

R Textbook Companion for  
Statistics for Psychology  
by Arthur Aron, Elliot J. Coups, and Elaine  
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# Book Description

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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.

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# Chapter 1

## Displaying the Order in a Group of Numbers Using Tables and Graphs

R code Exa 1.1a Frequency Tables an Example

```
1 # Page no. : 7
2
3 stress_rating <- c(8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3,
4                   7, 6, 5, 0, 9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7,
5                   10, 8, 8)
6
7 frequency_table <- data.frame(table(stress_rating))
8
9 percent <- round((prop.table(frequency_table$Freq) *
10                  100), 1)
11
12 frequency_table <- cbind(frequency_table, percent)
13
14 View(frequency_table)
```

---

### R code Exa 1.1c Frequency Tables Another Example

```
1 # Page no. : 8 - 9
2
3 social_interaction <- c(48, 15, 33, 3, 21, 19, 17,
4     16, 44, 25, 30, 3, 5, 9, 35, 32, 26, 13, 14,
5     14, 47, 47, 18, 11, 5, 19,
6     24, 17, 6, 25, 8, 18, 29,
7     1, 18, 22, 3, 22,
8     29, 2, 6, 10, 29, 10, 29,
9     21, 38, 41, 16, 17, 8,
10    40, 8, 10, 18, 7, 4, 4,
11    8, 11, 3, 23, 10, 19, 21,
12    13, 12, 10, 4, 17, 11,
13    21, 9, 8, 7, 5, 3, 22,
14    14, 25, 4, 11, 10, 18, 1,
15    28, 27, 19, 24, 35, 9,
16    30, 8, 26)
17
18 breaks <- seq(0, 49, by = 1)
19
20 social_interaction <- cut(social_interaction, breaks
21     , right = F)
22
23 frequency_table <- data.frame(table(social.
24     interaction))
25
26 View(frequency_table)
```

---

### R code Exa 1.1d Grouped Frequency Tables

```
1 # Page no. : 9
2
3 stress_rating <- c(8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3,
4     7, 6, 5, 0, 9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7,
```

```

    10, 8, 8)
4
5 breaks <- seq(-1, 11, by = 2)
6
7 stress.rating <- cut(stress_rating, breaks, right =
  T)
8
9 grouped_frequency_table <- data.frame(table(stress.
  rating))
10
11 percent <- round((prop.table(grouped_frequency_table
  $Freq) * 100), 1)
12
13 grouped_frequency_table <- cbind(grouped_frequency_
  table, percent)
14
15 View(grouped_frequency_table)

```

---

### R code Exa 1.1e Grouped Frequency Tables Another Example

```

1 # Page no. : 10
2
3 social_interaction <- c(48, 15, 33, 3, 21, 19, 17,
  16, 44, 25, 30, 3, 5, 9, 35, 32, 26, 13, 14,
4
5     14, 47, 47, 18, 11, 5, 19,
6     24, 17, 6, 25, 8, 18, 29,
7     1, 18, 22, 3, 22,
8     29, 2, 6, 10, 29, 10, 29,
9     21, 38, 41, 16, 17, 8,
10    40, 8, 10, 18, 7, 4, 4,
11    8, 11, 3, 23, 10, 19, 21,
12    13, 12, 10, 4, 17, 11,
13    21, 9, 8, 7, 5, 3, 22,
14    14, 25, 4, 11, 10, 18, 1,
15    28, 27, 19, 24, 35, 9,

```

```

                                30, 8, 26)
8
9 breaks <- seq(0, 50, by = 5)
10
11 social.interaction <- cut(social_interaction, breaks
    , right = F)
12
13 grouped_frequency_table <- data.frame(table(social.
    interaction))
14
15 percent <- round((prop.table(grouped_frequency_table
    $Freq) * 100), 1)
16
17 grouped_frequency_table <- cbind(grouped_frequency_
    table, percent)
18
19 View(grouped_frequency_table)

```

---

### R code Exa 1.2a Histogram for Frequency Table

```

1 # Page no. : 11
2
3 stress_rating <- c(8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3,
    7, 6, 5, 0, 9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7,
    10, 8, 8)
4
5 frequency_table <- data.frame(table(stress_rating))
6
7 library(ggplot2)
8
9 ggplot(data = frequency_table, aes(x = stress_rating
    , y = Freq)) +
10   geom_bar(stat = "identity", fill = "violet") +
11   labs(title = "Histogram for frequency table", x =
    "Stress Rating", y = "Frequency") +

```

```
12 theme_bw()
```

---

### R code Exa 1.2b Histogram for Grouped Frequency Table

```
1 # Page no. : 11
2
3 stress_rating <- c(8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3,
4                   7, 6, 5, 0, 9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7,
5                   10, 8, 8)
6
7 frequency_table <- data.frame(table(stress_rating))
8
9 View(frequency_table)
10
11 library(ggplot2)
12
13 ggplot(data = frequency_table, aes(x = stress_rating
14   , y = Freq)) +
15   geom_bar(stat = "identity", fill = "violet") +
16   labs(title = "Histogram for grouped frequency
17     table", x = "Stress Rating", y = "Frequency") +
18   theme_bw()
```

---

### R code Exa 1.2c Histogram for Grouped Frequency Table Example 2

```
1 # Page no. : 12
2
3 social_interaction <- c(48, 15, 33, 3, 21, 19, 17,
4   16, 44, 25, 30, 3, 5, 9, 35, 32, 26, 13, 14,
5   14, 47, 47, 18, 11, 5, 19,
6   24, 17, 6, 25, 8, 18, 29,
7   1, 18, 22, 3, 22,
```

```

5           29, 2, 6, 10, 29, 10, 29,
           21, 38, 41, 16, 17, 8,
           40, 8, 10, 18, 7, 4, 4,
6           8, 11, 3, 23, 10, 19, 21,
           13, 12, 10, 4, 17, 11,
           21, 9, 8, 7, 5, 3, 22,
7           14, 25, 4, 11, 10, 18, 1,
           28, 27, 19, 24, 35, 9,
           30, 8, 26)
8
9 breaks <- seq(0, 50, by = 5)
10
11 mid_values <- seq(0+5/2,50-5/2, 5)
12
13 social.interaction <- cut(social_interaction, breaks
    , right = F)
14
15 grouped_frequency_table <- data.frame(table(social.
    interaction))
16 grouped_frequency_table$social_interacton_mid <- mid
    _values
17
18 View(grouped_frequency_table)
19
20 library(ggplot2)
21
22 ggplot(data = grouped_frequency_table, aes(x =
    factor(social_interacton_mid), y = Freq)) +
23   geom_bar(stat = "identity", fill = "violet") +
24   labs(title = "Histogram for grouped frequency
    table", x = "Social Interaction Mid Values",
25         y = "Frequency") +
26   theme_bw()

```

---

**R code Exa 1.2d** Histogram for Nominal Variables



```

1 # Page no. : 14
2
3 closest_person <- c("Family member", "Nonromantic
  friend", "Romantic friend", "Other")
4
5 frequency <- c(33, 76, 92, 7)
6
7 frequency_table <- data.frame(closest_person,
  frequency)
8
9 library(ggplot2)
10
11 ggplot(data = frequency_table, aes(x = closest_
  person, y = frequency)) +
12   geom_bar(stat = "identity", fill = "violet") +
13   labs(title = "Histogram for nominal variables", x
    = "Closest Person", y = "Frequency") +
14   theme_bw()

```

---

### R code Exa 1.2e How are you doing

```

1 # Page no. : 15
2
3 value <- c(1, 2, 3, 4, 5)
4
5 frequency <- c(3, 4, 8, 5, 2)
6
7 frequency_table <- data.frame(value, frequency)
8
9 library(ggplot2)
10
11 ggplot(data = frequency_table, aes(x = value, y =
  frequency)) +
12   geom_bar(stat = "identity", fill = "violet") +
13   labs(title = "Histogram", x = "Value", y = "

```

```
    Frequency") +  
14   theme_bw()
```

---

### R code Exa 1.4a Worked Out Examples

```
1 # Page no. : 25  
2  
3 Interest <- c(2, 4, 5, 5, 1, 3, 6, 3, 6, 6)  
4  
5 frequency_table <- data.frame(table(Interest))  
6  
7 Percent <- round((prop.table(frequency_table$Freq) *  
8   100), 0)  
9  
10 frequency_table <- cbind(frequency_table, Percent)  
11  
12 View(frequency_table)  
13  
14 library(ggplot2)  
15 ggplot(data = frequency_table, aes(x = Interest, y =  
16   Freq)) +  
17   geom_bar(stat = "identity", fill = "violet") +  
   labs(title = "Histogram", x = "Interest", y = "  
     Frequency")
```

---

## Chapter 2

# Central Tendency and Variability

R code Exa 2.1a Mean Example 1

```
1 # Page no. : 36 - 37
2
3 x <- c(7, 8, 8, 7, 3, 1, 6, 9, 3, 8)
4
5 value <- mean(x)
6
7 cat("Mean of x is", value)
```

---

R code Exa 2.1b Mean Example 2

```
1 # Page no. : 37
2
3 x <- c(8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3, 7, 6, 5, 0,
4       9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7, 10, 8, 8)
5 value <- mean(x)
```

```

6
7 cat("Mean of x is", round(value,2))
8
9 library(ggplot2)
10
11 ggplot(data = data.frame(x), aes(x = x)) +
12   geom_bar(stat = "count", fill = "violet") +
13   geom_vline(xintercept = mean(x), col = "red", lwd
14             = 0.8) +
15   labs(title = "Histogram with mean value", x = "
16         Stress Rating", y = "Frequency") +
17   theme_bw()

```

---

### R code Exa 2.1c Mean Example 3

```

1 # Page no. : 38
2
3 x <- c(48, 15, 33, 3, 21, 19, 17, 16, 44, 25, 30, 3,
4       5, 9, 35, 32, 26, 13, 14, 14, 47, 47, 18,
5       11, 5, 19, 24, 17, 6, 25, 8, 18, 29, 1, 18,
6       22, 3, 22, 29, 2, 6, 10, 29, 10, 29, 21,
7       38,
8       41, 16, 17, 8, 40, 8, 10, 18, 7, 4, 4, 8, 11,
9       3, 23, 10, 19, 21, 13, 12, 10, 4, 17, 11,
10      21, 9, 8, 7, 5, 3, 22, 14, 25, 4, 11, 10, 18,
11      1, 28, 27, 19, 24, 35, 9, 30, 8, 26)
12
13 value <- mean(x)
14
15 cat("Mean of x is", round(value, 2))
16
17 library(ggplot2)
18
19 ggplot(data = data.frame(table(x)), aes(x = x, y =
20   Freq)) +

```

```
15 geom_bar(stat = "identity", fill = "violet") +
16 geom_vline(xintercept = mean(x), col = "red", lwd
    = 0.8) +
17 labs(title = "Histogram with mean value", x = "
    Social Interaction", y = "Frequency") +
18 theme_bw()
```

---

### R code Exa 2.1d How are you doing

```
1 # Page no. : 43
2
3 scores <- c(2, 3, 3, 6, 6)
4
5 value <- mean(scores)
6
7 cat("Mean value of scores is", value)
8
9 scores <- c(5, 3, 2, 13, 2)
10
11 value <- mean(scores)
12
13 cat("\nMean value of scores is", value)
14
15 mode <- function(v)
16 {
17   x <- unique(v)
18   x[which.max(tabulate(match(v, x)))]
19 }
20
21 value <- mode(scores)
22
23 cat("\nMode of scores is", value)
24
25 value <- median(scores)
26
```

```
27 cat("\nMedian of scores is", value)
```

---

### R code Exa 2.2a Variance and Standard Deviation Example 1

```
1 # Page no. : 48
2
3 scores <- c(7, 8, 8, 7, 3, 1, 6, 9, 3, 8)
4
5 library(rafalib)
6
7 variance <- popvar(scores)
8
9 standard_deviation <- popsd(scores)
10
11 cat("Variance is", round(variance, 2), "and Standard
    Deviation is", round(standard_deviation, 2))
```

---

### R code Exa 2.2b Variance and Standard Deviation Example 2

```
1 # Page no. : 49
2
3 interactions <- c(48, 15, 33, 3, 21, 19, 17, 16, 44,
4     25, 30, 3, 5, 9, 35, 32, 26, 13, 14,
5     14, 47, 47, 18, 11, 5, 19, 24, 17,
6     6, 25, 8, 18, 29, 1, 18, 22,
7     3, 22,
8     29, 2, 6, 10, 29, 10, 29, 21, 38,
9     41, 16, 17, 8, 40, 8, 10, 18,
10    7, 4, 4,
11    8, 11, 3, 23, 10, 19, 21, 13, 12,
12    10, 4, 17, 11, 21, 9, 8, 7, 5,
13    3, 22,
```

```

7             14, 25, 4, 11, 10, 18, 1, 28, 27,
              19, 24, 35, 9, 30, 8, 26)
8
9 library(rafalib)
10
11 variance <- popvar(interactions)
12
13 standard_deviation <- popsd(interactions)
14
15 cat("Variance is", round(variance, 2), "and Standard
      Deviation is", round(standard_deviation, 2))

```

---

**R code Exa 2.2c** How are you doing

```

1 # Page no. : 51 - 52
2
3 scores <- c(2, 4, 3, 7)
4
5 library(rafalib)
6
7 variance <- popvar(scores)
8
9 standard_deviation <- popsd(scores)
10
11 cat("Variance is", round(variance, 2), "and Standard
      Deviation is", round(standard_deviation, 2))

```

---

**R code Exa 2.3a** Worked Out Examples

```

1 # Page no. : 58 - 60
2
3 scores <- c(8, 6, 6, 9, 6, 5, 6, 2)
4

```

```
5 value <- mean(scores)
6
7 cat("Mean is", value)
8
9 scores <- c(1, 7, 4, 2, 3, 6, 2, 9, 7)
10
11 value <- median(scores)
12
13 cat("\nMedian is", value)
14
15 scores <- c(8, 6, 6, 9, 6, 5, 6, 2)
16
17 value <- sum((scores - mean(scores))**2)
18
19 cat("\nSum of Squares is", value)
20
21 library(rafalib)
22
23 variance <- popvar(scores)
24
25 cat("\nVariance is", variance)
26
27 standard_deviation <- popsd(scores)
28
29 cat("\nStandard Deviation is", round(standard_
    deviation, 2))
```

---



# Chapter 3

## Some Key Ingredients for Inferential Statistics

R code Exa 3.1a Formula to change Raw Score to Z Score and Vice Versa

```
1 # Page no. : 71
2
3 x <- 8
4 m <- 12
5 sd <- 4
6
7 Z <- (x - m) / sd
8
9 cat("Z Score is", Z)
10
11 Z <- 1.5
12 sd <- 4
13 m <- 12
14
15 X <- (Z * sd) + m
16
17 cat("\nRaw Score is", X)
```

---

**R code Exa 3.1b** Additional Example 1 to change Raw Score to Z Score and Vice Versa

```
1 # Page no. : 72
2
3 m <- 3.40
4 sd <- 1.47
5 x <- 6
6
7 Z <- (x - m) / sd
8
9 cat("Z Score is", round(Z, 2))
10
11 Z <- -1.63
12
13 X <- (Z * sd) + m
14
15 cat("\nRaw Score is", round(X, 2))
```

---

**R code Exa 3.1c** Additional Example 2 to change Raw Score to Z Score and Vice Versa

```
1 # Page no. : 72 - 73
2
3 m <- 6.43
4 sd <- 2.56
5 x <- 10
6
7 Z <- (x - m) / sd
8
9 cat("Z Score is", round(Z, 2))
10
```

```
11 Z <- -1.73
12
13 X <- (Z * sd) + m
14
15 cat("\nRaw Score is", round(X, 2))
```

---

**R code Exa 3.1d** How are you doing

```
1 # Page no. : 73
2
3 m <- 20
4 sd <- 5
5
6 x1 <- 30
7
8 z1 <- (x1 - m) / sd
9
10 cat("Z Score is", round(z1, 2))
11
12 x2 <- 15
13
14 z2 <- (x2 - m) / sd
15
16 cat("\nZ Score is", round(z2, 2))
17
18 x3 <- 20
19
20 z3 <- (x3 - m) / sd
21
22 cat("\nZ Score is", round(z3, 2))
23
24 x4 <- 22.5
25
26 z4 <- (x4 - m) / sd
27
```

```
28 cat("\nZ Score is", round(z4, 2))
```

---

**R code Exa 3.1e** How are you doing

```
1 # Page no. : 73
2
3 m <- 10
4 sd <- 2
5
6 z1 <- 2
7
8 x1 <- (z1 * sd) + m
9
10 cat("Raw Score is", round(x1, 2))
11
12 z2 <- 0.5
13
14 x2 <- (z2 * sd) + m
15
16 cat("\nRaw Score is", round(x2, 2))
17
18 z3 <- 0
19
20 x3 <- (z3 * sd) + m
21
22 cat("\nRaw Score is", round(x3, 2))
23
24 z4 <- -3
25
26 x4 <- (z4 * sd) + m
27
28 cat("\nRaw Score is", round(x4, 2))
```

---

**R code Exa 3.2a** Examples for finding Percentage from Z Scores and Raw Scores using Normal Curve Table

```
1 # Page no. : 79 - 81
2
3 m <- 100
4 sd <- 15
5
6 IQ1 <- 125
7
8 Z1 <- (IQ1 - m) / sd
9
10 cat("Z Score is", round(Z1, 2))
11
12 percent <- pnorm(Z1, lower.tail = F) * 100
13
14 cat("\nPercentage of IQ level is", round(percent, 2)
15     )
16
17 IQ2 <- 95
18
19 Z2 <- (IQ2 - m) / sd
20
21 cat("\nZ Score is", round(Z2, 2))
22
23 percent <- pnorm(Z2, lower.tail = F) * 100
24
25 cat("\nPercentage of IQ level is", round(percent, 2)
26     )
```

