifth_four_Month_Moving_Average,
                      sixth_four_Month_Moving_Average,
33                      seventh_four_Month_Moving_Average,
                      eight_four_Month_Moving_Average)
34 Average
35
36 a = " "
37 b= " "
38 c = " "
39 d = " "
40 Error_May = Shipments[5]-first_four_Month_Moving-
    Average
41 Error_June = Shipments[6]-Second_four_Month_Moving-
    Average
42 Error_July = Shipments[7]-Third_four_Month_Moving-
    Average
43 Error_Aug = Shipments[8]-fourth_four_Month_Moving-
    Average
44 Error_sep = Shipments[9]-fifth_four_Month_Moving-
    Average
45 Error_oct = Shipments[10]-sixth_four_Month_Moving-
    Average
46 Error_nov = Shipments[11]-seventh_four_Month_Moving-
    Average
47 Error_dec = Shipments[12]-eight_four_Month_Moving-
    Average
48 Error <- rbind(a,b,c,d>Error_May>Error_June>Error_
    July>Error_Aug>Error_sep>Error_oct>Error_nov,
    Error_dec)
49 Error
50 Month <- cbind(Month,Average>Error)

```

51 View(Month)

R code Exa 15.2 Weighted Moving Average

```
1 # Weighted MOving Average : 3*l + 3*p + 3*b_p/6
2
3 Month <- c("January","February","March","April","May",
4           "June","July","August","September","October",
5           "November","December")
4 Shipments <- c
5           (1056,1345,1381,1191,1259,1361,1110,1334,1416,1282,1341,1382)
6
7 Month <- data.frame(Month,Shipments)
8 Month
9 weights1 <- c(4,2,1,1)
10
11 # install.packages("stats")
12 library(stats)
13
14 f_weight_may <- weighted.mean(Shipments[4:1],
15                                 weights1)
16 f_weight_june <- weighted.mean(Shipments[5:2],
17                                 weights1)
18 f_weight_july <- weighted.mean(Shipments[6:3],
19                                 weights1)
20 f_weight_aug <- weighted.mean(Shipments[7:4],
21                                 weights1)
22 f_weight_sep <- weighted.mean(Shipments[8:5],
23                                 weights1)
24 f_weight_oct <- weighted.mean(Shipments[9:6],
25                                 weights1)
26 f_weight_nov <- weighted.mean(Shipments[10:7],
27                                 weights1)
28 f_weight_dec <- weighted.mean(Shipments[11:8],
29                                 weights1)
```

```

20 f_weights <- data.frame(f_weight_may,f_weight_june,f
21           _weight_july,f_weight_aug,
22           f_weight_sep,f_weight_oct,f_
23           weight_nov,f_weight_dec)
24 f_weights
25
26 # We noticed that in this problem the errors
27   obtained by using the 4-month weighted moving
28   average
27 # were greater than most of the errors obtained by
29   using an unweighted 4-month moving average
30 # in Ex15_1.

```

R code Exa 15.3 EXPONENTIAL SMOOTHING

```

1 # EXPONENTIAL SMOOTHING :
2 Year <- c(1:16)
3 Total_units <- c
4           (1193,1014,1200,1288,1457,1354,1477,1474,1617,1641,1569,
5           1603,1705,1848,1956,2068)
6 data <- data.frame(Year,Total_units)
7 data
8
9 library(ggplot2)
10 ggplot(data=data, aes(x=data$Year, y=data$Total_
11   units, group=1)) +
12   geom_line(linetype = "dashed")+
13   geom_point()
14
15 # using exponential smoothing function i.e. ses() :
16 # install.package("forecast")
17 library(forecast)

```

```

16 # Forecast and error values for alpha = 0.2 :
17 f_a <- ses(Total_units, h = 8, alpha = 0.2, initial
18     = "simple")[["fitted"]]
18 error_a <- ses(Total_units, h = 8, alpha = 0.2,
19     initial = "simple")[["residuals"]]
19
20 # Forecast and error values for alpha = 0.2 :
21 f_b <- ses(Total_units, h = 8, alpha = 0.5, initial
22     = "simple")[["fitted"]]
22 error_b <- ses(Total_units, h = 8, alpha = 0.5,
23     initial = "simple")[["residuals"]]
23
24 # Forecast and error values for alpha = 0.2 :
25 f_c <- ses(Total_units, h = 8, alpha = 0.8, initial
26     = "simple")[["fitted"]]
26 error_c <- ses(Total_units, h = 8, alpha = 0.8,
27     initial = "simple")[["residuals"]]
27
28 f_data <- data.frame(data,f_a,error_a,f_b,error_b,f_
29     c,error_c)
29 View(f_data)
30
31 # MAD and MSE values of alpha = 0.2, 0.5, 0.8 :
32 MAD_a <- sum(abs(error_a))/15
33 MSE_a <- sum(abs(error_a^2))/15
34
35 MAD_b <- sum(abs(error_b))/15
36 MSE_b <- sum(abs(error_b^2))/15
37
38 MAD_c <- sum(abs(error_c))/15
39 MSE_c <- sum(abs(error_c^2))/15
40
41 val <- rbind(MAD_a,MSE_a,MAD_b,MSE_b,MAD_c,MSE_c)
42 val

```

R code Exa 15.4 Regression Trend Analysis Using Quadratic Models

