R Textbook Companion for
John E. Freund's Mathematical Statistics With Applications
by John E. Freund[1]

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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.

Contents

List of R Codes

Chapter 1

Introduction

R code Exa 1.1 Counting travel options

```
# page no 2
transportation= 3
no_of_places= 5
total_ways=transportation*no_of_places
total_ways
print(total_ways)
```

R code Exa 1.2 Rolling two dice

```
# page no 3
selection_of_red_die=6
selection_of_green_die=6
total_ways=selection_of_green_die*selection_of_red_
   die
print(total_ways)
```

R code Exa 1.3 Choosing inspection parts

```
# page no 4
first_part=4
second_part=3
third_part=5
fourth_part=4
total_ways= first_part*second_part*third_part*fourth
    _part
print(total_ways)
```

R code Exa 1.4 Answering true false test

```
# page no 4
total_question=20
possible_ans=2
s=1
for (i in 1:20)
{
  s=s*possible_ans

}
print(s)
```

R code Exa 1.5 Permutations of abc

```
# page number 4
total_letter= 3
letter_tobe_chosen=3
total_ways=choose(total_letter,letter_tobe_chosen)*
    factorial(letter_tobe_chosen)
print(total_ways)
```

R code Exa 1.6 Introducing basketball players

```
# page number 5
no_of_player=5
ways__wich_th_introdce=factorial(no_of_player)
print(ways__wich_th_introdce)
```

R code Exa 1.7 Permutations of 2 letters

```
# page number 5
num_of_lettr=4
selct_frm_lettr=2
s=1
for (i in 1:selct_frm_lettr)
{
  s=s*num_of_lettr
  num_of_lettr=num_of_lettr-1
}
print(s)
```

R code Exa 1.8 combination

```
# page number 6
total_member= 24
position_tobe_chosen=4
total_ways=choose(total_member,position_tobe_chosen)
   *factorial(position_tobe_chosen)
print(total_ways)
```

R code Exa 1.9 Scheduling speakers for meetings

```
# page number= 6
total_dates= 5
num_of_spekr=3
total_ways= choose(total_dates,num_of_spekr)*
   factorial(num_of_spekr)
print(total_ways)
```

R code Exa 1.10 circular permutations

```
# page number = 7
no_of_prsn_play_circlr=4
ways=factorial(no_of_prsn_play_circlr-1)
print(ways)
```

R code Exa 1.11 Permutations of the word book

```
#page number= 7
letter="book"
n= nchar(letter)
letter_counts= table(strsplit(letter,"")[[1]])
s=1
for (i in 1:length(letter_counts))
{     s= s*(1/factorial(letter_counts[i][[1]]))
       print(s)
}
total_ways=factorial(n)*s
print(total_ways)
```

R code Exa 1.12 Arranging novels on a shelf

```
#page number 7
copies_of_one_novel=3
novel_with_one_copy=4
total_novel=copies_of_one_novel+novel_with_one_copy
print(choose(total_novel,novel_with_one_copy)*
   factorial(novel_with_one_copy))
```

R code Exa 1.13 Hanging paintings on a museum wall

```
# page number = 8
library(iterpc)


painting_by_monet=2
painting_by_renoir=3
painting_by_degas=2
total_painting= painting_by_degas+painting_by_renoir
   +painting_by_monet


total_way= multichoose(c(painting_by_degas,painting_
   by_monet,painting_by_renoir))

print(total_ways)
```

R code Exa 1.14 Selecting households for market research

```
#page number= 8
total_houshld=20
select_houshld=3




total_ways =choose(total_houshld,select_houshld)*
    factorial(select_houshld)
print(total_ways)

order_not_matters=total_ways/factorial(select_
    houshld)
print(order_not_matters)
```

R code Exa 1.15 Coin toss outcomes

```
# page number 9


total_tossed_coins=6
no.of.heads=2
no.of.tails=4

total_ways= choose(total_tossed_coins,no.of.heads)
print(total_ways)
```