---

**R code Exa 3.2b** Examples for finding Z Scores and Raw Scores from Percentage using Normal Curve Table

```
1 # Page no. : 81 - 84
2
```

```

3 m <- 100
4 sd <- 15
5
6 percent <- 0.05
7
8 Z1 <- qnorm(percent, lower.tail = F)
9
10 cat("Z Score is", round(Z1, 2))
11
12 IQ1 <- (sd * Z1) + m
13
14 cat("\nRaw Score is", round(IQ1, 2))
15
16 percent <- 0.55
17
18 Z2 <- qnorm(percent, lower.tail = F)
19
20 cat("\nZ Score is", round(Z2, 2))
21
22 IQ2 <- (sd * Z2) + m
23
24 cat("\nRaw Score is", round(IQ2, 2))
25
26 percent <- 0.95
27
28 Z3 <- qnorm(0.975, lower.tail = T)
29
30 cat("\nZ Score is", round(Z3, 2))
31
32 IQ3 <- (sd * Z3) + m
33
34 cat("\nRaw Score is", round(IQ3, 2))

```

---

**R code Exa 3.3a** Worked Out Examples 1

```

1 # Page no. : 100
2
3 m <- 80
4 sd <- 20
5 x <- 65
6
7 Z <- (x - m) / sd
8
9 cat("Z Score is", Z)
10
11 m <- 200
12 sd <- 50
13 z <- 1.26
14
15 X <- (z * sd) + m
16
17 cat("\nRaw Score is", X)

```

---

### R code Exa 3.3b Worked Out Examples 2

```

1 # Page no. : 100 - 102
2
3 m <- 20
4 sd <- 3
5 x <- 24
6
7 Z <- (x - m) / sd
8
9 cat("Z Score is", round(Z,2))
10
11 percent <- pnorm(Z, lower.tail = F) * 100
12
13 cat("\nPercentage of people have scores above 24 is"
14     , round(percent, 2))

```

```
15 m <- 20
16 sd <- 3
17 percent <- 0.75
18
19 Z <- qnorm(percent, lower.tail = F)
20
21 cat("\nZ Score is", round(Z, 2))
22
23 X <- (sd * Z) + m
24
25 cat("\nRaw Score is", round(X, 2))
```

---

### R code Exa 3.3c Worked Out Examples 3

```
1 # Page no. : 102 – 103
2
3 apple <- 20
4 strawberry <- 20
5 cherry <- 5
6 grape <- 5
7
8 total <- apple + strawberry + cherry + grape
9
10 case <- cherry + grape
11
12 probability <- case / total
13
14 cat("The required probability is", probability)
```

---



# Chapter 4

## Introduction to Hypothesis Testing

R code Exa 4.1a The Hypothesis Testing Process

```
1 # Page no. : 111 - 115
2
3 m <- 14
4 sd <- 3
5 x <- 6
6 alpha <- 0.01
7
8 cutoff <- qnorm(alpha)
9 cutoff <- round(cutoff, 2)
10
11 z <- (x - m) / sd
12
13 cat("\nCutoff Sample Z Score is ", cutoff)
14 cat("\nActual Sample Z Score is", round(z, 2))
15
16 if(z < cutoff)
17 {
18   cat("\nWe reject null hypothesis.")
19 }else{
```

```
20   cat("\nWe cannot reject null hypothesis.")
21 }
```

---

#### R code Exa 4.1b The Second Example

```
1 # Page no. : 116 - 118
2
3 m <- 70
4 sd <- 10
5 x <- 80
6 alpha <- 0.05
7
8 cutoff <- qnorm(1 - alpha)
9 cutoff <- round(cutoff, 2)
10
11 z <- (x - m) / sd
12
13 if(z > cutoff)
14 {
15   cat("We reject null hypothesis.")
16 }else{
17   cat("We cannot reject null hypothesis.")
18 }
```

---

#### R code Exa 4.1c How are you doing

```
1 # Page no. : 119 - 120
2
3 m <- 30
4 sd <- 4
5 x <- 40
6 alpha <- 0.05
7
```

```

8 cutoff <- qnorm(1 - alpha)
9 cutoff <- round(cutoff, 2)
10
11 z <- (x - m) / sd
12
13 cat("Cutoff Sample Z Score is ", cutoff)
14 cat("\nActual Sample Z Score is", z)
15
16 if(z > cutoff)
17 {
18   cat("\nWe reject null hypothesis.")
19 }else{
20   cat("\nWe cannot reject null hypothesis.")
21 }

```

---

**R code Exa 4.2a** Example of Hypothesis Testing with a Two Tailed Test

```

1 # Page no. : 123 - 124
2
3 m <- 69.5
4 sd <- 14.1
5 x <- 41
6 alpha <- 0.05
7
8 cutoff1 <- qnorm(0.025)
9 cutoff1 <- round(cutoff1, 2)
10
11 cutoff2 <- qnorm(0.975)
12 cutoff2 <- round(cutoff2, 2)
13
14 z <- (x - m) / sd
15
16 cat("Cutoff Z scores are", cutoff1, "and", cutoff2)
17 cat("\nActual Z score is", round(z, 2))
18

```

```
19 if(z > cutoff1 & z < cutoff2)
20 {
21   cat("\nWe cannot reject null hypothesis.")
22 }else{
23   cat("\nWe can reject null hypothesis.")
24 }
```

---

**R code Exa 4.2b** How are you doing

```
1 # Page no. : 125
2
3 m <- 500
4 sd <- 40
5 x <- 400
6 alpha <- 0.01
7
8 cutoff1 <- qnorm(0.005)
9 cutoff1 <- round(cutoff1, 2)
10
11 cutoff2 <- qnorm(0.995)
12 cutoff2 <- round(cutoff2, 2)
13
14 z <- (x - m) / sd
15
16 cat("Cutoff Z scores are", cutoff1, "and", cutoff2)
17 cat("\nActual Z score is", round(z, 2))
18
19 if(z > cutoff1 & z < cutoff2)
20 {
21   cat("\nWe cannot reject null hypothesis.")
22 }else{
23   cat("\nWe can reject null hypothesis..")
24 }
```

---

### R code Exa 4.3a Worked Out Examples

```
1 # Page no. : 131 - 132
2
3 m <- 19
4 sd <- 4
5 x <- 27
6 alpha <- 0.05
7
8 cutoff1 <- qnorm(0.025)
9 cutoff1 <- round(cutoff1, 2)
10
11 cutoff2 <- qnorm(0.975)
12 cutoff2 <- round(cutoff2, 2)
13
14 z <- (x - m) / sd
15
16 cat("Cutoff Z scores are", cutoff1, "and", cutoff2)
17 cat("\nActual Z score is", round(z, 2))
18
19 if(z > cutoff1 & z < cutoff2)
20 {
21   cat("\nWe cannot reject null hypothesis.")
22 }else{
23   cat("\nWe can reject null hypothesis.")
24 }
```

---

# Chapter 5

## Hypothesis Tests with Means of Samples

R code Exa 5.1a Determining the Characteristics of a Distribution of Means

```
1 # Page no. : 144
2
3 grade <- 6.67
4 N <- 2
5
6 ans <- grade / N
7
8 cat("Answer is", round(ans,2))
9
10 pv <- 400
11 N <- 25
12
13 ans <- pv / N
14
15 cat("\nAnswer is", round(ans, 2))
```

---

**R code Exa 5.1b** Example of Determining the Characteristics of a Distribution of Means

```
1 # Page no. : 146 - 147
2
3 mean <- 200
4 sd <- 48
5 N <- 64
6
7 var <- sd ** 2
8 ans <- var / N
9
10 cat("Answer is",ans)
11
12 sd2 <- sqrt(ans)
13
14 cat("\nAnswer is",sd2)
```

---

**R code Exa 5.1c** How are you doing

```
1 # Page no. : 148
2
3 mean <- 60
4 sd <- 10
5 N <- 4
6
7 var <- sd ** 2
8 ans <- var / N
9
10 cat("Answer is",ans)
11
12 var2 <- sqrt(ans)
13
14 cat("\nAnswer is",var2)
```

---

**R code Exa 5.2a** Hypothesis testing with a distribution of means The Z Test

```
1 # Page no. : 148 - 149
2
3 mean <- 18
4 d_mean <- 10
5 sd <- 4
6
7 z <- (mean - d_mean) / sd
8
9 cat("Z score is", z)
```

---

**R code Exa 5.2b** Example 1 for Hypothesis testing with a distribution of means The Z Test

```
1 # Page no. : 150 - 152
2
3 n <- 64
4 mean <- 220
5 d_mean <- 200
6 sd <- 48
7 var <- sd ** 2
8 d_var <- var / n
9 d_sd <- sqrt(d_var)
10 alpha <- 0.05
11 zval <- qnorm(alpha, lower.tail = F)
12
13 z <- (mean - d_mean) / d_sd
14
15 cat("The value of z-score is", z)
16
```



```

17 if(z > zval)
18 {
19   cat("\nReject null hypothesis")
20 } else
21 {
22   cat("\nWe cannot reject null hypothesis")
23 }

```

---

**R code Exa 5.2c** Example 2 for Hypothesis testing with a distribution of means The Z Test

```

1 # Page no. : 152 - 154
2
3 n <- 25
4 mean <- 48
5 d_mean <- 53
6 sd <- 7
7 var <- sd ** 2
8 d_var <- var / n
9 d_sd <- sqrt(d_var)
10 alpha <- 0.01
11
12 zval <- qnorm(1 - alpha/2)
13 zval <- round(c(zval, -zval),2)
14
15 z <- (mean - d_mean) / d_sd
16
17 cat("The value of z-score is", z)
18
19 if(z > zval[1] || z < zval[2])
20 {
21   cat("\nReject null hypothesis")
22 } else
23 {
24   cat("\nWe cannot reject null hypothesis")

```

25 }

---

**R code Exa 5.2d** How are you doing

```
1 # Page no. : 154 - 155
2
3 n <- 36
4 mean <- 70
5 d_mean <- 75
6 sd <- 12
7 var <- sd ** 2
8 d_var <- var / n
9 d_sd <- sqrt(d_var)
10 alpha <- 0.05
11
12 zval <- qnorm(1 - alpha/2)
13 zval <- round(c(zval, -zval),2)
14
15 z <- (mean - d_mean) / d_sd
16
17 cat("The value of z-score is", z)
18
19 if(z > zval[1] || z < zval[2])
20 {
21   cat("\nReject null hypothesis")
22 } else
23 {
24   cat("\nWe cannot reject null hypothesis")
25 }
```

---

**R code Exa 5.3a** Confidence interval

```
1 # Page no. : 161
```

```

2
3 c_i <- 0.995
4 n <- 25
5 d_mean <- 53
6 mean <- 48
7 sd <- 7
8 var <- sd ** 2
9
10 se <- sqrt(var/n)
11
12 cat("Standard error is", se)
13
14 r_s <- round(qnorm(c_i), 2)
15
16 x <- se * r_s
17
18 y <- mean + c(-x, x)
19
20 cat("\nThe margin of error is given by", x)
21 cat("\nThe 99% confidence interval is given by", y)

```

---

**R code Exa 5.3b** How are you doing

```

1 # Page no. : 163
2
3 n <- 36
4 mean <- 70
5 d_mean <- 75
6 sd <- 12
7 var <- sd ** 2
8 c_i <- 0.975
9
10 se <- sqrt(var/n)
11
12 cat("Standard error is", se)

```

```
13
14 r_s <- round(qnorm(c_i), 2)
15
16 x <- se * r_s
17
18 y <- mean + c(-x, x)
19
20 cat("\nThe margin of error is given by", x)
21 cat("\nThe 99% confidence interval is given by", y)
```

---

#### R code Exa 5.4a Worked out examples 1

```
1 # Page no. : 167
2
3 sd <- 13
4 var <- sd ** 2
5 n <- 20
6
7 d_sd <- sqrt(var/n)
8
9 cat("Standard deviation for distribution of means is
    ", round(d_sd, 2))
```

---

#### R code Exa 5.4b Worked out examples 2

```
1 # Page no. : 167 - 168
2
3 n <- 75
4 mean <- 16
5 d_mean <- 15
6 sd <- 5
7 var <- sd ** 2
8 d_var <- var / n
```

```

 9 d_sd <- sqrt(d_var)
10 alpha <- 0.05
11
12 zval <- qnorm(1 - alpha/2)
13 zval <- round(c(zval, -zval),2)
14
15 z <- (mean - d_mean) / d_sd
16
17 cat("Z Score is", z)
18
19 if(z > zval[1] || z < zval[2])
20 {
21   cat("\nCan reject null hypothesis")
22 } else
23 {
24   cat("\nCannot reject null hypothesis")
25 }

```

---

### R code Exa 5.4c Worked out examples 3

```

1 # Page no. : 169
2
3 n <- 75
4 mean <- 16
5 d_mean <- 15
6 sd <- 5
7 var <- sd ** 2
8 d_var <- var / n
9 d_sd <- sqrt(d_var)
10 c_i <- 0.995
11
12 se <- d_sd
13
14 cat("Standard error is", se)
15

```

```
16 r_s <- round(qnorm(c_i), 2)
17
18 x <- se * r_s
19
20 y <- mean + c(-x, x)
21
22 cat("\nThe margin of error is given by", x)
23 cat("\nThe 99% confidence interval is given by", y)
```

---

## Chapter 6

# Making Sense of Statistical Significance

R code Exa 6.1a Figuring effect size

```
1 # Page no. : 184 - 185
2
3 m1 <- 220
4 m2 <- 200
5 sd <- 48
6
7 d1 <- (m1 - m2) / sd
8
9 cat("Estimated effect size is", round(d1, 2))
10
11 m1 <- 210
12
13 d2 <- (m1 - m2) / sd
14
15 cat("\nEstimated effect size is", round(d2, 2))
16
17 m1 <- 170
18
19 d3 <- (m1 - m2) / sd
```

20

```
21 cat("\nEstimated effect size is", round(d3, 2))
```

---

**R code Exa 6.1b** How are you doing

```
1 # Page no. : 188 - 189
2
3 m1 <- 540
4 m2 <- 500
5 sd <- 100
6
7 d1 <- (m1 - m2) / sd
8
9 cat("Estimated effect size is", round(d1, 2))
```

---

**R code Exa 6.2a** Determining power from predicted effect size

```
1 # Page no. : 197
2
3 m2 <- 200
4 d <- .20
5 sd <- 48
6
7 m <- m2 + (d * sd)
8
9 cat("Predicted value is", round(m, 2))
10
11 d <- .50
12
13 m <- m2 + (d * sd)
14
15 cat("\nPredicted value is", round(m, 2))
```

---



**R code Exa 6.2b** How are you doing

```
1 # Page no. : 204
2
3 m2 <- 500
4 d <- .80
5 sd <- 100
6
7 m <- m2 + (d * sd)
8
9 cat("Predicted value is", round(m, 2))
```

---

**R code Exa 6.3a** Advanced topic Figuring Statistical Power

```
1 # Page no. : 214 - 215
2
3 m <- 200
4 sd <- 48
5 var <- sd ** 2
6 n <- 64
7
8 d_sd <- sqrt(var/n)
9
10 m2 <- 208
11
12 alpha <- 0.05
13 zval <- qnorm(alpha, lower.tail = F)
14
15 r_s <- round((zval * d_sd) + m, 2)
16
17 z <- (r_s - m2) / d_sd
18
```

```
19 cat("Z is", round(z, 2))
```

---

**R code Exa 6.3b** How are you doing

```
1 # Page no. : 216 - 217
2
3 m <- 500
4 sd <- 100
5 var <- sd ** 2
6 n <- 60
7
8 d_sd <- sqrt(var/n)
9
10 m2 <- 540
11
12 alpha <- 0.05
13 zval <- qnorm(alpha, lower.tail = F)
14
15 r_s <- round((zval * d_sd) + m, 2)
16
17 z <- (r_s - m2) / d_sd
18
19 cat("Z is", round(z, 2))
```

---

**R code Exa 6.4a** Worked out examples 1

```
1 # Page no. : 218
2
3 m1 <- 37
4 m2 <- 40
5 sd <- 10
6
7 d1 <- (m1 - m2) / sd
```

```
8
9 cat("Estimated effect size is", round(d1, 2))
```

---

#### R code Exa 6.4b Worked out examples 2

```
1 # Page no. : 218 - 219
2
3 m2 <- 40
4 d <- -0.20
5 sd <- 10
6
7 m <- m2 + (d * sd)
8
9 cat("Predicted effect size is", round(m, 2))
```

---

#### R code Exa 6.4c Worked out examples 3

```
1 # Page no. : 219
2
3 m <- 40
4 sd <- 10
5 var <- sd ** 2
6 n <- 25
7
8 d_sd <- sqrt(var/n)
9
10 m2 <- 49
11
12 alpha <- 0.01
13 zval <- qnorm(alpha, lower.tail = F)
14
15 r_s <- round((zval * d_sd) + m, 2)
16
```

```
17 z <- (r_s - m2) / d_sd
18
19 cat("Z is", round(z, 2))
```

---

# Chapter 7

## Introduction to t Tests

**R code Exa 7.1a** Basic Principle of the t Test Estimating the Population Variance from the Sample Scores

```
1 # Page no. : 229 - 230
2
3 n <- 16
4 ss <- 694
5
6 var <- (ss)/(n - 1)
7
8 cat("Estimated population variance is", round(var,
9     2))
```

---

**R code Exa 7.1b** The Standard Deviation of the Distribution of Means

```
1 # Page no. : 231
2
3 s <- 16
4 var <- 46.27
5
```

```
6 d_var <- var / s
7
8 cat("Variance is", round(d_var, 2))
9
10 d_sd <- sqrt(d_var)
11
12 cat("\nStandard deviation is", round(d_sd, 2))
```

---

**R code Exa 7.1c** The Sample means score on the comparison distribution  
the t score

```
1 # Page no. : 234
2
3 m1 <- 21
4 m2 <- 17
5 sd <- 1.70
6
7 t <- (m1 - m2) / sd
8
9 cat("The t score is", round(t, 2))
```