```
1 # Regression Trend Analysis Using Quadratic Models
2
3 Year <- c(1991:2007)
4 Labour_force <- c
5 (117.72,118.49,120.26,123.06,124.90,126.71,129.56,131.46,133.49,135.43,137.38,139.33,141.28,143.23,145.18,147.13,149.08,150.03,151.98,153.93,155.88,157.83,159.78,161.73,163.68,165.63,167.58,169.53,171.48,173.43,175.38,177.33,179.28,181.23,183.18,185.13,187.08,188.03,189.98,191.93,193.88,195.83,197.78,199.73,201.68,203.63,205.58,207.53,209.48,211.43,213.38,215.33,217.28,219.23,221.18,223.13,225.08,226.03,227.98,229.93,231.88,233.83,235.78,237.73,239.68,241.63,243.58,245.53,247.48,249.43,251.38,253.33,255.28,257.23,259.18,261.13,263.08,264.03,265.98,267.93,269.88,271.83,273.78,275.73,277.68,279.63,281.58,283.53,285.48,287.43,289.38,291.33,293.28,295.23,297.18,299.13,301.08,303.03,304.98,306.93,308.88,310.83,312.78,314.73,316.68,318.63,320.58,322.53,324.48,326.43,328.38,330.33,332.28,334.23,336.18,338.13,340.08,342.03,343.98,345.93,347.88,349.83,351.78,353.73,355.68,357.63,359.58,361.53,363.48,365.43,367.38,369.33,371.28,373.23,375.18,377.13,379.08,381.03,382.98,384.93,386.88,388.83,390.78,392.73,394.68,396.63,398.58,399.53,401.48,403.43,405.38,407.33,409.28,411.23,413.18,415.13,417.08,418.03,419.98,421.93,423.88,425.83,427.78,429.73,431.68,433.63,435.58,437.53,439.48,441.43,443.38,445.33,447.28,449.23,451.18,453.13,455.08,456.03,457.98,459.93,461.88,463.83,465.78,467.73,469.68,471.63,473.58,475.53,477.48,479.43,481.38,483.33,485.28,487.23,489.18,491.13,493.08,494.03,495.98,497.93,499.88,501.83,503.78,505.73,507.68,509.63,511.58,513.53,515.48,517.43,519.38,521.33,523.28,525.23,527.18,529.13,531.08,532.03,533.98,535.93,537.88,539.83,541.78,543.73,545.68,547.63,549.58,551.53,553.48,555.43,557.38,559.33,561.28,563.23,565.18,567.13,569.08,570.03,571.98,573.93,575.88,577.83,579.78,581.73,583.68,585.63,587.58,589.53,591.48,593.43,595.38,597.33,599.28,601.23,603.18,605.13,607.08,608.03,609.98,611.93,613.88,615.83,617.78,619.73,621.68,623.63,625.58,627.53,629.48,631.43,633.38,635.33,637.28,639.23,641.18,643.13,645.08,646.03,647.98,649.93,651.88,653.83,655.78,657.73,659.68,661.63,663.58,665.53,667.48,669.43,671.38,673.33,675.28,677.23,679.18,681.13,683.08,684.03,685.98,687.93,689.88,691.83,693.78,695.73,697.68,699.63,701.58,703.53,705.48,707.43,709.38,711.33,713.28,715.23,717.18,719.13,721.08,722.03,723.98,725.93,727.88,729.83,731.78,733.73,735.68,737.63,739.58,741.53,743.48,745.43,747.38,749.33,751.28,753.23,755.18,757.13,759.08,760.03,761.98,763.93,765.88,767.83,769.78,771.73,773.68,775.63,777.58,779.53,781.48,783.43,785.38,787.33,789.28,791.23,793.18,795.13,797.08,798.03,799.98,801.93,803.88,805.83,807.78,809.73,811.68,813.63,815.58,817.53,819.48,821.43,823.38,825.33,827.28,829.23,831.18,833.13,835.08,836.03,837.98,839.93,841.88,843.83,845.78,847.73,849.68,851.63,853.58,855.53,857.48,859.43,861.38,863.33,865.28,867.23,869.18,871.13,873.08,874.03,875.98,877.93,879.88,881.83,883.78,885.73,887.68,889.63,891.58,893.53,895.48,897.43,899.38,901.33,903.28,905.23,907.18,909.13,911.08,912.03,913.98,915.93,917.88,919.83,921.78,923.73,925.68,927.63,929.58,931.53,933.48,935.43,937.38,939