R code Exa 1.16 Forming committees of chemists and physicists

```
#page number= 9

total_chemist=4
number.of.chemist.selct=2
```

```
total_physicist=3
number.of.physicist.selct=1
way_chemist=choose(total_chemist,number.of.chemist.
   selct)
way_physicist=choose(total_physicist,number.of.
   physicist.selct)
total_ways=way_chemist*way_physicist
print(total_ways)
```

R code Exa 1.17 Partitioning a set into subsets

```
#page no 9
library(iterpc)
total_object=4
first_subset=1
second_subset=2
third_subset=1

total.subset= multichoose(c(first_subset,second_
   subset,third_subset))
print(total.subset)
```

R code Exa 1.18 Assigning businessmen to hotel rooms

```
# page number =11
 total_hotel_rooms=7
 assign_first_room=3
 assign_second_room=2
 assign_thired_room=2
 total.ways= multichoose(c(assign_first_room,assign_
    second_room,assign_thired_room))
 print(total.ways)
```

R code Exa 1.19 finding combination for n

```r
# page number = 12
print(choose(4,3))
print(choose(4,4))
```

R code Exa 1.20 finding combination of n

```r
# page number =12

print(choose(5,3))
print(choose(5,5))
```

R code Exa 1.21 finding the combination

```r
# page number= 13
print(choose(20,12))
print(choose(17,10))
```

R code Exa 1.22 multinom

```r
# page numebr= 15
m=2
n=3
k=4
sum=0
for(i in 0:k)
```

```
{
  sum=sum+choose(m,i)*choose(n,k-i)
}

result= choose(m+n,k)

if(result==sum)
{
    print(sum)
}
```

R code Exa 1.23 multinom

```
#page number= 15
library(iterpc)
n=6
r1=3
r2=1
r3=2
result= multichoose(c(r1,r2,r3))
print(result)
```

R code Exa 1.24 Selecting integrated circuit chips for assembly

```
# page number = 17
no.integrated.chips= 20
no_of_chips_must_solder=3
result= choose(no.integrated.chips,no_of_chips_must_
   solder)*factorial(no_of_chips_must_solder)
print(result)
```

R code Exa 1.25 Selecting units for inspection

```
# page number = 17
#- The answer provided in the textbook is wrong.
total_units=16
units_selected=4
result=choose(total_units,units_selected)
print(result)
```

Chapter 2

probability

R code Exa 2.1 ace in cards

```
# page number 21
library(MASS)
total_ace = 4
total_cards= 52
prob_of_ace= (total_ace)/total_cards
print(fractions(prob_of_ace))
```

R code Exa 2.2 pair of dice

```
# page number 23
red_dice <- 6
green_dice <- 6
dice_combinations <- expand.grid(1:red_dice, 1:green
    _dice)
dice_combinations
sums <- rowSums(dice_combinations)
cat(paste(sums, collapse = ","))
```

R code Exa 2.3 divisible by 3

```r
# page numeber 24
red_dice <- 6
k <- 1:red_dice
divisible_by_3 <- k[k %% 3 == 0]
cat(paste(divisible_by_3, collapse = ","))
```

R code Exa 2.4 sum is 7

```r
# page number=24

red_dice <- 6
green_dice <- 6
dice_combinations <- expand.grid(red_die = 1:red_
    dice, green_die = 1:green_dice)
valid_combinations <- subset(dice_combinations, red_
    die + green_die == 7)
x_coord <- valid_combinations$red_die
y_coord <- valid_combinations$green_die
cat(paste("(", x_coord, ",", y_coord, ")", sep = "",
     collapse = ","))


plot(x_coord, y_coord, col = "blue", pch = 19, xlab
    = "Red die", ylab = "Green die")
```

R code Exa 2.5 hit the target once and miss it twice

```r
# page number = 25
combinations <- expand.grid(m = 2:1, n = 2:1, l =
    2:1)
all_hit <- subset(combinations, m == 1 & n == 1 & l
    == 1)
one_miss <- subset(combinations, (m == 2 & n == 1 &
    l == 1) | (m == 1 & n == 2 & l == 1) | (m == 1 &
    n == 1 & l == 2))
cat(paste("(", all_hit$m-1, ",", all_hit$n-1, ",",
    all_hit$l-1, ")", sep = "", collapse = ","))
if (nrow(one_miss) > 0) {
cat(paste("(", one_miss$m-1, ",", one_miss$n-1, ",",
     one_miss$l-1, ")", sep = "", collapse = ","))
}
```