---

**R code Exa 7.1d** Another example of a t test for a single sample

```
1 # Page no. : 235 – 236
2
3 rating <- c(5, 3, 6, 2, 7, 6, 7, 4, 2, 5)
4 n <- 10
5
6 mean <- mean(rating)
7
8 diff <- rating - mean
9
10 sq_diff <- diff ** 2
```

```

11
12 data_frame <- data.frame(rating, diff, sq_diff)
13
14 View(data_frame)
15
16 df <- n - 1
17
18 mu <- 4
19
20 var <- sum(data_frame$sq_diff) / df
21
22 d_var <- var / n
23
24 d_sd <- sqrt(d_var)
25
26 alpha <- 0.01
27
28 tval <- round(qt(1 - alpha/2, df), 2)
29 tval <- c(tval, -tval)
30
31 t <- (mean - mu) / d_sd
32
33 cat("\nValue of t is", t)
34
35 if(t > tval[1] || t < tval[2])
36 {
37   cat("\nReject null hypothesis")
38 } else
39 {
40   cat("\nCannot reject null hypothesis")
41 }

```

---

**R code Exa 7.1e** How are you doing

1 # Page no. : 238 – 240

```

2
3 n <- 4
4 df <- n - 1
5
6 m1 <- 23
7
8 scores <- c(20, 22, 22, 20)
9
10 mean <- mean(scores)
11
12 diff <- scores - mean
13
14 sq_diff <- diff ** 2
15
16 alpha <- 0.05
17
18 var <- sum(sq_diff) / df
19
20 d_var <- var / n
21
22 d_sd <- sqrt(d_var)
23
24 tval <- round(qt(alpha, df, lower.tail = T), 2)
25
26 t <- (mean - m1) / d_sd
27
28 cat("Value of t is", t)
29
30 if(t < tval)
31 {
32   cat("\nReject null hypothesis")
33 } else
34 {
35   cat("\nCannot reject null hypothesis")
36 }

```

---



**R code Exa 7.2a** Example of a t test for dependent means

```
1 # Page no. : 241 - 242
2
3 Husband <- LETTERS[1:19]
4
5 n <- 19
6
7 df <- n - 1
8
9 before <- c(126, 133, 126, 115, 108, 109, 124, 98,
             95, 120, 118, 126, 121, 116, 94, 105, 123, 125,
             128)
10 after <- c(115, 125, 96, 115, 119, 82, 93, 109, 72,
             104, 107, 118, 102, 115, 83, 87, 121, 100, 118)
11
12 diff <- after - before
13 mean <- mean(diff)
14
15 deviation <- round(diff - mean, 2)
16
17 sq_dev <- round(deviation ** 2, 2)
18
19 data_frame <- data.frame(Husband, before, after,
                           diff, deviation, sq_dev)
20
21 View(data_frame)
22
23 mu <- 0
24
25 var <- sum(data_frame$sq_dev) / df
26
27 d_var <- var / n
28
```

```

29 d_sd <- sqrt(d_var)
30
31 alpha <- 0.05
32
33 tval <- round(qt(1 - alpha/2, df), 2)
34 tval <- c(tval, -tval)
35
36 t <- (mean - mu) / d_sd
37
38 cat("\nValue of t is", t)
39
40 if(t > tval[1] || t < tval[2])
41 {
42   cat("\nReject null hypothesis")
43 } else
44 {
45   cat("\nCannot reject null hypothesis")
46 }

```

---

**R code Exa 7.2b** A second example of a t test for dependent means

```

1 # Page no. : 245 - 246
2
3 student <- c(1:10)
4
5 n <- 10
6
7 df <- n - 1
8
9 b_p <- c(1487.8, 1329.4, 1407.9, 1236.1, 1299.8,
10         1447.2, 1354.1, 1204.6, 1322.3, 1388.5)
11 c_p <- c(1487.2, 1328.1, 1405.9, 1234.0, 1298.2,
12         1444.7, 1354.3, 1203.7, 1320.8, 1386.8)

```

```

13 mean <- mean(diff)
14
15 deviation <- round(diff - mean, 2)
16
17 sq_dev <- round(deviation ** 2, 2)
18
19 data_frame <- data.frame(student, b_p, c_p, diff,
    deviation, sq_dev)
20
21 View(data_frame)
22
23 mu <- 0
24
25 var <- sum(data_frame$sq_dev) / df
26
27 d_var <- var / n
28
29 d_sd <- sqrt(d_var)
30
31 alpha <- 0.05
32
33 tval <- round(qt(alpha, df, lower.tail = F), 2)
34
35 t <- (mean - mu) / d_sd
36
37 cat("\nValue of t is", t)
38
39 if(t > tval)
40 {
41   cat("\nReject null hypothesis")
42 } else
43 {
44   cat("\nCannot reject null hypothesis")
45 }

```

---

### R code Exa 7.2c How are you doing

```
1 # Page no. : 249 - 250
2
3 person <- c(1:5)
4 n <- 5
5 df <- n - 1
6
7 before <- c(20, 30, 20, 40, 30)
8 after <- c(30, 50, 10, 30, 40)
9
10 diff <- after - before
11 mean <- mean(diff)
12
13 deviation <- round(diff - mean, 2)
14
15 sq_dev <- round(deviation ** 2, 2)
16
17 data_frame <- data.frame(person, before, after, diff
18   , deviation, sq_dev)
19 View(data_frame)
20
21 mu <- 0
22
23 var <- sum(data_frame$sq_dev) / df
24
25 d_var <- var / n
26
27 d_sd <- sqrt(d_var)
28
29 alpha <- 0.05
30
31 tval <- round(qt(1 - alpha/2, df), 2)
32 tval <- c(tval, -tval)
33
34 t <- (mean - mu) / d_sd
35
```

```
36 cat("\nValue of t is", t)
37
38 if(t > tval[1] || t < tval[2])
39 {
40   cat("\nReject null hypothesis")
41 } else
42 {
43   cat("\nCannot reject null hypothesis")
44 }
```

---

**R code Exa 7.3a** Effect size for the t test for dependent means

```
1 # Page no. : 252
2
3 mu1 <- 4
4 mu2 <- 0
5 sd <- 8
6
7 d <- (mu1 - mu2) / sd
8
9 cat("Effect size is", d)
10
11 m_d <- -12.05
12 var <- 153.49
13 sd <- round(sqrt(var), 2)
14
15 d <- round((m_d - mu2) / sd, 2)
16
17 cat("\nEffect size is", d)
```

---

**R code Exa 7.3b** How are you doing

```
1 # Page no. : 254
```

```

2
3 mu1 <- 40
4 mu2 <- 0
5 sd <- 80
6 alpha <- 0.05
7
8 d <- round((mu1 - mu2) / sd, 2)
9
10 cat("Effect size is", d)

```

---

#### R code Exa 7.4a Worked out examples 1

```

1 # Page no. : 259
2
3 scores <- c(14, 8, 6, 5, 13, 10, 10, 6)
4 n <- length(scores)
5 df <- n - 1
6 mean <- 6
7 alpha <- 0.05
8
9 m <- mean(scores)
10
11 diff <- scores - m
12
13 sq_diff <- diff ** 2
14
15 var <- sum(sq_diff) / df
16
17 d_var <- var / n
18
19 d_sd <- sqrt(d_var)
20
21 tval <- round(qt(1 - alpha/2, df), 2)
22 tval <- c(tval, -tval)
23

```

```

24 t <- (m - mean) / d_sd
25
26 cat(" Value of t is", t)
27
28 if(t > tval[1] || t < tval[2])
29 {
30   cat("\nReject null hypothesis")
31 } else
32 {
33   cat("\nCannot reject null hypothesis")
34 }

```

---

#### R code Exa 7.4b Worked out examples 2

```

1 # Page no. : 259 - 261
2
3 participant <- c(1:10)
4 n <- 10
5 df <- n - 1
6
7 before <- c(10.4, 12.6, 11.2, 10.9, 14.3, 13.2, 9.7,
8            11.5, 10.8, 13.1)
9 after <- c(10.8, 12.1, 12.1, 11.4, 13.9, 13.5, 10.9,
10          11.5, 10.4, 12.5)
11
12 diff <- after - before
13 mean <- mean(diff)
14
15 deviation <- round(diff - mean, 2)
16
17 sq_dev <- round(deviation ** 2, 2)
18
19 data_frame <- data.frame(participant, before, after,
20                          diff, deviation, sq_dev)

```

```

19 View(data_frame)
20
21 mu <- 0
22
23 var <- sum(data_frame$sq_dev) / df
24
25 d_var <- var / n
26
27 d_sd <- sqrt(d_var)
28
29 alpha <- 0.05
30
31 tval <- round(qt(1 - alpha/2, df), 2)
32 tval <- c(tval, -tval)
33
34 t <- (mean - mu) / d_sd
35
36 cat("\nValue of t is", t)
37
38 if(t > tval[1] || t < tval[2])
39 {
40   cat("\nReject null hypothesis")
41 } else
42 {
43   cat("\nCannot reject null hypothesis")
44 }

```

---



# Chapter 8

## The t Test for Independent Means

R code Exa 8.1a Estimating the population variance

```
1                                     # Page no. : 278
2                                     - 279
3 # Estimating the population variance
4
5 n1 <- 11   # Group 1 participants
6 df1 <- n1 - 1 # Degree of freedom for group 1
7 var1 <- 60  # Variance
8
9 n2 <- 31   # Group 2 participants
10 df2 <- n2 - 1 # Degree of freedom for group 2
11 var2 <- 80  # Variance
12
13 df <- df1 + df2 # Total degrees of freedom
14
15 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
16         # Pooled variance
17 cat("Pooled variance is", p_var)
```

---

**R code Exa 8.1b** Figuring the variance of each of the two distributions of means

```
1                                     # Page no. : 279 -
                                     280
2
3 # Figuring the variance of each of the two
  distributions of means
4
5 n1 <- 11 # Group 1 participants
6 n2 <- 31 # Group 2 participants
7 p_var <- 75 # Pooled variance
8
9 var1 <- p_var / n1 # Variance for group 1
10
11 cat("Variance for group 1 is", round(var1, 2))
12
13 var2 <- p_var / n2 # Variance for group 1
14
15 cat("Variance for group 2 is", round(var2, 2))
```

---

**R code Exa 8.1c** The variance and standard deviation of the distribution of differences between means

```
1                                     # Page no. :
                                     280
2
3 # The variance and standard deviation of the
  distribution of differences between means
4
5 var1 <- 6.82 # Variance of the distribution of
  means of group 1
```

```

6 var2 <- 2.42 # Variance of the distribution of
  means of group 2
7
8 diff_var <- var1 + var2 # Variance difference
9
10 cat("Variance difference is", diff_var)
11
12 diff_sd <- sqrt(diff_var) # Standard deviation
  difference
13
14 cat("Standard deviation difference is", round(diff_
  sd, 2))

```

---

**R code Exa 8.1d** The t score for the difference between the two actual means

```

1 # Page no. : 281
  - 282
2
3 # The t score for the difference between the two
  actual means
4
5 m1 <- 198 # Mean of the first sample
6 m2 <- 190 # Mean of the second sample
7
8 diff_sd <- 3.04 # Standard deviation difference
9
10 t <- (m1 - m2) / diff_sd # t score
11
12 cat("t score is", round(t, 2))

```

---

**R code Exa 8.1e** How are you doing

```

1
# Page no. : 282
# - 283
2
3 # How are you doing?
4
5 # 5th Question (a) part
6
7 n1 <- 21 # Sample 1 participants
8 df1 <- n1 - 1 # Degree of freedom 1
9 var1 <- 100 # Variance
10
11 n2 <- 31 # Sample 1 participants
12 df2 <- n2 - 1 # Degree of freedom 1
13 var2 <- 200 # Variance
14
15 df <- df1 + df2 # Total degrees of freedom
16
17 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
# Pooled variance
18
19 cat("Pooled variance is", p_var)
20
21 d_var1 <- p_var / n1 # Variance of the
# distribution of means of sample 1
22
23 cat("Variance of the distribution of means of sample
# 1 is", round(d_var1, 2))
24
25 d_var2 <- p_var / n2 # Variance of the
# distribution of means of sample 2
26
27 cat("Variance of the distribution of means of sample
# 2 is", round(d_var2, 2))
28
29 diff_var <- d_var1 + d_var2 # Variance difference
30
31 cat("Variance difference is", round(diff_var, 2))
32

```

```

33 diff_sd <- sqrt(diff_var) # Standard deviation
    difference
34
35 cat("Standard deviation difference is", round(diff_
    sd, 2))

```

---

**R code Exa 8.2a** Example of a T test for independent means

```

1 # # Page no. :
    284
2 #
3 # # Example of a T test for independent means
4
5 # Expressive Writing Group
6
7 score1 <- c(77, 88, 77, 90, 68, 74, 62, 93, 82, 79)
8 n1 <- length(score1) # Sample size 1
9 df1 <- n1 - 1 # Degree of freedom
10 m1 <- mean(score1) # Mean
11 deviation1 <- score1 - m1
12 sq_dev1 <- deviation1 ** 2 # Squared deviation
13
14 data_frame1 <- data.frame(score1, deviation1, sq_
    dev1)
15 View(data_frame1)
16
17 # Control Writing Group
18
19 score2 <- c(87, 77, 71, 70, 63, 50, 58, 63, 76, 65)
20 n2 <- length(score2) # Sample size 2
21 df2 <- n2 - 1 # Degree of freedom
22 m2 <- mean(score2) # Mean
23 deviation2 <- score2 - m2
24 sq_dev2 <- deviation2 ** 2 # Squared deviation
25

```

```

26 data_frame2 <- data.frame(score2, deviation2, sq_
    dev2)
27 View(data_frame2)
28
29 var1 <- sum(data_frame1$sq_dev1) / df1 # Variance
    1
30 var2 <- sum(data_frame2$sq_dev2) / df2 # Variance
    2
31
32 df <- df1 + df2 # Total degrees of freedom
33
34 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
    # Pooled variance
35
36 cat("Pooled variance is", round(p_var, 2))
37
38 d_var1 <- p_var / n1 # Variance of the
    distribution of means of sample 1
39
40 cat("# Variance of the distribution of means of
    sample 1 is", round(d_var1, 2))
41
42 d_var2 <- p_var / n2 # Variance of the
    distribution of means of sample 2
43
44 cat("# Variance of the distribution of means of
    sample 2 is", round(d_var2, 2))
45
46 diff_var <- d_var1 + d_var2 # Variance difference
47
48 cat("Variance difference is", diff_var)
49
50 diff_sd <- sqrt(diff_var) # Standard deviation
    difference
51
52 cat("Standard deviation difference is", round(diff_
    sd, 2))
53

```

```

54 # Two - Tailed
55
56 alpha <- 0.05 # 5% significance level
57
58 tval <- qt(1-alpha/2, df)
59 tval <- c(tval, -tval)
60
61 t <- round((m1 - m2) / diff_sd, 2) # t score
62
63 cat("t score is", t)
64
65 if(t > tval[1] || t < tval[2])
66 {
67   cat("Reject null hypothesis")
68 } else
69 {
70   cat("Cannot reject null hypothesis")
71 }

```

---

**R code Exa 8.2b** A second example of a T test for independent means

```

1
2
3 # A second example of a T test for independent means
4
5 # Experimental Group (Receiving Special Program)
6
7 score1 <- c(6, 4, 9, 7, 7, 3)
8 n1 <- length(score1) # Sample size 1
9 df1 <- n1 - 1 # Degree of freedom
10 m1 <- mean(score1) # Mean
11 deviation1 <- score1 - m1
12 sq_dev1 <- deviation1 ** 2 # Squared deviation
13

```

```

14 data_frame1 <- data.frame(score1, deviation1, sq_
    dev1)
15 View(data_frame1)
16
17 # Control Group (Receiving Ordinary Program)
18
19 score2 <- c(6, 1, 5, 3, 1, 1, 4, 3)
20 n2 <- length(score2) # Sample size 2
21 df2 <- n2 - 1 # Degree of freedom
22 m2 <- mean(score2) # Mean
23 deviation2 <- score2 - m2
24 sq_dev2 <- deviation2 ** 2 # Squared deviation
25
26 data_frame2 <- data.frame(score2, deviation2, sq_
    dev2)
27 View(data_frame2)
28
29 var1 <- sum(data_frame1$sq_dev1) / df1 # Variance
    1
30 var2 <- sum(data_frame2$sq_dev2) / df2 # Variance
    2
31
32 df <- df1 + df2 # Total degrees of freedom
33
34 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
    # Pooled variance
35
36 cat("Pooled variance is", round(p_var, 2))
37
38 d_var1 <- p_var / n1 # Variance of the
    distribution of means of sample 1
39
40 cat("# Variance of the distribution of means of
    sample 1 is", round(d_var1, 2))
41
42 d_var2 <- p_var / n2 # Variance of the
    distribution of means of sample 2
43

```



```

44 cat("# Variance of the distribution of means of
      sample 2 is", round(d_var2, 2))
45
46 diff_var <- d_var1 + d_var2 # Variance difference
47
48 cat("Variance difference is", diff_var)
49
50 diff_sd <- sqrt(diff_var) # Standard deviation
      difference
51
52 cat("Standard deviation difference is", round(diff_
      sd, 2))
53
54 # Two - Tailed
55
56 alpha <- 0.05 # 5% significance level
57
58 tval <- qt(1-alpha/2, df)
59 tval <- c(tval, -tval)
60
61 t <- round((m1 - m2) / diff_sd, 2) # t score
62
63 cat("t score is", t)
64
65 if(t > tval[1] || t < tval[2])
66 {
67   cat("Reject null hypothesis")
68 } else
69 {
70   cat("Cannot reject null hypothesis")
71 }