.33,941.28,943.23,945.18,947.13,949.08,950.03,951.98,953.93,955.88,957.83,959.78,961.73,963.68,965.63,967.58,969.53,971.48,973.43,975.38,977.33,979.28,981.23,983.18,985.13,987.08,988.03,989.98,991.93,993.88,995.83,997.78,999.73,1001.68,1003.63,1005.58,1007.53,1009.48,1011.43,1013.38,1015.33,1017.28,1019.23,1021.18,1023.13,1025.08,1026.03,1027.98,1029.93,1031.88,1033.83,1035.78,1037.73,1039.68,1041.63,1043.58,1045.53,1047.48,1049.43,1051.38,1053.33,1055.28,1057.23,1059.18,1061.13,1063.08,1064.03,1065.98,1067.93,1069.88,1071.83,1073.78,1075.73,1077.68,1079.63,1081.58,1083.53,1085.48,1087.43,1089.38,1091.33,1093.28,1095.23,1097.18,1099.13,1101.08,1102.03,1103.98,1105.93,1107.88,1109.83,1111.78,1113.73,1115.68,1117.63,1119.58,1121.53,1123.48,1125.43,1127.38,1129.33,1131.28,1133.23,1135.18,1137.13,1139.08,1140.03,1141.98,1143.93,1145.88,1147.83,1149.78,1151.73,1153.68,1155.63,1157.58,1159.53,1161.48,1163.43,1165.38,1167.33,1169.28,1171.23,1173.18,1175.13,1177.08,1178.03,1179.98,1181.93,1183.88,1185.83,1187.78,1189.73,1191.68,1193.63,1195.58,1197.53,1199.48,1201.43,1203.38,1205.33,1207.28,1209.23,1211.18,1213.13,1215.08,1216.03,1217.98,1219.93,1221.88,1223.83,1225.78,1227.73,1229.68,1231.63,1233.58,1235.53,1237.48,1239.43,1241.38,1243.33,1245.28,1247.23,1249.18,1251.13,1253.08,1254.03,1255.98,1257.93,1259.88,1261.83,1263.78,1265.73,1267.68,1269.63,1271.58,1273.53,1275.48,1277.43,1279.38,1281.33,1283.28,1285.23,1287.18,1289.13,1291.08,1292.03,1293.98,1295.93,1297.88,1299.83,1301.78,1303.73,1305.68,1307.63,1309.58,1311.53,1313.48,1315.43,1317.38,1319.33,1321.28,1323.23,1325.18,1327.13,1329.08,1330.03,1331.98,1333.93,1335.88,1337.83,1339.78,1341.73,1343.68,1345.63,1347.58,1349.53,1351.48,1353.43,1355.38,1357.33,1359.28,1361.23,1363.18,1365.13,1367.08,1368.03,1369.98,1371.93,1373.88,1375.83,1377.78,1379.73,1381.68,1383.63,1385.58,1387.53,1389.48,1391.43,1393.38,1395.33,1397.28,1399.23,1401.18,1403.13,1405.08,1406.03,1407.98,1409.93,1411.88,1413.83,1415.78,1417.73,1419.68,1421.63,1423.58,1425.53,1427.48,1429.43,1431.38,1433.33,1435.28,1437.23,1439.18,1441.13,1443.08,1444.03,1445.98,1447.93,1449.88,1451.83,1453.78,1455.73,1457.68,1459.63,1461.58,1463.53,1465.48,1467.43,1469.38,1471.33,1473.28,1475.23,1477.18,1479.13,1481.08,1482.03,1483.98,1485.93,1487.88,1489.83,1491.78,1493.73,1495.68,1497.63,1499.58,1501.53,1503.48,1505.43,1507.38,1509.33,1511.28,1513.23,1515.18,1517.13,1519.08,1520.03,1521.98,1523.93,1525.88,1527.83,1529.78,1531.73,1533.68,1535.63,1537.58,1539.53,1541.48,1543.43,1545.38,1547.33,1549.28,1551.23,1553.18,1555.13,1557.08,1558.03,1559.98,1561.93,1563.88,1565.83,1567.78,1569.73,1571.68,1573.63,1575.58,1577.53,1579.48,1581.43,1583.38,1585.33,1587.28,1589.23,1591.18,1593.13,1595.08,1596.03,1597.98,1599.93,1601.88,1603.83,1605.78,1607.73,1609.68,1611.63,1613.58,1615.53,1617.48,1619.43,1621.38,1623.33,1625.28,1627.23,1629.18,1631.13,1633.08,1634.03,1635.98,1637.93,1639.88,1641.83,1643.78,1645.73,1647.68,1649.63,1651.58,1653.53,1655.48,1657.43,1659.38,1661.33,1663.28,1665.23,1667.18,1669.13,1671.08,1672.03,1673.98,1675.93,1677.88,1679.83,1681.78,1683.73,1685.68,1687.