R code Exa 2.7 union

```r
# page number 28
prob_A <- 0.12
prob_B <- 0.63
prob_C <- 0.45
prob_D <- -0.20
condition_one <- all(c(prob_A, prob_B, prob_C, prob_
    D) > 0)
condition_two <- sum(prob_A, prob_B, prob_C, prob_D)
     == 1
if(!condition_one){
  print("violates Postulate 1")
}
if(condition_two){
  print(" violates Postulate 2.")
}
```

R code Exa 2.8 atleast one head

```
# page number= 29
library(MASS)
prob_HH=1/4
prob_HT=1/4
prob_TH=1/4
probability=prob_HH+prob_HT+prob_TH
print(fractions(probability))
```

R code Exa 2.9 a number greater than 3

```
# page nummber= 30
library(MASS)
w= 1/9
s=c(1,2,1)
sum= w*sum(s)
print(fractions(sum))
```

R code Exa 2.10 a probability measure

```
# page number= 30
prob_0=1/2
sum=prob_0/(1-prob_0)
print(sum)
```

R code Exa 2.11 a full house

```
# page number 31
king_to_be_selected= 3
```

```
full_house_card=4
aces_to_be_selected=2
way_to_slct_king=choose(full_house_card,king_to_be_
    selected)
ways_to_selct_ace=choose(full_house_card,aces_to_be_
    selected)
total_cards_type1=13
n= total_cards_type1*(total_cards_type1-1)*way_to_
    slct_king*ways_to_selct_ace
total_ways_for5=choose(52,5)
prob= n/total_ways_for5
print(round(prob,4))
```

R code Exa 2.12 either or both kinds of sets

```
# page number =34
tv_set=0.86
hdtv_set=0.35
both_set=0.29
either_of_both=tv_set+hdtv_set-both_set
print(either_of_both)
```

R code Exa 2.13 faulty brakes

```
# page number = 34
faulty_breaks=0.23
badly_worn= 0.24
faulty_break_or_worn=0.38
both= faulty_breaks+badly_worn-faulty_break_or_worn
print(both)
```

R code Exa 2.14 dentist

```
# page number = 35
clean_teeth=0.44
cavity=0.24
extracted= 0.21
clean_filled=0.08
cleaned_extracted=0.11
filled_extracted=0.07
cleaned_filled_extracted=0.03
atleast_one_case= clean_teeth+cavity+extracted-clean_filled-cleaned_extracted-filled_extracted+cleaned_filled_extracted
print(atleast_one_case)
```

R code Exa 2.15 services under warranty

```
# page number= 37
good_sevice_under_warranty= c(16,10)
poor_service_under_warranty=c(4,20)
df=(data.frame(good_sevice_under_warranty,poor_service_under_warranty))
rownames(df)=c("In business 10 years or more","in business less than 10 years")

good_ser_provider= sum(df$good_sevice_under_warranty)
total_sum=0
for (i in colnames(df))
{
  total_sum= total_sum+colSums(df[i])
}

prob_good_service= good_ser_provider/total_sum
print(prob_good_service[[1]])
```

```

provider_more_then_10= rowSums(df['In business 10 years or more',])

value=df["In business 10 years or more","good_sevice_under_warranty"]
prob_good_service_with_10_years= value/provider_more_then_10
print(round(prob_good_service_with_10_years[[1]],2))
```

R code Exa 2.16 good service under warranty

```
# page number = 38
library(MASS)
good_sevice_under_warranty= c(16,10)
poor_service_under_warranty=c(4,20)
df=(data.frame(good_sevice_under_warranty,poor_service_under_warranty))
rownames(df)=c("In business 10 years or more","in business less than 10 years")
total_sum=0
total_sum = sum(sapply(df, sum))
less_then_10_good_ser=df["in business less than 10 years",'good_sevice_under_warranty']
prob_less_then_10_good_ser=less_then_10_good_ser/total_sum
print(prob_less_then_10_good_ser[[1]])
less_then_10= rowSums(df["in business less than 10 years",])
prob_less_then_10=less_then_10/total_sum
print(prob_less_then_10[[1]])

result= prob_less_then_10_good_ser/prob_less_then_10
print(fractions(result[[1]]))
```