```

---

**R code Exa 8.2c** How are you doing

```

1                                     # Page no. : 289 -
                                     291
2
3 # How are you doing?
4
5 # 2nd Question (a) part
6
7 alpha <- 0.05   # 5% significance level
8
9 n1 <- 26   # Sample size 1
10 df1 <- n1 - 1   # Degree of freedom
11 m1 <- 5   # Mean 1
12 var1 <- 10   # Variance 1
13
14 n2 <- 36   # Sample size 2
15 df2 <- n2 - 1   # Degree of freedom
16 m2 <- 8   # Mean 2
17 var2 <- 12   # Variance 2
18
19 df <- df1 + df2   # Total degrees of freedom
20
21 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
    # Pooled variance
22
23 cat("Pooled variance is \n", round(p_var, 2))
24
25 d_var1 <- p_var / n1   # Variance of the
    distribution of means of sample 1
26
27 cat("Variance of the distribution of means of sample
    1 is \n", round(d_var1, 2))
28
29 d_var2 <- p_var / n2   # Variance of the
    distribution of means of sample 2
30
31 cat("Variance of the distribution of means of sample
    2 is \n", round(d_var2, 2))
32

```

```

33 diff_var <- d_var1 + d_var2 # Variance difference
34
35 cat("Variance difference is \n", round(diff_var, 2))
36
37 diff_sd <- sqrt(diff_var) # Standard deviation
   difference
38
39 cat("Standard deviation difference is \n", round(
   diff_sd, 2))
40
41 # One - Tailed
42
43 tval <- qt(alpha, df)
44
45 t <- round((m1 - m2) / diff_sd, 2) # t score
46
47 cat("t score is \n", t)
48
49 if(t < tval)
50 {
51   cat("Reject null hypothesis")
52 } else
53 {
54   cat("Cannot reject null hypothesis")
55 }

```

---

**R code Exa 8.3a** Effect size for the t test for independent means

```

1 # Page no. :
   293 - 294
2
3 # Effect size for the t test for independent means
4
5 mu1 <- 29 # Mean 1
6 mu2 <- 21 # Mean 2

```

```

7 sd <- 10 # Standard deviation
8
9 d <- (mu1 - mu2) / sd # Effect size
10
11 cat("Effect size is \n", d)
12
13 m1 <- 33.10 # Mean 1
14 m2 <- 27.00 # Mean 2
15 p_sd <- 12.99 # Pooled standard deviation
16
17 e_d <- round((m1 - m2) / p_sd, 2) # Estimated
    effect size
18
19 cat("Estimated effect size is \n", e_d)

```

---

#### R code Exa 8.4a Harmonic mean

```

1 # Page no. : 300
2
3 # Harmonic mean
4
5 n1 <- 11 # Sample 1
6 n2 <- 31 # Sample 2
7
8 total <- n1 + n2
9
10 h_m <- round((2 * n1 * n2) / total, 2) # Harmonic
    mean
11
12 cat("Harmonic mean is \n", h_m)
13
14 # How are you doing?
15
16 # 1st Question (Only harmonic mean)
17

```

```

18 n1 <- 6   # Sample 1
19 n2 <- 34  # Sample 2
20
21 total <- n1 + n2
22
23 h_m <- round((2 * n1 * n2) / total, 2)  # Harmonic
    mean
24
25 cat("Harmonic mean is \n", h_m)

```

---

#### R code Exa 8.5a Worked out examples 1

```

1
                                     # Page no. : 301
                                     - 302
2
3 # Worked out examples 1
4
5 n1 <- 40   # Sample 1
6 df1 <- n1 - 1  # Degree of freedom
7 var1 <- 15   # Variance 1
8
9 n2 <- 60   # Sample 2
10 df2 <- n2 - 1  # Degree of freedom
11 var2 <- 12   # Variance 2
12
13 df <- df1 + df2  # Total degrees of freedom
14
15 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
    # Pooled variance
16
17 cat("Pooled variance is \n", round(p_var, 2))
18
19 d_var1 <- p_var / n1  # Variance of the
    distribution of means of sample 1
20

```

```

21 cat(" Variance of the distribution of means of sample
      1 is \n", round(d_var1, 2))
22
23 d_var2 <- p_var / n2 # Variance of the
      distribution of means of sample 2
24
25 cat(" Variance of the distribution of means of sample
      2 is \n", round(d_var2, 2))
26
27 diff_var <- d_var1 + d_var2 # Variance difference
28
29 cat(" Variance difference is \n", round(diff_var, 2))
30
31 diff_sd <- sqrt(diff_var) # Standard deviation
      difference
32
33 cat(" Standard deviation difference is \n", round(
      diff_sd, 2))

```

---

### R code Exa 8.5b Worked out examples 2

```

1 # Page no. : 302 -
      303
2
3 # Worked out examples 2
4
5 score1 <- c(7, 6, 9, 7, 6)
6 n1 <- length(score1) # Sample size 1
7 df1 <- n1 - 1 # Degree of freedom
8 m1 <- mean(score1) # Mean
9 deviation1 <- score1 - m1
10 sq_dev1 <- deviation1 ** 2 # Squared deviation
11
12 data_frame1 <- data.frame(score1, deviation1, sq_
      dev1)

```

```

13 View(data_frame1)
14
15 score2 <- c(5, 2, 4, 3, 6)
16 n2 <- length(score2) # Sample size 2
17 df2 <- n2 - 1 # Degree of freedom
18 m2 <- mean(score2) # Mean
19 deviation2 <- score2 - m2
20 sq_dev2 <- deviation2 ** 2 # Squared deviation
21
22 data_frame2 <- data.frame(score2, deviation2, sq_
    dev2)
23 View(data_frame2)
24
25 var1 <- sum(data_frame1$sq_dev1) / df1 # Variance
    1
26 var2 <- sum(data_frame2$sq_dev2) / df2 # Variance
    2
27
28 df <- df1 + df2 # Total degrees of freedom
29
30 p_var <- ((df1 / df) * var1) + ((df2 / df) * var2)
    # Pooled variance
31
32 cat("Pooled variance is \n", round(p_var, 2))
33
34 d_var1 <- p_var / n1 # Variance of the
    distribution of means of sample 1
35
36 cat("Variance of the distribution of means of sample
    1 is \n", round(d_var1, 2))
37
38 d_var2 <- p_var / n2 # Variance of the
    distribution of means of sample 2
39
40 cat("Variance of the distribution of means of sample
    2 is \n", round(d_var2, 2))
41
42 diff_var <- d_var1 + d_var2 # Variance difference

```

```

43
44 cat("Variance difference is \n", diff_var)
45
46 diff_sd <- sqrt(diff_var) # Standard deviation
    difference
47
48 cat("Standard deviation difference is \n", round(
    diff_sd, 2))
49
50 # Two - Tailed
51
52 alpha <- 0.05 # 5% significance level
53
54 tval <- qt(1-alpha/2, df)
55 tval <- c(tval, -tval)
56
57 t <- round((m1 - m2) / diff_sd, 2) # t score
58
59 cat("t score is \n", t)
60
61 if(t > tval[1] || t < tval[2])
62 {
63   cat("Reject null hypothesis")
64 } else
65 {
66   cat("Cannot reject null hypothesis")
67 }

```

---

**R code Exa 8.5c** Worked out examples 3

```

1 # Page no. :
    304
2
3 # Worked out examples 3
4

```



```
5 n1 <- 22 # Sample 1
6 n2 <- 51 # Sample 2
7
8 total <- n1 + n2
9
10 h_m <- round((2 * n1 * n2) / total, 2) # Harmonic
    mean
11
12 cat("Harmonic mean is", h_m)
```

---

## Chapter 9

# Introduction to the Analysis of Variance

R code Exa 9.1a Carrying out an Analysis of Variance

```
1                                     # Page no. : 325
                                     #   - 331
2
3 # Carrying out an Analysis of Variance
4
5 # Page no. : 325 - 326
6
7 # Criminal Record Group
8
9 rating1 <- c(10, 7, 5, 10, 8)
10 n1 <- length(rating1) # Sample 1 size
11 df1 <- n1 - 1 # Degree of freedom
12 m1 <- mean(rating1) # Mean of rating 1
13 deviation1 <- rating1 - m1 # Deviation from mean 1
14 sq_dev1 <- deviation1 ** 2 # Squared deviation
    from mean 1
15
16 data_frame1 <- data.frame(rating1, deviation1, sq_
    dev1)
```

```

17 View(data_frame1)
18
19 # Clean Record Group
20
21 rating2 <- c(5, 1, 3, 7, 4)
22 n2 <- length(rating2) # Sample 2 size
23 df2 <- n2 - 1 # Degree of freedom
24 m2 <- mean(rating2) # Mean of rating 2
25 deviation2 <- rating2 - m2 # Deviation from mean 2
26 sq_dev2 <- deviation2 ** 2 # Squared deviation
    from mean 2
27
28 data_frame2 <- data.frame(rating2, deviation2, sq_
    dev2)
29 View(data_frame2)
30
31 # No Information Group
32
33 rating3 <- c(4, 6, 9, 3, 3)
34 n3 <- length(rating1) # Sample 3 size
35 df3 <- n3 - 1 # Degree of freedom
36 m3 <- mean(rating3) # Mean of rating 3
37 deviation3 <- rating3 - m3 # Deviation from mean 3
38 sq_dev3 <- deviation3 ** 2 # Squared deviation
    from mean 3
39
40 data_frame3 <- data.frame(rating3, deviation3, sq_
    dev3)
41 View(data_frame3)
42
43 var1 <- var(data_frame1$rating1) # Variance for
    rating 1
44 var2 <- var(data_frame2$rating2) # Variance for
    rating 2
45 var3 <- var(data_frame3$rating3) # Variance for
    rating 3
46
47 cat("Variance for rating 1 is", var1)

```

```

48 cat("Variance for rating 2 is", var2)
49 cat("Variance for rating 3 is", var3)
50
51 # Figuring the within – groups estimate of the
    population variance
52
53 # Page no. : 326 – 327
54
55 n_g <- 3 # Number of groups
56 df_within <- (n1 + n2 + n3) - n_g # Degree of
    freedom within-groups
57
58 var_within <- round((var1 + var2 + var3) / n_g, 2)
    # Variance within-groups
59
60 cat("Variance within-groups is", var_within)
61
62 # Figuring the between – groups estimate of the
    population variance
63
64 # Page no. : 327 – 329
65
66 df_between <- n_g - 1 # Degree of freedom between-
    groups
67 gm <- round((m1 + m2 + m3) / n_g, 2) # Grand mean
68
69 gm_dev <- c((m1 - gm), (m2 - gm), (m3 - gm)) #
    Deviation from the grand mean
70 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
71
72 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
73
74 cat("Variance for the distribution of means is", d_
    var)
75
76 N <- 5 # 5 elements in each rating

```

```

77 var_between <- d_var * N # Variance between-groups
78
79 cat("Variance between-groups is", var_between)
80
81 # Figuring the F ratio
82
83 # Page no. : 329
84
85 fvalue <- round(var_between / var_within, 2) # F
      ratio
86 cat("F ratio is", fvalue)
87
88 # Direct method to find F ratio
89
90 DF <- data.frame(rating1, rating2, rating3)
91 x <- c(t(as.matrix(DF)))
92 f <- c("r_1", "r_2", "r_3")
93 tm <- gl(3, 1, 5*3, factor(f))
94 result <- anova(lm(x ~ tm)) # Similar to aov(x ~
      tm)
95
96 cat("F ratio is", round(result$'F value'[1], 2))
97
98 # F value
99
100 # Page no. : 331
101
102 alpha <- 0.05 # 5% Sgnificance level
103
104 fval <- qf(0.95, df_between, df_within) # 1 - alpha
      = 1 - 0.05 = 0.95
105 fval <- round(fval, 2)
106
107 if(fvalue >= fval)
108 {
109   cat("Reject Null Hypothesis")
110 } else {
111   cat("Cannot reject Null Hypothesis")

```

---

**R code Exa 9.1b** How are you doing

```
1 # Page no. : 331 - 333
2
3 # How are you doing?
4
5 # Data given
6
7 scores_A <- c(5, 7)
8 m1 <- 6 # Mean 1
9 n1 <- 2 # Sample size
10
11 scores_B <- c(6, 9)
12 m2 <- 7.5 # Mean 2
13 n2 <- 2 # Sample size
14
15 scores_c <- c(8, 9)
16 m3 <- 8.5 # Mean 3
17 n3 <- 2 # Sample size
18
19 # 1st Question (c) part
20
21 n_s <- 3 # Number of samples
22 df_within <- (n1 + n2 + n3) - n_s # Degree of
    freedom within-groups
23
24 var_within <- round((var(scores_A) + var(scores_B) +
    var(scores_c)) / n_s, 2)
25 # Variance within-groups
26
27
28 cat("Variance within-groups is", var_within)
29
```

```

30 # 2nd and 3rd Question (c) parts
31
32 df_between <- n_s - 1 # Degree of freedom between-
    groups
33 gm <- round((m1 + m2 + m3) / n_s, 2) # Grand mean
34
35 gm_dev <- c((m1 - gm), (m2 - gm), (m3 - gm)) #
    Deviation from the grand mean
36 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
37
38 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
39
40 cat("Variance for the distribution of means is", d_
    var)
41
42 N <- 2 # 2 elements in each rating
43 var_between <- d_var * N # Variance between-groups
44
45 cat("Variance between-groups is", var_between)
46
47 # 4th Question (c) part
48
49 fvalue <- round(var_between / var_within, 2) # F
    ratio
50 cat("F ratio is", fvalue)
51
52 # 5th and 6th Question (c) parts
53
54 cat("Between-groups degree of freedom is", df_
    between)
55 cat("Within-groups degree of freedom is", df_within)
56
57 alpha <- 0.05 # 5% Sgnificance level
58
59 fval <- qf(0.95, df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95

```

```
60 fval <- round(fval, 2)
61
62 cat("Cutoff F for the 0.05 significance level is",
      fval)
```

---

### R code Exa 9.1c Another example

```
1
2
3 # Another example
4
5 # Attachment Styl – Secure
6
7 n1 <- 10 # Sample size
8 df1 <- n1 - 1 # Degree of freedom
9 m1 <- 2.10 # Mean
10 sd1 <- 1.66 # Standard deviation
11 var1 <- 2.76 # Variance
12
13 # Attachment Styl – Avoidant
14
15 n2 <- 10 # Sample size
16 df2 <- n2 - 1 # Degree of freedom
17 m2 <- 3.70 # Mean
18 sd2 <- 1.89 # Standard deviation
19 var2 <- 3.57 # Variance
20
21 # Attachment Styl – Anxious–Ambivalent
22
23 n3 <- 10 # Sample size
24 df3 <- n3 - 1 # Degree of freedom
25 m3 <- 4.20 # Mean
26 sd3 <- 1.93 # Standard deviation
27 var3 <- 3.72 # Variance
```

# Page no. :  
334 – 335



```

28
29 n_s <- 3 # Number of samples
30 df_within <- (n1 + n2 + n3) - n_s # Degree of
    freedom within-groups
31 df_between <- n_s - 1 # Degree of freedom between-
    groups
32
33 alpha <- 0.05 # 5% Sgnificance level
34
35 fval <- qf(0.95, df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95
36 fval <- round(fval, 2)
37
38 cat("Cutoff F for the 0.05 significance level is",
    fval)
39
40 var_within <- round((var1 + var2 + var3) / n_s, 2)
    # Variance within-groups
41
42 cat("Variance within-groups is", var_within)
43
44 gm <- round((m1 + m2 + m3) / n_s, 2) # Grand mean
45
46 gm_dev <- c((m1 - gm), (m2 - gm), (m3 - gm)) #
    Deviation from the grand mean
47 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
48
49 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
50
51 cat("Variance for the distribution of means is", d_
    var)
52
53 N <- 10 # 10 elements in each rating
54 var_between <- d_var * N # Variance between-groups
55
56 cat("Variance between-groups is", var_between)

```

```

57
58 fvalue <- round(var_between / var_within, 2) # F
    ratio
59 cat("F ratio is", fvalue)
60
61 if(fvalue >= fval)
62 {
63   cat("Reject Null Hypothesis")
64 } else {
65   cat("Cannot reject Null Hypothesis")
66 }

```

---

**R code Exa 9.1d** How are you doing

```

1
# Page no. :
# 338 - 339
2
3 # How are you doing?
4
5 # 1st Question (a) part
6
7 N <- 16 # Participants in each group
8 df <- N - 1 # Degree of freedom
9
10 # Group 1
11
12 m1 <- 20 # Mean
13 var1 <- 8 # Variance
14
15 # Group 2
16
17 m2 <- 22 # Mean
18 var2 <- 9 # Variance
19
20 # Group 3

```

```

21
22 m3 <- 18 # Mean
23 var3 <- 7 # Variance
24
25 alpha <- 0.01 # 1% Sgnificance level
26
27 n_s <- 3 # Number of samples
28 df_within <- (3 * N) - n_s # Degree of freedom
    within-groups
29 df_between <- n_s - 1 # Degree of freedom between-
    groups
30
31
32 fval <- qf(0.99,df_between, df_within) # 1 - alpha
    = 1 - 0.01 = 0.99
33 fval <- round(fval, 2)
34
35 cat("Cutoff F for the 0.05 significance level is",
    fval)
36
37 var_within <- round((var1 + var2 + var3) / n_s, 2)
    # Variance within-groups
38
39 cat("Variance within-groups is", var_within)
40
41 gm <- round((m1 + m2 + m3) / n_s, 2) # Grand mean
42
43 gm_dev <- c((m1 - gm), (m2 - gm), (m3 - gm)) #
    Deviation from the grand mean
44 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
45
46 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
47
48 cat("Variance for the distribution of means is", d_
    var)
49

```

```

50 var_between <- d_var * N # Variance between-groups
51
52 cat("Variance between-groups is", var_between)
53
54 fvalue <- round(var_between / var_within, 2) # F
    ratio
55 cat("F ratio is", fvalue)
56
57 if(fvalue >= fval)
58 {
59   cat("Reject Null Hypothesis")
60 } else {
61   cat("Cannot reject Null Hypothesis")
62 }