63,1689.58,1691.53,1693.48,1695.43,1697.38,1699.33,1701.28,1703.23,1705.18,1707.13,1709.08,1710.03,1711.98,1713.93,1715.88,1717.83,1719.78,1721.73,1723.68,1725.63,1727.58,1729.53,1731.48,1733.43,1735.38,1737.33,1739.28,1741.23,1743.18,1745.13,1747.08,1748.03,1749.98,1751.93,1753.88,1755.83,1757.78,1759.73,1761.68,1763.63,1765.58,1767.53,1769.48,1771.43,1773.38,1775.33,1777.28,1779.23,1781.18,1783.13,1785.08,1786.03,1787.98,1789.93,1791.88,1793.83,1795.78,1797.73,1799.68,1801.63,1803.58,1805.53,1807.48,1809.43,1811.38,1813.33,1815.28,1817.23,1819.18,1821.13,1823.08,1824.03,1825.98,1827.93,1829.88,1831.83,1833.78,1835.73,1837.68,1839.63,1841.58,1843.53,1845.48,1847.43,1849.38,1851.33,1853.28,1855.23,1857.18,1859.13,1861.08,1862.03,1863.98,1865.93,1867.88,1869.83,1871.78,1873.73,1875.68,1877.63,1879.58,1881.53,1883.48,1885.43,1887.38,1889.33,1891.28,1893.23,1895.18,1897.13,1899.08,1900.03,1901.98,1903.93,1905.88,1907.83,1909.78,1911.73,1913.68,1915.63,1917.58,1919.53,1921.48,1923.43,1925.38,1927.33,1929.28,1931.23,1933.18,1935.13,1937.08,1938.03,1939.98,1941.93,1943.88,1945.83,1947.78,1949.73,1951.68,1953.63,1955.58,1957.53,1959.48,1961.43,1963.38,1965.33,1967.28,1969.23,1971.18,1973.13,1975.08,1976.03,1977.98,1979.93,1981.88,1983.83,1985.78,1987.73,1989.68,1991.63,1993.58,1995.53,1997.48,1999.43,2001.38,2003.33,2005.28,2007.23,2009.18,2011.13,2013.08,2014.03,2015.98,2017.93,2019.88,2021.83,2023.78,2025.73,2027.68,2029.63,2031.58,2033.53,2035.48,2037.43,2039.38,2041.33,2043.28,2045.23,2047.18,2049.13,2051.08,2052.03,2053.98,2055.93,2057.88,2059.83,2061.78,2063.73,2065.68,2067.63,2069.58,2071.53,2073.48,2075.43,2077.38,2079.33,2081.28,2083.23,2085.18,2087.13,2089.08,2090.03,2091.98,2093.93,2095.88,2097.83,2099.78,2101.73,2103.68,2105.63,2107.58,2109.53,2111.48,2113.43,2115.38,2117.33,2119.28,2121.23,2123.18,2125.13,2127.08,2128.03,2129.98,2131.93,2133.88,2135.83,2137.78,2139.73,2141.68,2143.63,2145.58,2147.53,2149.48,2151.43,2153.38,2155.33,2157.28,2159.23,2161.18,2163.13,2165.08,2166.03,2167.98,2169.93,2171.88,2173.83,2175.78,2177.73,2179.68,2181.63,2183.58,2185.53,2187.48,2189.43,2191.38,2193.33,2195.28,2197.23,2199.18,2201.13,2203.08,2204.03,2205.98,2207.93,2209.88,2211.83,2213.78,2215.73,2217.68,2219.63,2221.58,2223.53,2225.48,2227.43,2229.38,2231.33,2233.28,2235.23,2237.18,2239.13,2241.08,2242.03,2243.98,2245.93,2247.88,2249.83,2251.78,2253.73,2255.68,2257.63,2259.58,2261.53,2263.48,2265.43,2267.38,2269.33,2271.28,2273.23,2275.18,2277.13,2279.08,2280.03,2281.98,2283.93,2285.88,2287.83,2289.78,2291.73,2293.68,2295.63,2297.58,2299.53,2301.48,2303.43,2305.38,2307.33,2309.28,2311.23,2313.18,2315.13,2317.08,2318.03,2319.98,2321.93,2323.88,2325.83,2327.78,2329.73,2331.68,2333.63,2335.58,2337.53,2339.48,2341.43,2343.38,2345.33,2347.28,2349.23,2351.18,2353.13,2355.08,2356.03,2357.98,2359.93,2361.88,2363.83,2365.78,2367.73,2369.68,2371.63,2373.58,2375.53,2377.48,2379.43,2381.38,2383.33,2385.28,2387.23,2389.18,2391.13,2393.08,2394.03,2395.98,2397.93,2399.88,2401.83,2403.78,2405.73,2407.68,2409.63,2411.58,2413.53,2415.48,2417.43,2419.38,2421.33,2423.28,2425.23,2427.18,2429.13