```

---

#### R code Exa 9.2a Planned contrast an example

```

1 # Page no. :
    340 - 341
2
3 # Planned contrast an example
4
5 m1 <- 8 # Mean 1
6 m2 <- 5 # Mean 2
7 n_s <- 2 # Number of samples for contrast
8 N <- 5 # 5 elements in each sample
9
10 var_within <- 5.33 # Variance within-groups
11
12 gm <- (m1 + m2) / n_s # Grand mean
13 gm_dev <- c((m1 - gm), (m2 - gm)) # Deviation from
    the grand mean
14 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
15 df_between <- n_s - 1 # Degree of freedom between-

```

```

    groups (2 samples)
16 df_within <- (3 * N) - (n_s + 1) # Degree of
    freedom within-groups (3 samples)
17
18 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
19
20 cat("Variance for the distribution of means is", d_
    var)
21
22 var_between <- d_var * N # Variance between-groups
23
24 cat("Variance between-groups is", var_between)
25
26 fvalue <- round(var_between / var_within, 2) # F
    ratio
27 cat("F ratio is", fvalue)
28
29 alpha <- 0.05 # 5% Sgnificance level
30
31 fval <- qf(0.95, df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95
32 fval <- round(fval, 2)
33
34 cat("Cutoff F for the 0.05 significance level is",
    fval)
35
36 if(fvalue >= fval)
37 {
38   cat("Reject null hypothesis (Significant)")
39 } else {
40   cat("Cannot reject null hypothesis (not
    significant)")
41 }

```

---

## R code Exa 9.2b Planned contrast a second example

```
1                                     # Page no. :
                                     341
2
3 # Planned contrast a second example
4
5 m1 <- 8   # Mean 1
6 m2 <- 4   # Mean 2
7 n_s <- 2  # Number of samples for contrast
8 N <- 5   # 5 elements in each sample
9
10 var_within <- 5.33 # Variance within-groups
11
12 gm <- (m1 + m2) / n_s # Grand mean
13 gm_dev <- c((m1 - gm), (m2 - gm)) # Deviation from
   the grand mean
14 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
   deviation from the grand mean
15 df_between <- n_s - 1 # Degree of freedom between-
   groups (2 samples)
16 df_within <- (3 * N) - (n_s + 1) # Degree of
   freedom within-groups (3 samples)
17
18 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
   Variance for the distribution of means
19
20 cat("Variance for the distribution of means is", d_
   var)
21
22 var_between <- d_var * N # Variance between-groups
23
24 cat("Variance between-groups is", var_between)
25
26 fvalue <- round(var_between / var_within, 2) # F
   ratio
27 cat("F ratio is", fvalue)
28
```

```

29 alpha <- 0.05 # 5% Sgnificance level
30
31 fval <- qf(0.95,df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95
32 fval <- round(fval, 2)
33
34 cat("Cutoff F for the 0.05 significance level is",
    fval)
35
36 if(fvalue >= fval)
37 {
38   cat("Reject null hypothesis (Significant)")
39 } else {
40   cat("Cannot reject null hypothesis (not
    significant)")
41 }

```

---

### R code Exa 9.2c How are you doing

```

1 # Page no. : 342
    - 343
2
3 # How are you doing?
4
5 # 3rd Question
6
7 N <- 25 # 25 elements in each sample
8 var_within <- 100 # Variance within-groups
9
10 m1 <- 10 # Mean 1
11 m2 <- 16 # Mean 2
12
13 n_s <- 2 # Number of samples for contrast
14
15 gm <- (m1 + m2) / n_s # Grand mean

```

```

16 gm_dev <- c((m1 - gm), (m2 - gm)) # Deviation from
    the grand mean
17 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
18 df_between <- n_s - 1 # Degree of freedom between-
    groups (2 samples)
19 df_within <- (3 * N) - (n_s + 1) # Degree of
    freedom within-groups (3 samples)
20
21 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
22
23 cat("Variance for the distribution of means is", d_
    var)
24
25 var_between <- d_var * N # Variance between-groups
26
27 cat("Variance between-groups is", var_between)
28
29 fvalue <- round(var_between / var_within, 2) # F
    ratio
30 cat("F ratio is", fvalue)
31
32 alpha <- 0.05 # 5% Sgnificance level
33
34 fval <- qf(0.95,df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95
35 fval <- round(fval, 2)
36
37 cat("Cutoff F for the 0.05 significance level is",
    fval)
38
39 if(fvalue >= fval)
40 {
41   cat("Reject null hypothesis (Significant)")
42 } else {
43   cat("Cannot reject null hypothesis (not
    significant)")

```



44 }

---

### R code Exa 9.3a Scheffe Test

```
1                                     # Page no. :
                                     344 - 345
2
3 # Scheffe Test
4
5 N <- 5   # 5 elements in each sample
6 f <- 4.22 # F value (overall)
7
8 df_between <- 2   # Degree of freedom between-groups
9 df_within <- (3 * N) - (df_between + 1) # Degree
   of freedom within-groups (3 samples)
10 fvalue <- f / df_between # F value (contrast)
11
12 cat("F value (contrast) is", fvalue)
13
14 alpha <- 0.05 # 5% Sgnificance level
15
16 fval <- qf(0.95, df_between, df_within) # 1 - alpha
   = 1 - 0.05 = 0.95
17 fval <- round(fval, 2)
18
19 cat("Cutoff F for the 0.05 significance level is",
   fval)
20
21 if(fvalue >= fval)
22 {
23   cat("Reject null hypothesis (Significant)")
24 } else {
25   cat("Cannot reject null hypothesis (not
   significant)")
26 }
```

```

27 # How are you doing?
28
29 # 5th Question
30
31 N <- 50 # 50 elements in each sample
32 f <- 12.60 # F value (overall)
33
34 df_between <- 3 # Degree of freedom between-groups
35 df_within <- (4 * N) - (df_between + 1) # Degree
  of freedom within-groups (4 samples)
36 fvalue <- f / df_between # F value (contrast)
37
38 cat("F value (contrast) is", fvalue)
39
40 alpha <- 0.05 # 5% Sgnificance level
41
42 fval <- qf(0.95, df_between, df_within) # 1 - alpha
  = 1 - 0.05 = 0.95
43 fval <- round(fval, 2)
44
45 cat("Cutoff F for the 0.05 significance level is",
  fval)
46
47 if(fvalue >= fval)
48 {
49   cat("Reject null hypothesis (Significant)")
50 } else {
51   cat("Cannot reject null hypothesis (not
  significant)")
52 }

```

---

**R code Exa 9.4a** Effect size for the analysis of variance

1

# Page no. : 345  
- 346

```

2
3 # Effect size for the analysis of variance
4
5 var_within <- 5.33 # Variance within-groups
6 var_between <- 21.70 # Variance within-groups
7
8 df_between <- 2 # Degree of freedom between-groups
9 df_within <- 12 # Degree of freedom within-groups
10
11 r_sq <- round((var_between * df_between)/((var_
    between * df_between)+(var_within * df_within))
    ,2)
12
#
Proportion
of
variance
accounted
for

13
14 cat("Proportion of variance accounted for is", r_sq)
15
16 # Another approach
17
18 f <- 4.07 # F value (Ratio)
19
20 r_sq <- round((f * df_between)/((f * df_between) + (
    df_within)),2)
21
# Proportion
of
variance
accounted
for

```

```
22
23 cat("Proportion of variance accounted for is", r_sq)
```

---

**R code Exa 9.4b** How are you doing

```
1                                     # Page no. :
                                     348
2
3 # How are you doing?
4
5 # 2nd Question (d) part
6
7 var_within <- 7.20 # Variance within-groups
8 var_between <- 12.22 # Variance within-groups
9
10 df_between <- 2 # Degree of freedom between-groups
11 df_within <- 8 # Degree of freedom within-groups
12
13 r_sq <- round((var_between * df_between)/((var_
    between * df_between)+(var_within * df_within))
    ,2)
14                                     #
                                     Proportion
                                     of
                                     variance
                                     accounted
                                     for
15
16 cat("Proportion of variance accounted for is", r_sq)
17
18 # 3rd Question (c) part
19
20 N <- 18 # 18 participants in each group
21 t_g <- 3 # Total groups
```

```

22 f <- 4.50 # F value (Ratio)
23
24 df_between <- t_g - 1 # Degree of freedom between-
    groups
25 df_within <- (t_g * N) - t_g # Degree of freedom
    within-groups
26
27 r_sq <- round((f * df_between)/((f * df_between) + (
    df_within)),2)
28
    # Proportion
    of
    variance
    accounted
    for
29
30 cat("Proportion of variance accounted for is", r_sq)

```

---

**R code Exa 9.5a** Advanced Topic The Structural Model in the Analysis of Variance an example

```

1
    # Page no. : 351
    - 354
2
3 # Advanced Topic: The Structural Model in the
    Analysis of Variance an example
4
5 # Criminal Record Group
6
7 rating1 <- c(10, 7, 5, 10, 8)
8
9 # Clean Record Group
10
11 rating2 <- c(5, 1, 3, 7, 4)
12
13 # No Information Group

```

```

14
15 rating3 <- c(4, 6, 9, 3, 3)
16
17 DF <- data.frame(rating1, rating2, rating3)
18
19 # Direct Method
20
21 k <- ncol(DF) # Number of Treatments
22 n <- nrow(DF) # Number of Observations for each
    Treatment
23 N <- n * k # Total Observations
24
25 x <- c(t(as.matrix(DF)))
26 f <- c("r_1", "r_2", "r_3")
27 tm <- gl(k, 1, n*k, factor(f))
28 result <- anova(lm(x ~ tm)) # Similar to aov(x ~
    tm)
29
30 result
31
32 ss_total <- round(sum(result$'Sum Sq'), 2) # Total
    sum of squared deviation
33
34 cat("Total sum of squared deviation is", ss_total)
35
36 ss_within <- round(result$'Sum Sq'[2], 2) # Sum of
    squared deviation within-groups
37
38 cat("Sum of squared deviation within-groups is", ss_
    within)
39
40 ss_between <- round(result$'Sum Sq'[1], 2) # Sum
    of squared deviation between-groups
41
42 cat("Sum of squared deviation between-groups is", ss
    _between)
43
44 df_total <- sum(result$Df) # Total degrees of

```

```

        freedom
45
46 cat("Total degrees of freedom is", df_total)
47
48 df_within <- result$Df[2]    # Degree of freedom
        within-groups
49
50 cat("Degree of freedom within-groups is", df_within)
51
52 df_between <- result$Df[1]   # Degree of freedom
        between-groups
53
54 cat("Degree of freedom between-groups is", df_
        between)
55
56 var_within <- round(result$'Mean Sq'[2], 2)    #
        Variance within-groups
57
58 cat("Variance within-groups is", var_within)
59
60 var_between <- round(result$'Mean Sq'[1], 2)    #
        Variance between-groups
61
62 cat("Variance between-groups is", var_between)
63
64 f <- round(result$'F value'[1], 2)    # F value (
        Ratio)
65
66 cat("F value (Ratio) is", f)

```

---

**R code Exa 9.6a** Worked out examples 1

```

1                                     # Page no. : 359
2                                     - 360

```

```

3 # Worked out examples 1
4
5 N <- 20 # 20 participants in each group
6 n_g <- 4 # Numbr of groups
7
8 m1 <- 15 # Mean 1
9 var1 <- 20 # Variance 1
10
11 m2 <- 12 # Mean 2
12 var2 <- 25 # Variance 2
13
14 m3 <- 18 # Mean 3
15 var3 <- 14 # Variance 3
16
17 m4 <- 15 # Mean 4
18 var4 <- 27 # Variance 4
19
20 alpha <- 0.05 # 5% significant level
21
22 df_between <- n_g - 1 # Degree of freedom between-
    groups
23 df_within <- (4 * N) - (n_g) # Degree of freedom
    within-groups
24
25 var_within <- round((var1 + var2 + var3 + var4) / n_
    g, 2) # Variance within-groups
26 cat("Variance within-groups is", var_within)
27
28 gm <- (m1 + m2 + m3 + m4) / n_g # Grand mean
29 gm_dev <- c((m1 - gm), (m2 - gm), (m3 - gm), (m4 -
    gm)) # Deviation from the grand mean
30 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
31
32 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
33
34 cat("Variance for the distribution of means is", d_

```



```

    var)
35
36 var_between <- d_var * N # Variance between-groups
37
38 cat("Variance between-groups is", var_between)
39
40 fvalue <- round(var_between / var_within, 2) # F
    ratio
41 cat("F ratio is", fvalue)
42
43 fval <- qf(0.95, df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95
44 fval <- round(fval, 2)
45
46 if(fvalue >= fval)
47 {
48   cat("Reject Null Hypothesis")
49 } else {
50   cat("Cannot reject Null Hypothesis")
51 }

```

---

### R code Exa 9.6b Worked out examples 2

```

1 # Page no. :
    360 - 361
2
3 # Worked out examples 2
4
5 m1 <- 12 # Mean 1
6 var1 <- 25 # Variance 1
7
8 m2 <- 18 # Mean 2
9 var2 <- 14 # Variance 2
10
11 alpha <- 0.01 # 1% significant level

```

```

12 n_s <- 2 # Number of samples for contrast
13 N <- 20 # 20 elements in each sample
14
15 var_within <- 21.5 # Variance within-groups (
    overall)
16
17 df_between <- n_s - 1 # Degree of freedom between
    -groups (2 samples)
18 df_within <- (4 * N) - (n_s + 2) # Degree of
    freedom within-groups (4 samples)
19
20 gm <- (m1 + m2) / n_s # Grand mean
21 gm_dev <- c((m1 - gm), (m2 - gm)) # Deviation from
    the grand mean
22 sq_gm_dev <- round(gm_dev ** 2, 2) # Squared
    deviation from the grand mean
23
24 d_var <- round(sum(sq_gm_dev) / df_between, 2) #
    Variance for the distribution of means
25
26 cat("Variance for the distribution of means is", d_
    var)
27
28 var_between <- d_var * N # Variance between-groups
29
30 cat("Variance between-groups is", var_between)
31
32 fvalue <- round(var_between / var_within, 2) # F
    ratio
33 cat("F ratio is", fvalue)
34
35 fval <- qf(0.95, df_between, df_within) # 1 - alpha
    = 1 - 0.05 = 0.95
36 fval <- round(fval, 2)
37
38 cat("Cutoff F for the 0.05 significance level is",
    fval)
39

```

```

40 if(fvalue >= fval)
41 {
42   cat("Reject null hypothesis (Significant)")
43 } else {
44   cat("Cannot reject null hypothesis (not
      significant)")
45 }

```

---

### R code Exa 9.6c Worked out examples 3

```

1
2
3 # Worked out examples 3
4
5 n <- 6 # Six planned contrasts
6 alpha <- 0.05 # 5% significance level
7
8 b_c_s <- round(alpha / n, 4) # Bonferroni
   corrected significance level
9
10 cat("Bonferroni corrected significance level is", b_c
     _s)
11
12
13
14 # The Bonferroni Procedure
15
16 n <- 2 # Two planned contrasts
17 alpha <- 0.05 # 5% significance level
18
19 b_c_s <- round(alpha / n, 4) # Bonferroni
   corrected significance level
20

```

```

21 cat(" Bonferroni corrected significance level is", b_c
    _s)
22
23 n <- 3 # Two planned contrasts
24 alpha <- 0.05 # 5% significance level
25
26 b_c_s <- round(alpha / n, 4) # Bonferroni
    corrected significance level
27
28 cat(" Bonferroni corrected significance level is", b_c
    _s)
29
30 n <- 3 # Two planned contrasts
31 alpha <- 0.01 # 1% significance level
32
33 b_c_s <- round(alpha / n, 4) # Bonferroni corrected
    significance level
34
35 cat(" Bonferroni corrected significance level is", b_c
    _s)

```

---

#### R code Exa 9.6d Worked out examples 4

```

1 # Page no. :
    361
2
3 # Worked out examples 4
4
5 N <- 10 # 10 elements in each sample
6 f <- 11.21 # F value (overall)
7 n_g <- 5 # Number of groups
8
9 df_between <- n_g - 1 # Degree of freedom between-
    groups
10 df_within <- (5 * N) - (n_g) # Degree of freedom

```

```

    within-groups (5 samples)
11 fvalue <- f / df_between # F value (contrast)
12
13 cat("F value (contrast) is", fvalue)
14
15 alpha <- 0.01 # 1% Sgnificance level
16
17 fval <- qf(0.99, df_between, df_within) # 1 - alpha
    = 1 - 0.01 = 0.99
18 fval <- round(fval, 2)
19
20 cat("Cutoff F for the 0.01 significance level is",
    fval)
21
22 if(fvalue >= fval)
23 {
24   cat("Reject null hypothesis (Significant)")
25 } else {
26   cat("Cannot reject null hypothesis (not
    significant)")
27 }

```

---

### R code Exa 9.6e Worked out examples 5

```

1
    # Page no. :
    361
2
3 # Worked out examples 5
4
5 N <- 20 # 20 participants in each group
6 n_g <- 4 # Number of groups
7
8 df_between <- n_g - 1 # Degree of freedom between-
    groups
9 df_within <- (4 * N) - (n_g) # Degree of freedom

```

```

    within-groups
10
11 var_between <- 120 # Variance between-groups
12 var_within <- 21.5 # Variance within-groups
13
14 r_sq <- round((var_between * df_between)/((var_
    between * df_between)+(var_within * df_within))
    ,2)
15 #
# Proportion
# of
# variance
# accounted
# for
16
17 cat("Proportion of variance accounted for is", r_sq)

```

---

### R code Exa 9.6f Worked out examples 6

```

1 # Page no. : 362
2
3 # Worked out examples 6
4
5 # Treatment A
6
7 x1 <- c(8, 13, 10, 9)
8
9 # Treatment B