,2431.08,2432.03,2433.98,2435.93,2437.88,2439.83,2441.78,2443.73,2445.68,2447.63,2449.58,2451.53,2453.48,2455.43,2457.38,2459.33,2461.28,2463.23,2465.18,2467.13,2469.08,2470.03,2471.98,2473.93,2475.88,2477.83,2479.78,2481.73,2483.68,2485.63,2487.58,2489.53,2491.48,2493.43,2495.38,2497.33,2499.28,2501.23,2503.18,2505.13,2507.08,2508.03,2509.98,2511.93,2513.88,2515.83,2517.78,2519.73,2521.68,2523.63,2525.58,2527.53,2529.48,2531.43,2533.38,2535.33,2537.28,2539.23,2541.18,2543.13,2545.08,2546.03,2547.98,2549.93,2551.88,2553.83,2555.78,2557.73,2559.68,2561.63,2563.58,2565.53,2567.48,2569.43,2571.38,2573.33,2575.28,2577.23,2579.18,2581.13,2583.08,2584.03,2585.98,2587.93,2589.88,2591.83,2593.78,2595.73,2597.68,2599.63,2601.58,2603.53,2605.48,2607.43,2609.38,2611.33,2613.28,2615.23,2617.18,2619.13,2621.08,2622.03,2623.98,2625.93,2627.88,2629.83,2631.78,2633.73,2635.68,2637.63,2639.58,2641.53,2643.48,2645.43,2647.38,2649.33,2651.28,2653.23,2655.18,2657.13,2659.08,2660.03,2661.98,2663.93,2665.88,2667.83,2669.78,2671.73,2673.68,2675.63,2677.58,2679.53,2681.48,2683.43,2685.38,2687.33,2689.28,2691.23,2693.18,2695.13,2697.08,2698.03,2699.98,2701.93,2703.88,2705.83,2707.78,2709.73,2711.68,2713.63,2715.58,2717.53,2719.48,2721.43,2723.38,2725.33,2727.28,2729.23,2731.18,2733.13,2735.08,2736.03,2737.98,2739.93,2741.88,2743.83,2745.78,2747.73,2749.68,2751.63,2753.58,2755.53,2757.48,2759.43,2761.38,2763.33,2765.28,2767.23,2769.18,2771.13,2773.08,2774.03,2775.98,2777.93,2779.88,2781.83,2783.78,2785.73,2787.68,2789.63,2791.58,2793.53,2795.48,2797.43,2799.38,2801.33,2803.28,2805.23,2807.18,2809.13,2811.08,2812.03,2813.98,2815.93,2817.88,2819.83,2821.78,2823.73,2825.68,2827.63,2829.58,2831.53,2833.48,2835.43,2837.38,2839.33,2841.28,2843.23,2845.18,2847.13,2849.08,2850.03,2851.98,2853.93,2855.88,2857.83,2859.78,2861.73,2863.68,2865.63,2867.58,2869.53,2871.48,2873.43,2875.38,2877.33,2879.28,2881.23,2883.18,2885.13,2887.08,2888.03,2889.98,2891.93,2893.88,2895.83,2897.78,2899.73,2901.68,2903.63,2905.58,2907.53,2909.48,2911.43,2913.38,2915.33,2917.28,2919.23,2921.18,2923.13,2925.08,2926.03,2927.98,2929.93,2931.88,2933.83,2935.78,2937.73,2939.68,2941.63,2943.58,2945.53,2947.48,2949.43,2951.38,2953.33,2955.28,2957.23,2959.18,2961.13,2963.08,2964.03,2965.98,2967.93,2969.88,2971.83,2973.78,2975.73,2977.68,2979.63,2981.58,2983.53,2985.48,2987.43,2989.38,2991.33,2993.28,2995.23,2997.18,2999.13,2000.08,2001.03,2002.98,2003.93,2004.88,2005.83,2006.78,2007.73,2008.68,2009.63,2010.58,2011.53,2012.48,2013.43,2014.38,2015.33,2016.28,2017.23,2018.18,2019.13,2020.08,2021.03,2022.98,2023.93,2024.88,2025.83,2026.78,2027.73,2028.68,2029.63,2030.58,2031.53,2032.48,2033.43,2034.38,2035.33,2036.28,2037.23,2038.18,2039.13,2040.08,2041.03,2042.98,2043.93,2044.88,2045.83,2046.78,2047.73,2048.68,2049.63,2050.58,2051.53,2052.48,2053.43,2054.38,2055.33,2056.28,2057.23,2058.18,2059.13,2060.08,2061.03,2062.98,2063.93,2064.88,2065.83,2066.78,2067.73,2068.68,2069.63,2070.58,2071.53,2072.48,2073.43,2074.38,2075.33,2076.28,2077.23,2078.18,2079.13,2080.08,2081.
```

R code Exa 15.5 LASPEYRES PRICE INDEX and PAASCHE PRICE INDEX