```

```

10
11 x2 <- c(7, 3, 8)
12
13 # Treatment C
14
15 x3 <- c(6, 4, 2)
16
17 DF <- data.frame( Y=c(x1, x2, x3), Treatment =factor
18                   (rep(c("x1", "x2", "x3"),
19                       times=c(length(x1), length(x2), length(
20                               x3))))))
19
20 View(DF)
21
22 res <- aov(Y~Treatment, data=DF)
23 result <- anova(res)
24 result
25
26 df_total <- sum(result$Df) # Total degree of
27   freedom
28 cat("Total degrees of freedom is", df_total)
29
30 df_within <- result$Df[2] # Degree of freedom
31   within-groups
32 cat("Degree of freedom within-groups is", df_within)
33
34 df_between <- result$Df[1] # Degree of freedom
35   between-groups
36 cat("Degree of freedom between-groups is", df_
37   between)
38 alpha <- 0.05 # 5% significance level
39
40 f <- round(result$`F value`[1], 2) # F value (
41   Ratio)

```

```

41
42 cat("F value (Ratio) is", f)
43
44 ss_total <- round(sum(result$'Sum Sq'), 2) # Total
      sum of squared deviation
45
46 cat("Total sum of squared deviation is", ss_total)
47
48 ss_within <- round(result$'Sum Sq'[2], 2) # Sum of
      squared deviation within-groups
49
50 cat("Sum of squared deviation within-groups is", ss_
      within)
51
52 ss_between <- round(result$'Sum Sq'[1], 2) # Sum
      of squared deviation between-groups
53
54 cat("Sum of squared deviation between-groups is", ss
      _between)
55
56 fval <- qf(0.95, df_between, df_within) # 1 -
      alpha = 1 - 0.05 = 0.95
57 fval <- round(fval, 2)
58
59 cat("Cutoff F for the 0.05 significance level is",
      fval)
60
61 if(f >= fval)
62 {
63   cat("Reject null hypothesis")
64 } else {
65   cat("Cannot reject null hypothesis")
66 }

```

---



# Chapter 10

## Factorial Analysis of Variance

R code Exa 10.1a Table for a Two way Analysis of Variance

```
1                                     # Page no. : 406
2                                     - 407
3 # Table for a Two-way Analysis of Variance
4
5 DF <- data.frame(Sensitivity = c(rep("Not High", 10)
6   , rep("High", 10)),
7   Test_Difficulty = c(rep(c("Easy", "
8     Hard"), 10)),
9   Value = c(2.63, 2.69, 2.53, 2.31,
10    2.25, 2.45, 2.22, 2.80, 2.52,
11    2.55, 2.06,
12    3.21, 2.32, 3.21, 2.04,
13    2.77, 2.31, 2.83,
14    2.22, 3.03)
15 )
16 View(DF)      # Table no. 10-10   (Table is different
17   as compared to book)
18
19 res <- aov(Value ~ Test_Difficulty*Sensitivity, data
```

```

      = DF)
14 result <- round(anova(res), 2)
15
16 # Table no. 10-11
17
18 result # Values differ with book's values (table
      values)
19
20 # Below results are in table no. 10-10
21
22 ss_total <- round(sum(result$'Sum Sq'), 2) # Total
      sum of squared deviation
23
24 cat("Total sum of squared deviation is \n", ss_total
      )
25
26 ss_within <- round(result$'Sum Sq'[4], 2) # Sum of
      squared deviation within-groups
27
28 cat("Sum of squared deviation within-groups is \n",
      ss_within)
29
30 ss_interaction <- round(result$'Sum Sq'[3], 2) #
      Sum of squared deviation of interaction
31
32 cat("Sum of squared deviation of interaction is \n",
      ss_interaction)
33
34 ss_rows <- round(result$'Sum Sq'[2], 2) # Sum of
      squared deviation of rows
35
36 cat("Sum of squared deviation of rows is \n", ss_
      rows)
37
38 ss_columns <- round(result$'Sum Sq'[1], 2) # Sum
      of squared deviation of columns
39
40 cat("Sum of squared deviation of columns is \n", ss_

```

```

        columns)
41
42 alpha <- 0.05 # 5% significance level
43 df_numerator <- 1 # 2 - 1 = 1 (2 groups)
44 df_denomenator <- result$Df[4]
45
46 fval <- qf(0.95, df_numerator, df_denomenator)
47 fval <- round(fval, 2)
48
49 # Note that fval is same for sensitivity , test
    difficulty and for interaction effect
50
51 cat("F value is \n", fval)
52
53 f1 <- result$`F value`[1] # F value for test
    difficulty
54 f2 <- result$`F value`[2] # F value for
    sensitivity
55 f3 <- result$`F value`[3] # F value for test
    difficulty : sensitivity
56
57 if(f1 >= fval)
58 {
59   cat("Reject null hypothesis for test difficulty")
60 } else {
61   cat("Cannot reject null hypothesis for test
        difficulty")
62 }
63
64 if(f2 >= fval)
65 {
66   cat("Reject null hypothesis for sensitivity")
67 } else {
68   cat("Cannot reject null hypothesis for sensitivity
        ")
69 }
70
71 if(f3 >= fval)

```

```

72 {
73   cat("Reject null hypothesis for test difficulty :
       sensitivity")
74 } else {
75   cat("Cannot reject null hypothesis for test
       difficulty : sensitivity")
76 }

```

---

### R code Exa 10.1b How are you doing

```

1                                     # Page no. :
                                     411 - 413
2
3 # How are you doing?
4
5 # 5th Question
6
7 DF <- data.frame(Participant = LETTERS[1:8],
8                  Length_condition = c(rep("Short",
9                  4), rep("Long", 4)),
9                  Vividness_condition = c(rep(c("Low"
10                 , "High"), 4)),
10                 Number_recalled = c(6, 9, 4, 5, 2,
11                 1, 4, 1)
11                 )
12
13 View(DF)   # Book's table is little bit different
14
15 res <- aov(Number_recalled ~ Vividness_condition*
16            Length_condition, data = DF)
17 result <- anova(res)
18 result
19 ss_total <- round(sum(result$'Sum Sq'), 2)   # Total
       sum of squared deviation

```

```

20
21 cat("Total sum of squared deviation is", ss_total)
22
23 ss_within <- round(result$'Sum Sq'[4], 2) # Sum of
      squared deviation within-groups
24
25 cat("Sum of squared deviation within-groups is", ss_
      within)
26
27 ss_interaction <- round(result$'Sum Sq'[3], 2) #
      Sum of squared deviation of interaction
28
29 cat("Sum of squared deviation of interaction is", ss
      _interaction)
30
31 ss_rows <- round(result$'Sum Sq'[2], 2) # Sum of
      squared deviation of rows
32
33 cat("Sum of squared deviation of rows is", ss_rows)
34
35 ss_columns <- round(result$'Sum Sq'[1], 2) # Sum
      of squared deviation of columns
36
37 cat("Sum of squared deviation of columns is", ss_
      columns)
38
39 alpha <- 0.05 # 5% significance level
40 df_numerator <- 1 # 2 - 1 = 1 (2 groups)
41 df_denominator <- result$Df[4]
42
43 fval <- qf(0.95, df_numerator, df_denominator)
44 fval <- round(fval, 2)
45
46 f1 <- result$'F value'[1] # F value for vividness
      condition
47 f2 <- result$'F value'[2] # F value for length
      condition
48 f3 <- result$'F value'[3] # F value for vividness

```

```

        condition : length condition
49
50 if(f1 >= fval)
51 {
52   cat("Reject null hypothesis")
53 } else {
54   cat("Cannot reject null hypothesis")
55 }
56
57 if(f2 >= fval)
58 {
59   cat("Reject null hypothesis")
60 } else {
61   cat("Cannot reject null hypothesis")
62 }
63
64 if(f3 >= fval)
65 {
66   cat("Reject null hypothesis")
67 } else {
68   cat("Cannot reject null hypothesis")
69 }

```

---

**R code Exa 10.2a** Advanced Topic Effect Size in the Factorial Analysis of Variance

```

1                                     # Page no. : 413 -
                                     414
2
3 # Advanced Topic : Effect Size in the Factorial
  Analysis of Variance
4
5 var_col <- 1.20 # Variance (columns)
6 df_col <- 1    # Degree of freedom (columns)
7

```

```

8 var_within <- 0.03 # Variance within-groups
9 df_within <- 16 # Degree of freedom within-groups
10
11 r_sq1 <- round((var_col * df_col) / ((var_col * df_
    col) + (var_within * df_within)), 2)
12 # The proportion of
    Variance announced
    for (test
    difficulty)
13
14 cat("The proportion of Variance announced for (test
    difficulty) is", r_sq1)
15
16 var_rows <- 0.00 # Variance (rows)
17 df_rows <- 1 # Degree of freedom (rows)
18
19 r_sq2 <- round((var_rows * df_rows) / ((var_rows *
    df_rows) + (var_within * df_within)), 2)
20 # The proportion of Variance announced for (
    sensitivity)
21
22 cat("The proportion of Variance announced for (
    sensitivity) is", r_sq2)
23
24 var_int <- 0.60 # Variance (interaction)
25 df_int <- 1 # Degree of freedom (interaction)
26
27 var_within <- 0.03 # Variance within-groups
28 df_within <- 16 # Degree of freedom within-groups
29
30 r_sq3 <- round((var_int * df_int) / ((var_int * df_
    int) + (var_within * df_within)), 2)
31 # The proportion of Variance announced for (test
    difficulty)
32
33 cat("The proportion of Variance announced for (test
    difficulty) is", r_sq3)

```

---

**R code Exa 10.2b** How are you doing

```
1                                     # Page no. :
                                     416 - 417
2
3 # How are you doing?
4
5 # 1st Question (c) part
6
7 var_rows <- 9.45 # Variance (rows)
8 df_rows <- 1    # Degree of freedom (rows)
9
10 var_within <- 3.67 # Variance within-groups
11 df_within <- 36   # Degree of freedom within-groups
12
13 r_sq2 <- round((var_rows * df_rows) / ((var_rows *
      df_rows) + (var_within * df_within)), 2)
14 # The proportion of Variance announced for
15
16 cat("The proportion of Variance announced for is", r
      _sq2)
```

---

**R code Exa 10.3a** worked out examples 1

```
1                                     # Page no. :
                                     419 - 421
2
3 # worked out examples 1
4
5 # Only (b) and (c) part
6
```



```

7 DF <- data.frame(Variable_A = c(rep("Level1", 8),
  rep("Level2", 8), rep("Level3", 8)),
8     Variable_B = c(rep(c("Level1", "
  Level2"), 12)),
9     Values = c(25, 19, 20, 24, 23, 21,
  24, 20, 22, 24, 19, 18, 22, 22,
10     21, 20,
  16, 18, 19, 21, 13, 16,
  16, 17)
11 )
12
13 View(DF) # Book's table is little bit different
14
15 # install.packages(ggplot2)
16 library(ggplot2)
17
18 ggplot(DF, aes(x = Variable_A, y = Values, fill =
  Variable_B)) + geom_bar(position = "dodge",
19
20 # Litte bit different barplot as compare with book's
  barplot
21
22 res <- aov(Values ~ Variable_B*Variable_A, data = DF
  )
23 result <- anova(res)
24 result
25
26 ss_total <- round(sum(result$'Sum Sq'), 2) # Total
  sum of squared deviation
27

```

```

28 cat("Total sum of squared deviation is", ss_total)
29
30 ss_within <- round(result$'Sum Sq'[4], 2) # Sum of
      squared deviation within-groups
31
32 cat("Sum of squared deviation within-groups is", ss_
      within)
33
34 ss_interaction <- round(result$'Sum Sq'[3], 2) #
      Sum of squared deviation of interaction
35
36 cat("Sum of squared deviation of interaction is", ss_
      _interaction)
37
38 ss_rows <- round(result$'Sum Sq'[2], 2) # Sum of
      squared deviation of rows
39
40 cat("Sum of squared deviation of rows is", ss_rows)
41
42 ss_columns <- round(result$'Sum Sq'[1], 2) # Sum
      of squared deviation of columns
43
44 cat("Sum of squared deviation of columns is", ss_
      columns)
45
46 alpha <- 0.05 # 5% significance level
47 df_numerator <- 2 # 3 - 1 = 1 (2 groups)
48 df_denominator <- result$Df[4]
49
50 fval <- qf(0.95, df_numerator, df_denominator)
51 fval <- round(fval, 2)
52
53 f1 <- result$'F value'[1] # F value for variable B
54 f2 <- result$'F value'[2] # F value for variable A
55 f3 <- result$'F value'[3] # F value for variable B
      : variable A
56
57 if(f1 >= fval)

```

```
58 {
59   cat("Reject null hypothesis")
60 } else {
61   cat("Cannot reject null hypothesis")
62 }
63
64 if(f2 >= fval)
65 {
66   cat("Reject null hypothesis")
67 } else {
68   cat("Cannot reject null hypothesis")
69 }
70
71 if(f3 >= fval)
72 {
73   cat("Reject null hypothesis")
74 } else {
75   cat("Cannot reject null hypothesis")
76 }
```

---

# Chapter 11

## Correlation

**R code Exa 11.1a** Graphing Correlations The Scatter Diagram An example

```
1                                     # Page no. : 441 -
                                     442
2
3 # Graphing Correlations : The Scatter Diagram An
  example
4
5 Hours_slept <- c(5, 7, 8, 6, 6, 10)
6 Happy_mood <- c(2, 4, 7, 2, 3, 6)
7
8 DF <- data.frame(Hours_slept, Happy_mood)
9 View(DF)
10
11 # Install Library if not install
12
13 # install.packages("ggplot2")
14
15 # Import Library
16
17 library(ggplot2)
18
```

```

19 ggplot(DF, aes(x = Hours_slept, y = Happy_mood)) +
    geom_point() + labs(title =
20     "Scatter plot", x = "Hours slept last night"
    , y = "Happy mood") + theme_bw() +
21     scale_x_continuous(limits=c(1, 12), breaks = c
    (1:12)) +
22     scale_y_continuous(limits=c(1, 8), breaks = c(1:8)
    )

```

---

### R code Exa 11.1b How are you doing

```

1
# Page no. :
# 443
2
3 # How are you doing?
4
5 # 3rd Question
6
7 person <- LETTERS[1:4]
8 x <- c(3, 6, 1, 4)
9 y <- c(4, 7, 2, 6)
10
11 DF <- data.frame(person, x, y)
12 View(DF)
13
14 # Install Library if not install
15
16 # install.packages("ggplot2")
17
18 # Import Library
19
20 library(ggplot2)
21
22 ggplot(DF, aes(x = x, y = y)) + geom_point() + labs(
    title = "Scatter plot", x = "X", y = "Y") +

```

```

23   theme_bw() + scale_x_continuous(limits=c(0, 6),
      breaks = c(0:6)) +
24   scale_y_continuous(limits=c(0, 7), breaks = c(0:7)
      )

```

---

### R code Exa 11.2a Figuring the correlation coefficient an example

```

1                                     # Page no. : 455
                                     # - 456
2
3 # Figuring the correlation coefficient an example
4
5 Hours_slept <- c(5, 7, 8, 6, 6, 10)
6 Happy_mood <- c(2, 4, 7, 2, 3, 6)
7
8 # Book Method
9
10 m1 <- mean(Hours_slept) # Mean
11 m2 <- mean(Happy_mood) # Mean
12
13 deviation1 <- Hours_slept - m1
14 sq_dev1 <- deviation1 ** 2 # Squared deviation
15 sd1 <- round(sqrt(sum(sq_dev1) / 6), 2) # Standard
      deviation
16
17 z_score1 <- round(deviation1 / sd1, 2)
18
19 deviation2 <- Happy_mood - m2
20 sq_dev2 <- deviation2 ** 2 # Squared deviation
21 sd2 <- round(sqrt(sum(sq_dev2) / 6), 2) # Standard
      deviation
22
23 z_score2 <- round(deviation2 / sd2, 2)
24
25 c_p <- round(z_score1 * z_score2, 2) # Cross

```

```

    Product
26
27 DF <- data.frame(Hours_slept, deviation1, sq_dev1, z
    _score1, Happy_mood, deviation2, sq_dev2,
28                 z_score2, c_p)
29 View(DF)
30
31 r <- round(sum(DF$c_p) / nrow(DF), 2)  #
    Correlation Coefficient
32
33 cat(" Correlation coefficient is", r)
34
35 # Direct method
36
37 r2 <- round(cor(Happy_mood,Hours_slept), 2)
38 cat(" Correlation coefficient is", r2)

```

---

**R code Exa 11.2b** Figuring the correlation coefficient a second example

```

1                                     # Page no. : 456
                                     - 457
2
3 # Figuring the correlation coefficient a second
    example
4
5 No_of_exposures <- c(1:8)
6 No_of_words_recalled <- c(3, 2, 6, 4, 5, 5, 6, 9)
7
8 # Direct method
9
10 r <- round(cor(No_of_exposures, No_of_words_recalled)
    , 2)  # Correlation Coefficient
11 cat(" Correlation coefficient is", r)

```

---

**R code Exa 11.2c** How are you doing

```
1                                     # Page no. : 457
                                     - 458
2
3 # How are you doing?
4
5 # 4th Question
6
7 person <- c("K", "L", "M")
8 z_score1 <- c(0.5, -1.4, 0.9)
9 z_score2 <- c(-0.7, -0.8, 1.5)
10
11 c_p <- round(z_score1 * z_score2, 2) # Cross
    product
12
13 r <- round(sum(c_p) / 3, 2) # Correlation
    coefficient
14
15 cat("Correlation coefficient is", r)
```

---

**R code Exa 11.3a** Significance of a correlation coefficient

```
1                                     # Page no. : 458 -
                                     459
2
3 # Significance of a correlation coefficient
4
5 N <- 3 # No. of perons
6 r <- 0.24 # Correlation coefficient
7
```



```

8 t <- round(r / sqrt((1 - (r ** 2)) / (N - 2)), 2)
  # t value
9
10 cat("t value is", t)