```

1 # LASPEYRES PRICE INDEX and PAASCHE PRICE INDEX :
2 year <- c(2008,2009)
3 p.Syrings <- c(6.70,6.95)
4 q.Syrings <- c(150,135)
5 p.Cotton <- c(1.35,1.45)
6 q.Cotton <- c(60,65)
7 p.Patient <- c(5.10,6.25)
8 q.Patient <- c(8,12)
9 p.ChildrenTylenol <- c(4.50,4.95)

```

```

10 q.ChildrenTylenol <- c(25,30)
11 p.Computerpaper <- c(11.95,13.20)
12 q.Computerpaper <- c(6,8)
13 p.Thermometer <- c(7.90,9.00)
14 q.Thermometer <- c(4,2)
15
16 data <- data.frame(year,p.Syrings,q.Syrings,p.Cotton
17   ,q.Cotton,p.Patient,q.Patient,
18   p.ChildrenTylenol,q.
19   ChildrenTylenol,p.
20   Computerpaper,q.Computerpaper,
21   p.Thermometer,q.Thermometer)
22
23 data
24
25 # Unweighted Aggregate Index for 2009 :
26 p_2009 <- sum(p.Syrings[2],p.Cotton[2],p.Patient[2],
27   p.ChildrenTylenol[2],p.Computerpaper[2],
28   p.Thermometer[2])
29 p_2008 <- sum(p.Syrings[1],p.Cotton[1],p.Patient[1],
30   p.ChildrenTylenol[1],p.Computerpaper[1],
31   p.Thermometer[1])
32 I = (p_2009/p_2008)*100
33 I
34
35 # Laspeyres Price Indices
36 # install.packages("micEcon")
37 # install.packages("micEconIndex")
38 library(micEconIndex)
39 library(micEcon)
40 a <- priceIndex(c("p.Syrings","p.Cotton","p.Patient"
41   ,"p.ChildrenTylenol","p.Computerpaper",
42   "p.Thermometer"), c("q.Syrings","q.
43   Cotton","q.Patient","q.
44   ChildrenTylenol",
45   "q.Computerpaper","
46   q.Thermometer")
47   ,1,data)
48
49 a

```

```
38 I_2009_Laspeyres <- a[2]*100
39 I_2009_Laspeyres
40
41 # Paasche Price Indices
42 b <- priceIndex(c("p.Syrings","p.Cotton","p.Patient",
43           ,"p.ChildrenTylenol","p.Computerpaper",
44           "p.Thermometer"), c("q.Syrings","q.
45           Cotton","q.Patient","q.
46           ChildrenTylenol",
47           "q.Computerpaper","
48           q.Thermometer")
49           ,1,data,"Paasche
50           "))
```

Chapter 16

Analysis of Categorical Data

R code Exa 16.1 CHI SQUARE GOODNESS OF FIT TEST

```
1 # CHI-SQUARE GOODNESS OF-FIT TEST : X_sq = sum((fo-
2   fe)^2/fe)
3 # df = k-1-c
4 Month <- c("January", "February", "March", "April", "May",
5   "June", "July", "August", "September", "October", "
6   November", "December")
7 fo <- c
8   (1610, 1585, 1649, 1590, 1540, 1397, 1410, 1350, 1495, 1564, 1602, 1655)

9
10 fe <- sum(fo)/12
11 for(i in 1:12){
12   X = (fo-fe)^2/fe
13 }
14 print(X)
15
16 # Observed chi-square value :
```

```

17 X_sq = sum(X)
18 X_sq
19
20 Month <- cbind(Month, fo, fe, X)
21 Month
22
23 # The observed value of chi-square is 74.37, greater
   than the critical table value i.e. 24.725,
24 # so the decision is to reject the null hypothesis.
   This problem provides enough
25 # evidence to indicate that the distribution of milk
   sales is not uniform.

```

R code Exa 16.2 Test data is whether in Poisson distributed

```

1 # Test data is whether in Poisson distributed :
2
3 no_of_arrival <- c(0,1,2,3,4,5)
4 obs_freq <- c(7,18,25,17,12,5)
5
6 # chi square value when alpha = 0.05 :
7 qchisq(.95,4)
8
9 for(i in 1:6){
10   arr_obs <- no_of_arrival*obs_freq
11 }
12 print(arr_obs)
13
14 l = sum(arr_obs)/sum(obs_freq)
15 l # lambda
16
17 # Expected probability using lambda and no_of_arrival
18   :
18 exp_pb <- c(.1003,.2306,.2652,.2033,.1169,.0837)
19

```

```

20 for(i in 0:5){
21   exp_freq = sum(obs_freq)*exp_pb
22 }
23 print(exp_freq)
24
25 no_of_arrival <- cbind(no_of_arrival,obs_freq,arr_
26 obs,exp_pb,exp_freq)
27 no_of_arrival
28 for(i in 0:5){
29   X = (obs_freq-exp_freq)^2/exp_freq
30 }
31 print(X)
32 sum(X)

```

R code Exa 16.3 CHI SQUARE GOODNESS OF FIT TEST example 2