```

---

**R code Exa 11.3b** Significance of a correlation coefficient an example

```

1                                     # Page no. : 459
2
3 # Significance of a correlation coefficient an
  example
4
5 N <- 6   # Sample size
6 r <- 0.85 # Correlation coefficient
7 alpha <- 0.05 # 5% significance level
8
9 df <- N - 2 # Degree of freedom
10
11 # Two - tailed
12
13 tval <- qt(1-alpha/2, df)
14 tval <- c(tval, -tval)
15
16 t <- round(r / sqrt((1 - (r ** 2)) / (N - 2)), 2)
  # t value
17
18 cat("t value is", t)
19
20 if(t > tval[1] || t < tval[2])
21 {
22   cat("Reject null hypothesis")
23 } else
24 {
25   cat("Cannot reject null hypothesis")
26 }

```

---

**R code Exa 11.3c** How are you doing

```
1                                     # Page no. : 461
2                                     - 462
3 # How are you doing?
4
5 # 3rd Question
6
7 N <- 60    # Sample size
8 r <- -0.31 # Correlation coefficient
9 alpha <- 0.05 # 5% significance level
10
11 df <- N - 2 # Degree of freedom
12
13 # Two - tailed
14
15 tval <- qt(1-alpha/2, df)
16 tval <- c(tval, -tval)
17
18 t <- round(r / sqrt((1 - (r ** 2)) / (N - 2)), 2)
19     # t value
20
21 cat("t value is", t)
22
23 if(t > tval[1] || t < tval[2])
24 {
25   cat("Reject null hypothesis")
26 } else
27 {
28   cat("Cannot reject null hypothesis")
29 }
```

---

### R code Exa 11.4a Worked out examples 1

```
1                                     # Page no. : 477
                                     - 478
2
3 # Worked out examples 1
4
5 Elementry_School <- c("Main Street", "Casat", "
   Lakeland", "Shady Grove", "Jefferson")
6 Class_size <- c(25, 14, 33, 28, 20)
7 Achievement <- c(80, 98, 50, 82, 90)
8
9 DF <- data.frame(Elementry_School, Class_size,
   Achievement)
10 View(DF)
11
12 # Install Library if not install
13
14 # install.packages("ggplot2")
15
16 # Import Library
17
18 library(ggplot2)
19
20 ggplot(DF, aes(x = Class_size, y = Achievement)) +
   geom_point() +
21   labs(title = "Scatter plot", x = "Class size", y =
   "Achievement test score") +
22   theme_bw()
```

---

### R code Exa 11.4b Worked out examples 2

```

1                                     # Page no. : 478 -
                                     479
2
3 # Worked out examples 2
4
5 Elementry_School <- c("Main Street", "Casat", "
   Lakeland", "Shady Grove", "Jefferson")
6 Class_size <- c(25, 14, 33, 28, 20)
7 Achievement <- c(80, 98, 50, 82, 90)
8
9 # Direct method
10
11 r <- round(cor(Class_size, Achievement), 2) #
   Correlation Coefficient
12 cat("Correlation coefficient is", r)

```

---

#### R code Exa 11.4c Worked out examples 3

```

1                                     # Page no. :
                                     479 - 480
2
3 # Worked out examples 3
4
5 N <- 5 # Sample size
6 r <- -0.90 # Correlation coefficient
7 alpha <- 0.05 # 5% significance level
8
9 df <- N - 2 # Degree of freedom
10
11 # Two - tailed
12
13 tval <- qt(1-alpha/2, df)
14 tval <- c(tval, -tval)
15
16 t <- round(r / sqrt((1 - (r ** 2)) / (N - 2)), 2)

```

```
    # t value
17
18 cat("t value is", t)
19
20 if(t > tval[1] || t < tval[2])
21 {
22   cat("Reject null hypothesis")
23 } else
24 {
25   cat("Cannot reject null hypothesis")
26 }
```

---

# Chapter 12

## Prediction

R code Exa 12.1a The linear prediction rule an example

```
1                                     # Page no. : 494
2                                     - 496
3 # The linear prediction rule an example
4
5 a <- 0.3   # Regression constant
6 b <- 0.004 # Regression coefficient
7 x <- 700   # SAT score
8
9 y_cap <- a + (b * x) # Predicted GPA (Linear
   predictor)
10
11 cat(" Predicted GPA (Linear predictor) is", y_cap)
12
13 # Another example
14
15 a <- -3   # Regression constant
16 b <- 1    # Regression coefficient
17 x <- 9    # Hours of sleep
18
19 y_cap <- a + (b * x) # Predicted mood (Linear
```

```
    predictor)
20
21 cat(" Predicted mood (Linear predictor) is", y_cap)
```

---

**R code Exa 12.1b** How are you doing

```
1                                     # Page no. :
                                     497
2
3 # How are you doing?
4
5 # 4th Question
6
7 a <- -1.23   # Regression constant
8 b <- 6.11   # Regression coefficient
9
10 # (a)
11
12 x <- 2.00   # Predictor variable
13
14 y_cap <- a + (b * x)   # Predicted score (Linear
    predictor)
15
16 cat(" Predicted score (Linear predictor) is", y_cap)
17
18 # (b)
19
20 x <- 4.87   # Predictor variable
21
22 y_cap <- a + (b * x)   # Predicted score (Linear
    predictor)
23
24 cat(" Predicted score (Linear predictor) is", round(y
    _cap, 2))
25
```

```

26 # (a)
27
28 x <- -1.92 # Predictor variable
29
30 y_cap <- a + (b * x) # Predicted score (Linear
    predictor)
31
32 cat("Predicted score (Linear predictor) is", round(y
    _cap, 2))

```

---

**R code Exa 12.2a** Another example of drawing the regression line

```

1 # Page no. : 501
2
3 # Another example of drawing the regression line
4
5 # Data on page no. : 442
6
7 Hours_slept <- c(5, 7, 8, 6, 6, 10)
8 Happy_mood <- c(2, 4, 7, 2, 3, 6)
9
10 DF <- data.frame(Hours_slept, Happy_mood)
11 View(DF)
12
13 # Import Library
14
15 library(ggplot2)
16
17 ggplot(DF, aes(x = Hours_slept, y = Happy_mood)) +
    geom_point() +
18   labs(title = "Scatter plot", x = "Hours slept
    last night", y = "Happy mood") + theme_bw() +
19   scale_x_continuous(limits=c(1, 12), breaks = c
    (1:12)) +
20   scale_y_continuous(limits=c(1, 8), breaks = c(1:8))

```



```
    ) +  
21 geom_smooth(method='lm', se = F)
```

---

**R code Exa 12.3a** Finding the best linear prediction rule

```
1 # Page no. : 502 - 504  
2  
3 # Finding the best linear prediction rule  
4  
5 # Rule 1 ==> y_cap <- 8 - (.18)*X  
6 # Rule 2 ==> y_cap <- 4 + (0)*X  
7 # Rule 3 ==> y_cap <- -2.5 + (1)*X  
8 # Rule 4 ==> y_cap <- -3 + (1)*X  
9  
10 Hours_slept <- c(5, 6, 6, 7, 8, 10)  
11 Actual_mood <- c(2, 2, 3, 4, 7, 6)  
12  
13 # Rule 1  
14  
15 y_cap1 <- 8 - (.18) * Hours_slept  
16  
17 # Rule 2  
18  
19 y_cap2 <- 4 + (0) * Hours_slept  
20  
21 # Rule 3  
22  
23 y_cap3 <- -2.5 + (1) * Hours_slept  
24  
25 # Rule 4  
26  
27 y_cap4 <- -3 + (1) * Hours_slept  
28  
29 DF <- data.frame(Hours_slept, Actual_mood, y_cap1, y  
    _cap2, y_cap3, y_cap4)
```

---

**R code Exa 12.3b** The least squared error principle

```
1 # Page no. : 504 - 505
2
3 # The least squared error principle
4
5 # Rule 1 ==> y_cap <- 8 - (.18)*X
6 # Rule 2 ==> y_cap <- 4 + (0)*X
7 # Rule 3 ==> y_cap <- -2.5 + (1)*X
8 # Rule 4 ==> y_cap <- -3 + (1)*X
9
10 Hours_slept <- c(5, 6, 6, 7, 8, 10)
11 Actual_mood <- c(2, 2, 3, 4, 7, 6)
12
13 # Rule 1
14
15 y_cap1 <- 8 - (.18) * Hours_slept
16
17 error1 <- Actual_mood - y_cap1
18
19 error1_sq <- round(error1 ** 2, 2)
20
21 # Rule 2
22
23 y_cap2 <- 4 + (0) * Hours_slept
24
25 error2 <- Actual_mood - y_cap2
26
27 error2_sq <- error2 ** 2
28
29 # Rule 3
30
31 y_cap3 <- -2.5 + (1) * Hours_slept
```

```

32
33 error3 <- Actual_mood - y_cap3
34
35 error3_sq <- error3 ** 2
36
37 # Rule 4
38
39 y_cap4 <- -3 + (1) * Hours_slept
40
41 error4 <- Actual_mood - y_cap4
42
43 error4_sq <- error4 ** 2
44
45 DF <- data.frame(Hours_slept, Actual_mood, y_cap1,
46                 error1, error1_sq, y_cap4, error4, error4_sq)
47 View(DF)
48
49 s1 <- sum(DF$error1_sq)
50
51 cat("Rule 1 sum of squared errors is", s1)
52
53 s2 <- sum(error2_sq)
54
55 cat("Rule 2 sum of squared errors is", s2)
56
57 s3 <- sum(error3_sq)
58
59 cat("Rule 3 sum of squared errors is", s3)
60
61 s4 <- sum(DF$error4_sq)
62
63 cat("Rule 4 sum of squared errors is", s4)

```

---

**R code Exa 12.3c** Finding a and b for the least squares linear prediction rule

```

1                                     # Page no. :
                                     505 - 507
2
3 # Finding a and b for the least squares linear
  prediction rule
4
5 Hours_slept <- c(5, 7, 8, 6, 6, 10)
6 Happy_mood <- c(2, 4, 7, 2, 3, 6)
7
8 DF <- data.frame(Hours_slept, Happy_mood)
9 View(DF)
10
11 # Direct method
12
13 regressor <- lm(Happy_mood ~ Hours_slept, data = DF)
14 res <- summary(regressor)
15
16 res
17
18 b <- res$coefficients[[2]]
19
20 a <- res$coefficients[[1]]
21
22 cat("Linear Prediction Rule is y_cap =", a, "+", b, "x")

```

---

**R code Exa 12.3d** How are you doing

```

1 # Page no. : 507 - 508
2
3 # How are you doing?
4
5 # 4th Question
6
7 x <- c(4, 6, 7, 3)
8 y <- c(6, 8, 3, 7)

```

```

9
10 DF <- data.frame(x, y)
11 View(DF)
12
13 # (a) part
14
15 # Direct method
16
17 regressor <- lm(y ~ x, data = DF)
18 res <- summary(regressor)
19
20 res
21
22 b <- res$coefficients[[2]]
23
24 a <- res$coefficients[[1]]
25
26 cat("Linear Prediction Rule is y_cap =", a, "+", b, "x")
27
28 # (b) part
29
30 y_cap1 <- a + b * x
31
32 error1 <- y - y_cap1
33
34 error1_sq <- round(error1 ** 2, 2)
35
36 s1 <- sum(error1_sq)
37
38 cat("Sum of squared errors is", s1)
39
40 # (c) part
41
42 y_cap2 <- 9 - (0.7) * x
43
44 error2 <- y - y_cap2
45
46 error2_sq <- round(error2 ** 2, 2)

```

```
47
48 s2 <- sum(error2_sq)
49
50 cat("Sum of squared errors is", s2)
```

---

**R code Exa 12.4a** The standardized regression coefficient

```
1 # Page no. : 509 - 510
2
3 # The standardized regression coefficient
4
5 ss_x <- 16
6 ss_y <- 22
7 b <- 1
8
9 beta <- round(b * (sqrt(ss_x) / sqrt(ss_y)), 2)
10
11 cat("Standardized regression coefficient is", beta)
```

---

**R code Exa 12.4b** How are you doing

```
1 # Page no. : 511 - 512
2
3 # How are you doing?
4
5 # 2nd Question (b) part
6
7 ss_x <- 2.57
8 ss_y <- 7.21
9 b <- -1.21
10
11 beta <- round(b * (sqrt(ss_x) / sqrt(ss_y)), 2)
12
```

```
13 cat(" Standardized regression coefficient is", beta)
```

---

### R code Exa 12.5a Multiple regression

```
1                                     # Page no. : 512
2                                     - 513
3 # Multiple regression
4
5 a <- -3.78
6
7 b1 <- 0.87
8 x1 <- 7
9
10 b2 <- 0.33
11 x2 <- 3
12
13 b3 <- 0.20
14 x3 <- 1
15
16 y_cap <- round(a + (b1 * x1) + (b2 * x2) + (b3 * x3)
17           , 2) # Predicted mood (multiple regression)
18 cat(" Predicted mood (multiple regression) is", y_cap
19     )
```

---

### R code Exa 12.5b How are you doing

```
1                                     # Page no. :
2                                     514 - 515
3 # How are you doing?
4
```

```

5 # 3rd Question
6
7 a <- 2.19
8
9 b1 <- -3.16
10
11 b2 <- 0.99
12
13 # (a) part
14
15 x1 <- 0.40
16 x2 <- 10.50
17
18 y_cap1 <- round(a + (b1 * x1) + (b2 * x2), 2) #
    Predicted score (multiple regression)
19
20 cat("Predicted score (multiple regression) is", y_
    cap1)
21
22 # (b) part
23
24 x1 <- 0.15
25 x2 <- 5.50
26
27 y_cap2 <- round(a + (b1 * x1) + (b2 * x2), 2) #
    Predicted score (multiple regression)
28
29 cat("Predicted score (multiple regression) is", y_
    cap2)

```

---

**R code Exa 12.6a** Proportionate reduction in error

```

1
2
# Page no. :
520 - 522

```



```

3 # Proportionate reduction in error
4
5 Hours_slept <- c(5, 6, 6, 7, 8, 10)
6 Actual_mood <- c(2, 2, 3, 4, 7, 6)
7
8 DF <- data.frame(Hours_slept, Actual_mood)
9 View(DF)
10
11 # Direct method
12
13 regressor <- lm(Actual_mood ~ Hours_slept, data = DF
14 )
15 res <- summary(regressor)
16 res
17
18 p_r <- round(res$r.squared, 2) # Proportionate
19 reduction in error
20 cat("Proportionate reduction in error is", p_r)

```

---

**R code Exa 12.6b** How are you doing

```

1 # Page no. : 523 -
2 524
3 # How are you doing?
4
5 # 4th Question
6
7 score <- c(6, 4, 2, 8)
8 predicted_score <- c(5.7, 4.3, 2.9, 7.1)
9
10 m <- mean(score) # mean
11

```

```

12 error <- score - m
13 error_sq <- error ** 2 # Error square
14
15 error2 <- score - predicted_score
16 error2_sq <- error2 ** 2 # Error square
17
18 DF <- data.frame(score, error, error_sq, predicted_
    score, error2, error2_sq)
19 View(DF)
20
21 ss_total <- sum(DF$error_sq)
22
23 ss_error <- sum(DF$error2_sq)
24
25 p_r <- round((ss_total - ss_error) / ss_total, 2) #
    Proportionate reduction in error
26
27 cat("Proportionate reduction in error is", p_r)
28
29 r <- round(sqrt(p_r), 2) # Correlation coefficient
30
31 cat("Correlation coefficient is", r)

```

---

### R code Exa 12.7a Worked out examples 1

```

1 # Page no. :
    526
2
3 # Worked out examples 1
4
5 # This example includes solution of worked out
    examples 3
6
7 Elementry_School <- c("Main Street", "Casat", "
    Lakeland", "Shady Grove", "Jefferson")

```

```

8 Class_size <- c(25, 14, 33, 28, 20)
9 Achievement <- c(80, 98, 50, 82, 90)
10
11 DF <- data.frame(Elementary_School, Class_size,
12                   Achievement)
13 View(DF)
14 # Direct method
15
16 regressor <- lm(Achievement ~ Class_size, data = DF)
17 res <- summary(regressor)
18
19 res
20
21 b <- round(res$coefficients[[2]], 2)
22
23 a <- round(res$coefficients[[1]], 2)
24
25 cat("Linear Prediction Rule is y_cap =", a, "+", b, "x")
26
27 # (a) part
28
29 x <- 23 # Class size
30
31 y_cap <- a + (b * x) # Predicted achievement
32
33 cat("Predicted achievement is", y_cap)
34
35 # (b) part
36
37 x <- 14 # Class size
38
39 y_cap <- a + (b * x) # Predicted achievement
40
41 cat("Predicted achievement is", y_cap)

```

---

## R code Exa 12.7b Worked out examples 2

```
1                                     # Page no. :
2                                     526
3 # Worked out examples 2
4
5 Elementry_School <- c("Main Street", "Casat", "
  Lakeland", "Shady Grove", "Jefferson")
6 Class_size <- c(25, 14, 33, 28, 20)
7 Achievement <- c(80, 98, 50, 82, 90)
8
9 DF <- data.frame(Elementry_School, Class_size,
  Achievement)
10 View(DF)
11
12 # Install Library if not install
13
14 # install.packages("ggplot2")
15
16 # Import Library
17
18 library(ggplot2)
19
20 ggplot(DF, aes(x = Class_size, y = Achievement)) +
  geom_point() +
21   labs(title = "Scatter plot", x = "Class size", y =
    "Achievement test score") +
22   theme_bw() + geom_smooth(method = "lm", se = F)
23
24 # Book's figure is in page 527
```

---

**R code Exa 12.7c** Worked out examples 4

```
1                                     # Page no. :
2                                     528
3 # Worked out examples 4
4
5 ss_x <- 214
6 ss_y <- 1328
7 b <- -2.25
8
9 beta <- round(b * (sqrt(ss_x) / sqrt(ss_y)), 2) #
   Standardized regression coefficient
10
11 cat("Standardized regression coefficient is", beta)
```