```

1 # CHI SQUARE GOODNESS OF FIT TEST example 2 :
2 p <- c("Milk","non-Milk")
3 fo <- c(115,435)
4 fe <- c(93.5,456.5)
5
6 # critical value of chi-square :
7 qchisq(.95, df=1)
8
9 X_1 = (fo[1]-fe[1])^2/fe[1]
10 X_1
11
12 X_2 = (fo[2]-fe[2])^2/fe[2]
13 X_2
14
15 # Observed value of chi-square :
16 X_sq = X_1 + X_2
17 X_sq
18

```

```
19 # This observed chi-square , 5.95 , is greater than  
# the critical chi-square value of 3.8415.  
20 # The decision is to reject the null hypothesis.
```

R code Exa 16.4 CHI SQUARE TEST OF INDEPENDENCE

```
1 # CHI-SQUARE TEST OF INDEPENDENCE :  
2  
3 Age = matrix(c(26,95,18,41,40,20,24,13,32),nrow=3,  
# ncol=3,byrow = TRUE)  
4 dimnames(Age) = list(c("21-34","35-55",">55"),c(  
"Coffee_tea ", "Soft_Drink", "Other"))  
5 Age  
6  
7 # chi-square expected value when alpha =.01 :  
8 qchisq(.99,df=4)  
9  
10 # The degrees of freedom are  $(3 - 1)(3 - 1) = 4$ , and  
# the critical value is 13.2767.  
11 # The decision rule is to reject the null hypothesis  
# if the observed value of chisquare  
12 # is greater than 13.2767.  
13  
14  
15 # chi-square observed value :  
16 # installed.pacakges("stats")  
17 library(stats)  
18 chisq.test(Age)  
19  
20 # The observed value of chi-square , 59.41 , is  
# greater than the critical value , 13.2767,  
21 # so the null hypothesis is rejected.
```

Chapter 17

Nonparametric Statistics

R code Exa 17.1 Mann Whitney U test

```
1 # Mann-Whitney U test :
2
3 Total_emp_comp <- c
4   (18.75,19.80,20.10,20.75,21.64,21.90,22.36,22.96,23.45,23.88,24.12)
5 Rank <- c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
6 Group <- c("H","H","H","H","E","H","H","E","E","E","E","E")
7 Total_emp_comp <- data.frame(Total_emp_comp,Rank,
8                               Group)
9 Total_emp_comp
10 W1 = 1+2+3+4+6+7+8
11 W2 = 5+9+10+11+12+13+14+15
12 W2
13 U1 = (7)*(8) + ((7)*(8))/2 - W1
14 U1
15 U2 = (7)*(8) + ((8)*(9))/2 - W2
16 U2
17
```

```
18 # Using Wilcox test :
19 wilcox.test(Total_emp_comp ~ Group, data = Total_emp
               _comp, exact = FALSE)
20
21 #Because U2 is the smaller value of U, we use U=3 as
   the test statistic for Table A.13.
22 # Because it is the smallest size , let n1=7; n2=8.
23
24 # Because the p -value is less than a = .05 , the
   null hypothesis is rejected.
```

R code Exa 17.2 LARGE SAMPLE FORMULAS MANN WHITNEY U TEST

```

1 #LARGE-SAMPLE FORMULAS MANN-WHITNEY U TEST :
2
3 Value <- c
4 (2.25,2.70,2.75,2.97,2.97,3.10,3.15,3.29,3.50,3.60,3.61,3.65,3.68
4
4 4.01,4.05,4.10,4.10,4.25,4.29,4.53,4.75,4.80,4.80,4.98,5.
4
5 Rank <- c
5 (1,2,3,4.5,4.5,6,7,8,9,10,11,12,13,14,15,16,17,18.5,18.5,20,21,22
5
6 Group <- c('V','R','V','V','V','V','V','V','R','V','
6 V,'R','V','R','R',
7 'V','V','R','R','R','V','V','R','R','R','
7 R','R','R','R','R')
8 Value <- data.frame(Value,Rank,Group)
9 Value
10
11 W1 = 1 + 3 + 4.5 + 4.5 + 6 + 7 + 8 + 10 + 11 + 13 +
11 16 + 17 + 21 + 22
12 W1
13

```

```

14 U = (14)*(16) + ((14)*(15))/2 - W1
15 U
16
17 U_u = ((14)*(16))/2
18 U_u
19
20 sd_u = sqrt(((14)*(16)*(31))/12)
21 sd_u
22
23 # observed value
24 z = (U-U_u)/sd_u
25 z
26
27 # Wilcox test :
28 wilcox.test(Value ~ Group, data = Value, exact =
   FALSE)

```

R code Exa 17.3 WILCOXON MATCHED PAIRS SIGNED RANK TEST

```

1 # WILCOXON MATCHEDPAIRS SIGNED RANK TEST :
2
3 Worker <- c(1:20)
4 Before <- c
5   (5,4,9,6,3,8,7,10,3,7,2,5,4,5,8,7,9,5,4,3)
5 After <- c
6   (11,9,9,8,5,7,9,9,7,9,6,10,9,7,9,6,10,8,5,6)
6 d <- c
7   (-6,-5,0,-2,-2,1,-2,1,-4,-2,-4,-5,-5,-2,-1,1,-1,-3,-1,-3)