---

**R code Exa 12.7d** Worked out examples 5

```
1                                     # Page no. :
2                                     528 -
3                                     529
4
5 # Worked out examples 5
6
7 a <- 2.13
8
9
10 b1 <- 1.32
11 x1 <- 4
12
13 b2 <- 1.21
14 x2 <- 5
15
16 b3 <- 1.41
17 x3 <- 3
18
```

```

16 y_cap <- round(a + (b1 * x1) + (b2 * x2) + (b3 * x3)
    , 2) # Predicted talkativeness
17
18 cat("Predicted talkativeness is", y_cap)

```

---

### R code Exa 12.7e Worked out examples 6

```

1                                     # Page no. : 529
                                     - 530
2
3 # Worked out examples 6
4
5 Elementry_School <- c("Main Street", "Casat", "
    Lakeland", "Shady Grove", "Jefferson")
6 Class_size <- c(25, 14, 33, 28, 20)
7 Achievement <- c(80, 98, 50, 82, 90)
8
9 DF <- data.frame(Elementry_School, Class_size,
    Achievement)
10 View(DF)
11
12 # Direct method
13
14 regressor <- lm(Achievement ~ Class_size, data = DF)
15 res <- summary(regressor)
16
17 res
18
19 p_r <- round(res$r.squared, 2) # Proportionate
    reduction in error
20
21 cat("Proportionate reduction in error is", p_r)

```

---

# Chapter 13

## Chi Square Tests

**R code Exa 13.1a** An example

```
1 # Page no. : 543 -544
2
3 # An example
4
5 gender <- c("Male", "Female")
6 o <- c(996, 390) # Observed frequency
7 e <- c(693, 693) # Expected frequency
8
9 diff <- o - e
10 diff_sq <- diff ** 2
11
12 ans <- round(diff_sq / e, 2) # Difference squared
   weighted by expected frequency
13
14 DF <- data.frame(gender, o, e, diff, diff_sq, ans)
15 View(DF)
```

---

**R code Exa 13.1b** The chi square statistic and the chi square test for goodness of fit

```

1 # Page no. : 545 -546
2
3 # The chi - square statistic and the chi - square
  test for goodness of fit
4
5 o <- c(996, 390) # Observed frequency
6 e <- c(693, 693) # Expected frequency
7
8 diff <- o - e
9 diff_sq <- diff ** 2
10 ans <- round(diff_sq / e, 2)
11
12 chi_sq <- sum(ans)
13
14 cat("Value of chi-square is", chi_sq)

```

---

#### R code Exa 13.1c Another example

```

1 # Page no. : 549 -550
2
3 # Another example
4
5 condition <- c("Anxiety disorder", "Alcohol or drug
  abuse", "Mood disorder",
6               "Impulse - control disorder", "None
  of these conditions")
7
8 observed <- c(138, 99, 123, 111, 529)
9
10 expected <- c(146, 80, 110, 128, 536)
11
12 DF <- data.frame(condition, observed, expected)
13 View(DF)
14
15 alpha <- 0.05

```



```

16 df <- nrow(DF) - 1
17
18 chi_sq_val <- round(qchisq(alpha,df,lower.tail = F),
19                       2)
20
21 diff <- DF$observed - DF$expected
22 diff_sq <- diff ** 2
23
24 ans <- round(diff_sq / DF$expected, 2)
25
26 chi_sq <- sum(ans)
27
28 cat("Value of chi-square is", chi_sq)
29
30 if(chi_sq > chi_sq_val)
31 {
32   cat("Reject null hypothesis")
33 } else
34 {
35   cat("Cannot reject null hypothesis")
36 }

```

---

**R code Exa 13.1d** How are you doing

```

1 # Page no. : 551 - 553
2
3 # How are you doing?
4
5 # 5th Question (a) part
6
7 alpha <- 0.05
8 categories <- 2
9
10 observed <- c(15, 35)
11 N <- sum(observed)
12 expected <- c(0.6 * N, 0.4 * N)

```

```

13
14 df <- categories - 1
15
16 chi_sq_val <- round(qchisq(alpha,df,lower.tail = F),
    2)
17
18 diff <- observed - expected
19 diff_sq <- diff ** 2
20 ans <- round(diff_sq / expected, 2)
21
22 chi_sq <- sum(ans)
23
24 cat("Value of chi-square is", chi_sq)
25
26 if(chi_sq > chi_sq_val)
27 {
28   cat("Reject null hypothesis")
29 } else
30 {
31   cat("Cannot reject null hypothesis")
32 }

```

---

**R code Exa 13.2a** The chi square test for independence

```

1 # Page no. : 553 - 557
2
3 # The chi - square test for independence
4
5 # Contingency Table
6
7 gender <- c(rep("Male", 28), rep("Female", 30), rep(
    "Male", 125), rep("Female", 39))
8 age <- c(rep("Child", 58), rep("Adult", 164))
9
10 c_t <- table(age, gender)

```

```

11 c_t
12
13 # Direct method
14
15 result <- chisq.test(c_t)
16 result
17
18 # Expected values
19
20 expected <- round(result$expected, 2)
21 expected
22
23 # Figuring chi - square
24
25 chi_sq <- round(result$statistic, 2)
26
27 cat("Chi-square value is", chi_sq)
28 # Degrees of freedom
29
30 df <- result$parameter
31
32 cat("Degrees of freedom is", df)
33
34 # Hypothesis testing
35
36 alpha <- 0.05
37
38 chi_sq_val <- round(qchisq(alpha,df,lower.tail = F),
39                       2)
40 if(chi_sq > chi_sq_val)
41 {
42   cat("Reject null hypothesis")
43 } else
44 {
45   cat("Cannot reject null hypothesis")
46 }

```

---

### R code Exa 13.2b Another example

```
1 # Page no. : 558 - 559
2
3 # Another example
4
5 # Contingency Table
6
7 generation <- c(rep("First", 73), rep("Other", 89),
8               rep("First", 657), rep("Other", 1226))
9 drop <- c(rep("Dropped out", 162), rep("Did not drop
10         out", 1883))
11
12 c_t <- table(drop, generation)
13
14 # Direct method
15
16 result <- chisq.test(c_t)
17 result
18
19 # Expected values
20
21 expected <- round(result$expected, 2)
22 expected
23
24 # Figuring chi - square
25
26 chi_sq <- round(result$statistic, 2)
27
28 cat("Chi-square value is", chi_sq)
29
30 # Degrees of freedom
```

```

31
32 df <- result$parameter
33
34 cat("Degrees of freedom is", df)
35
36 # Hypothesis testing
37
38 alpha <- 0.01
39
40 chi_sq_val <- round(qchisq(alpha,df,lower.tail = F),
41                     2)
42 if(chi_sq > chi_sq_val)
43 {
44   cat("Reject null hypothesis")
45 } else
46 {
47   cat("Cannot reject null hypothesis")
48 }
49 # Book's answer differ with our answer

```

---

**R code Exa 13.2c** How are you doing

```

1 # Page no. : 560 – 561
2
3 # How are you doing?
4
5 # 4th Question (a) part
6
7 nominal_variable_A <- c(rep("Category1", 10), rep("
8   Category2", 10), rep("Category1", 50),
9   rep("Category2", 10), rep("
10  Category1", 10), rep("
11  Category2", 10))
12 nominal_variable_B <- c(rep("Category1", 20), rep("

```

```

    Category2", 60), rep("Category3", 20))
10
11 c_t <- table(nominal_variable_B, nominal_variable_A)
12
13 c_t
14
15 # Direct method
16
17 result <- chisq.test(c_t)
18 result
19
20 # Expected values
21
22 expected <- round(result$expected, 2)
23 expected
24
25 # Figuring chi - square
26
27 chi_sq <- round(result$statistic, 2)
28
29 cat("Chi-square value is", chi_sq)
30
31 # Degrees of freedom
32
33 df <- result$parameter
34
35 cat("Degrees of freedom is", df)
36
37 # Hypothesis testing
38
39 alpha <- 0.10
40
41 chi_sq_val <- round(qchisq(alpha, df, lower.tail = F),
42   2)
43 if(chi_sq > chi_sq_val)
44 {
45   cat("Reject null hypothesis")

```

```
46 } else
47 {
48   cat("Cannot reject null hypothesis")
49 }
```

---

### R code Exa 13.3a Effect Size for Chi Square Tests for Independence

```
1 # Page no. : 562 - 563
2
3 # Effect Size for Chi-Square Tests for Independence
4
5 chi_sq <- 6.73
6 N <- 2045
7
8 phi_coeff <- round(sqrt(chi_sq / N), 2)
9
10 cat("Phi coefficient is", phi_coeff)
11
12
13 chi_sq <- 12.70
14 N <- 100
15 df_smaller <- 1
16
17 c_phi_coeff <- round(sqrt(chi_sq / (N * df_smaller))
18   , 2)
19 cat("Cramer's phi coefficient is", c_phi_coeff) #
    Book's answer is wrong
```

---

### R code Exa 13.3b How are you doing

```
1 # Page no. : 565 - 566
2
```

```

3 # How are you doing?
4
5 # 2nd Question (d) part
6
7 chi_sq <- 12
8 N <- 100
9
10 phi_coeff <- round(sqrt(chi_sq / N), 2)
11
12 cat("Phi coefficient is", phi_coeff)
13
14 # 3rd Question (d) part
15
16 chi_sq <- 20
17 N <- 200
18 df_smaller <- 4 - 1
19
20 c_phi_coeff <- round(sqrt(chi_sq / (N * df_smaller))
21   , 2)
22 cat("Cramer's phi coefficient is", c_phi_coeff)

```

---

#### R code Exa 13.4a Worked out examples 1

```

1 # Page no. : 569 - 570
2
3 # Worked out examples 1
4
5 grade <- LETTERS[1:5]
6 observed <- c(10, 34, 140, 10, 6)
7 expected <- c(5, 28, 134, 28, 5)
8
9 DF <- data.frame(grade, observed, expected)
10 View(DF)
11

```



```

12 alpha <- 0.01
13 df <- nrow(DF) - 1
14
15 chi_sq_val <- round(qchisq(alpha,df,lower.tail = F),
    2)
16
17 diff <- DF$observed - DF$expected
18 diff_sq <- diff ** 2
19 ans <- round(diff_sq / DF$expected, 2)
20
21 chi_sq <- sum(ans)
22
23 cat(" Value of chi-square is", chi_sq)
24
25 if(chi_sq > chi_sq_val)
26 {
27   cat(" Reject null hypothesis")
28 } else
29 {
30   cat(" Cannot reject null hypothesis")
31 }

```

---

#### R code Exa 13.4b Worked out examples 2

```

1 # Page no. : 571 - 572
2
3 # Worked out examples 2
4
5 # Contingency Table
6
7 participant_gender <- c(rep("Men", 29), rep("Women",
    17), rep("Men", 4), rep("Women", 14),
8     rep("Men", 26), rep("Women",
    28))
9 comparision <- c(rep("Same sex", 46), rep("Opposite

```

```

    sex", 18), rep("Both sexes", 54))
10
11 c_t <- table(comparision, participant_gender)
12
13 c_t
14
15 # Direct method
16
17 result <- chisq.test(c_t)
18 result
19
20 # Expected values
21
22 expected <- round(result$expected, 2)
23 expected
24
25 # Figuring chi - square
26
27 chi_sq <- round(result$statistic, 2)
28
29 cat("Chi-square value is", chi_sq)
30
31 # Degrees of freedom
32
33 df <- result$parameter
34
35 cat("Degrees of freedom is", df)
36
37 # Hypothesis testing
38
39 alpha <- 0.05
40
41 chi_sq_val <- round(qchisq(alpha,df,lower.tail = F),
42                       2)
43 if(chi_sq > chi_sq_val)
44 {
45   cat("Reject null hypothesis")

```

```
46 } else
47 {
48   cat("Cannot reject null hypothesis")
49 }
```

---

**R code Exa 13.4c** Worked out examples 3 and 4

```
1                                     # Page no. :
                                     572
2
3 # Worked out examples 3 and 4
4
5 chi_sq <- 14.41 # Chi-square value
6 N <- 85 # No. of people
7
8 phi_coeff <- round(sqrt(chi_sq / N), 2) # Phi
   coefficient
9
10 cat("Phi coefficient is", phi_coeff)
11
12 chi_sq <- 8.78 # Chi-square value
13 N <- 118 # No. of people
14 df_smaller <- 2 - 1 # Degree of freedom on smaller
   side (2 x 2 contingency table)
15
16 c_phi_coeff <- round(sqrt(chi_sq / (N * df_smaller))
   , 2) # Cramer's phi coefficient
17
18 cat("Cramer's phi coefficient is", c_phi_coeff) #
   Book's answer is wrong
```

---

# Chapter 14

## Strategies When Population Distributions Are Not Normal

R code Exa 14.1a An example of a data transformation

```
1 # Page no. : 592 – 593
2
3 # An example of a data transformation
4
5 highly_sensitive_no <- c(0, 3, 10, 22)
6 highly_sensitive_yes <- c(17, 36, 45, 75)
7
8 m1 <- mean(highly_sensitive_no)
9 var1 <- round(var(highly_sensitive_no), 2)
10
11 m2 <- mean(highly_sensitive_yes)
12 var2 <- round(var(highly_sensitive_yes), 2)
13
14 sq_root1 <- round(sqrt(highly_sensitive_no), 2)
15 sq_root2 <- round(sqrt(highly_sensitive_yes), 2)
16
17 DF <- data.frame(highly_sensitive_no, sq_root1,
18                 highly_sensitive_yes, sq_root2)
18 View(DF)
```

```

19
20 alpha <- 0.05
21
22 df1 <- length(highly_sensitive_no) - 1
23 df2 <- length(highly_sensitive_yes) - 1
24
25 df_total <- df1 + df2
26
27 # One - tailed
28
29 tval <- round(qt(alpha, df_total, lower.tail = T),
30              2)
31 result <- t.test(DF$sq_root1, DF$sq_root2)
32 result
33
34 mean1 <- round(result$estimate[1], 2)
35 var_1 <- round(var(DF$sq_root1), 2)
36
37 mean2 <- round(result$estimate[2], 2)
38 var_2 <- round(var(DF$sq_root2), 2)
39
40 p_var <- round(((df1 / df_total) * var_1) + ((df2 /
41              df_total) * var_2), 2)
42
43 cat("Pooled variance is", p_var)
44
45 t <- round(result$statistic[[1]], 2) # t value
46
47 cat("t value is", t)
48
49 if(t < tval)
50 {
51   cat("Reject null hypothesis")
52 } else
53 {
54   cat("Cannot reject null hypothesis")
55 }

```

---

**R code Exa 14.2a** An example of a rank order test

```
1                                     # Page no. :
                                     595 – 596
2
3 # An example of a rank – order test
4
5 highly_sensitive_no <- c(0, 3, 10, 22)
6 highly_sensitive_yes <- c(17, 36, 45, 75)
7
8 DF <- data.frame( highly_sensitive = rep(c("No", "
  Yes"), each = 4),
9                   Values = c(highly_sensitive_no,
                                highly_sensitive_yes)
10                  )
11
12 Rank <- rank(DF$Values)
13 DF <- cbind(DF, Rank)
14
15 View(DF)
16
17 alpha <- 0.05 # 5% significance level
18
19 result <- wilcox.test(highly_sensitive_no, highly_
  sensitive_yes, paired = T)
20
21 result
22
23 p_value <- result$p.value
24
25 if(p_value > alpha)
26 {
27   cat("Reject null hypothesis")
28 } else
```

```
29 {
30   cat("Cannot reject null hypothesis")
31 }
```

---

**R code Exa 14.2b** Using parametric tests with rank transformed data

```
1 # Page no. : 596 - 597
2
3 # Using parametric tests with rank - transformed
  data
4
5 highly_sensitive_no <- c(1, 2, 3, 5)
6 highly_sensitive_yes <- c(4, 6, 7, 8)
7
8 m1 <- mean(highly_sensitive_no)
9 var1 <- round(var(highly_sensitive_no), 2)
10
11 m2 <- mean(highly_sensitive_yes)
12 var2 <- round(var(highly_sensitive_yes), 2)
13
14 df1 <- length(highly_sensitive_no) - 1
15 df2 <- length(highly_sensitive_yes) - 1
16 df_total <- df1 + df2
17 # One - tailed
18
19 alpha <- 0.05 # 5% significance level
20
21 tval <- round(qt(alpha, df_total, lower.tail = T),
  2)
22
23 p_var <- round(((df1 / df_total) * var1) + ((df2 /
  df_total) * var2), 2) # Pooled variance
24
25 cat("Pooled variance is", p_var)
26
```

```

27 result <-t.test(highly_sensitive_no, highly_
    sensitive_yes)
28 result
29
30 t <- round(result$statistic[[1]], 2) # t value
31
32 cat("t value is", t)
33
34 if(t < tval)
35 {
36   cat("Reject null hypothesis")
37 } else
38 {
39   cat("Cannot reject null hypothesis")
40 }

```

---

**R code Exa 14.2c** How are you doing

```

1 # Page no. : 598 - 599
2
3 # How are you doing?
4
5 # 2nd Question
6
7 scores <- c(5, 18, 3, 9, 2)
8
9 rank <- rank(scores)
10
11 DF <- data.frame(scores, rank)
12
13 View(DF)

```

---

**R code Exa 14.3a** Worked out examples 1 and 2



```

1
# Page no. :
605
2
3 # Worked out examples 1 and 2
4
5 group_A <- c(15, 4, 12, 14)
6 group_B <- c(21, 16, 49, 17)
7 group_C <- c(18, 19, 11, 22)
8
9 sq_root1 <- round(sqrt(group_A), 2) # Square root
  of group A
10 sq_root2 <- round(sqrt(group_B), 2) # Square root
  of group B
11 sq_root3 <- round(sqrt(group_C), 2) # Square root
  of group C
12
13 DF <- data.frame(sq_root1, sq_root2, sq_root3)
14 View(DF)
15
16 DF2 <- data.frame( Groups = rep(c("Group A", "Group
  B", "Group C"), each = 4),
17                   Values = c(group_A, group_B, group
  _C)
18                   )
19
20 Rank <- rank(DF2$Values)
21 DF2 <- cbind(DF2, Rank)
22
23 View(DF2)

```

---