7 Rank <- c
8   (-19,-17,0,-9,-9,3.5,-9,3.5,-14.5,-9,-14.5,-17,-17,-9,-3.5,3.5,-3
9 Worker
10

```

```

11 # test statistic z value :
12 qnorm(.99,lower.tail = FALSE)
13
14 # T positive and negative using wilcox test function
15 :  

15 wilcox.test(Worker$Before, Worker$After, paired=TRUE
16 )
16 wilcox.test(Worker$d, Worker$Rank, paired=TRUE)
17
18 # T positive and negative using formula :
19 T_p <- 3.5+3.5+3.5
20 T_p
21 T_n <- 19 + 17 + 9 + 9 + 9 + 14.5 + 9 + 14.5 + 17 +
22 17 + 9 + 3.5 + 3.5 + 12.5 + 3.5 + 12.5
22 T_n
23
24 T_min = min(T_p,T_n)
25 T_min
26
27 n = 19
28 T_mean = (n*(n+1))/4
29 T_mean
30
31 T_sd = sqrt((n*(n+1)*(2*n+1))/24)
32 T_sd
33
34 # observed z value :
35 z = (T_min - T_mean)/T_sd
36 z
37
38 # The observed z value (-3.41) is in the rejection
39 # region , so the analyst rejects the null
40 # hypothesis.
41 # The productivity is significantly greater after
42 # the implementation of quality control
43 # at this company.

```

R code Exa 17.4 KRUSKAL WALLIS TEST

```
1 # KRUSKAL-WALLIS TEST  :
2
3 Group_native <- c(8,5,7,11,9,6)
4 Group_water <- c(10,12,11,9,13,12)
5 Group_fertilizer <- c(11,14,10,16,17,12)
6 Group_water_fertilizer <- c(18,20,16,15,14,22)
7 Group <-data.frame(Group_native,Group_water,Group_
    fertilizer,Group_water_fertilizer)
8 Group
9
10 # alpha = .01, critical value :
11 qchisq(.99,df=3)
12
13 native<- Group$Group_native
14 water<- Group$Group_water
15 fertilizer<- Group$Group_fertilizer
16 water_fertilizer<- Group$Group_water_fertilizer
17 x1<-c(native,water,fertilizer,water_fertilizer)
18 x1
19 g<- factor(rep(1:4, c(6,6,6,6)),
20             labels = c("native",
21                         "water",
22                         "fertilizer",
23                         "water_fertilizer"))
24 kruskal.test(x1, g)
25
26
27 # The observed K value is 16.77 and the critical is
28 # 11.3449.
29 # Because the observed value is greater than the
#   table value , the null hypothesis
30 # is rejected. There is a signi??cant difference in
```

R code Exa 17.5 FRIEDMAN TEST

```
1 # FRIEDMAN TEST :
2
3 Brand <- matrix(c
4   (3,5,2,4,1,1,3,2,4,5,3,4,5,2,1,2,3,1,4,5,5,4,2,1,3,1,5,3,4,2,4,1,3,
5
6   2,3,4,5,1,2,4,5,3,1,3,5,4,2,1),
7   nrow=10,ncol=5,byrow = TRUE)
8 Brand
9
10 # Chi-square value , alpha =0.01 :
11 qchisq(.99,df=4)
12
13 # Because the observed value of = 3.68 is not
14 # greater than the critical value , 13.2767,
15 # the researchers fail to reject the null hypothesis
16 .
```

R code Exa 17.6 SPEARMANS RANK CORRELATION

```
1 # SPEARMAN'S RANK CORRELATION :
2
3 Crude_oil <- c
4   (14.60,10.50,12.30,15.10,18.35,22.60,28.90,31.40,26.75)
5
6 Gasoline <- c
7   (3.25,3.26,3.28,3.26,3.32,3.44,3.56,3.60,3.54)
```

```

5 Crude_rank <- c(3,1,2,4,5,6,8,9,7)
6 Gasoline_rank <- c(1,2.5,4,2.5,5,6,8,9,7)
7 d <- c(2,-1.5,-2,1.5,0,0,0,0,0)
8 d_sq <- c(4,2.25,4,2.25,0,0,0,0,0)
9 oil <- data.frame(Crude_oil, Gasoline, Crude_rank,
                      Gasoline_rank, d, d_sq)
10 oil
11 d_sq_sum <- sum(d_sq)
12 d_sq_sum
13
14 # Using cor.test :
15 # install.packages("stats")
16 library(stats)
17 cor.test(oil$Crude_oil, oil$Gasoline, method =
           "spearman")
18
19 # using formula :
20 n = 9
21 r_s <- 1 - ((6*d_sq_sum)/(n*(n^2-1)))
22 r_s
23
24
25 # A high positive correlation is computed between
      the price of a barrel of
26 # West Texas intermediate crude and a gallon of
      regular unleaded gasoline.

```