R code Exa 2.17 perfect square given that it is greater than 3

```
# page number 39
library(MASS)
prob_odd=  2/9
prob_even= 1/9
prob_dice=c(2/9,1/9,2/9,1/9,2/9,1/9)
prob_B=prob_dice[1]+prob_dice[4]
prob_a_and_b= prob_dice[4]
prob_a=prob_dice[4]+prob_dice[5]+prob_dice[6]
prob_B_by_A=prob_a_and_b/prob_a
print(fractions(prob_B))
print(fractions(prob_B_by_A))
```

R code Exa 2.18 shipment

```
# page number 39
prob_R=0.8
prob_r_and_d=0.72
prob_d_by_r=prob_r_and_d/prob_R
print(prob_d_by_r)
```

R code Exa 2.19 both be defective

```
# page number= 40
library(MASS)
total_tv=240
no.defective.picked<- 2
total_defective=15
```

```
result= (total_defective/total_tv)*((total_defective
   -1)/(total_tv-1))
print(fractions(result))
```

R code Exa 2.20 replacement

```
# page number = 40
library(MASS)
total_cards= 52
no.of.drawn.cards=2
total_aces=4
result_without_replacement=1
result_without_replacement=(total_aces/total_cards)*
   ((total_aces-1)/(total_cards-1))
print(fractions(result_without_replacement))
result_with_replacement=(total_aces/total_cards)*(
   total_aces/total_cards)
print(fractions(result_with_replacement))
```

R code Exa 2.21 3 fuses are defective

```
# page number = 41
library(MASS)
fuses= 20
defective=5
selected= 3
prob_a=defective/fuses
prob_b_by_a=(defective-1)/(fuses-1)
prob_c_by_a_and_b=(defective-2)/(fuses-2)
result= prob_a*prob_b_by_a*prob_c_by_a_and_b
print(fractions(result))
```

R code Exa 2.22 independent

```
# page number= 42
prob_a=1/4
prob_b= 1/2
prob_c=3/8
prob_a_and_b=1/8
prob_b_and_c= 1/4
if(prob_a*prob_b==prob_a_and_b){
  print("event A and B are independent")
}
if(!(prob_b*prob_c==prob_b_and_c)){
  print("event B and C are not independent")
}
```

R code Exa 2.23 independent

```
# page number= 44
prob_a=1/2
prob_b= 1/2
prob_c=1/2
prob_a_and_b=1/4
prob_b_and_c= 1/4
prob_a_and_c=1/4
prob_a_b_c=1/4
if(prob_a*prob_b==prob_a_and_b)
{
  print("P(A)*P(B)=1/4=P( A  B )")
}

if(prob_a*prob_c==prob_a_and_c){
  print("P(A)*P(C)=1/4=P( A  C )")
```

```
}

if(prob_b*prob_c==prob_b_and_c){
  print("P(B)*P(C)=1/4=P( B  C )")
}

if(!(prob_a*prob_b*prob_c==prob_a_b_c)){
  print("P(A)*P(B)*P(C)=1/8   P ( A   B   C )")
}
```

R code Exa 2.24 heads and die

```
# page number = 45

library(MASS)
prob_of_head <- 1/2
tossed <- 3
dice_prob <- 1/6
result1 <- prob_of_head^tossed
result2 <- 5 * (dice_prob)^5
print(fractions(result1))
print(fractions(result2))
```

R code Exa 2.25 construction job

```
# page number = 45
prob_b=0.6
prob_a_given_b=0.35
prob_a_given_b_com=0.85
prob_a=prob_b*prob_a_given_b+(1-prob_b)*prob_a_given_b_com
print(prob_a)
```

R code Exa 2.26 oil change

```
# page number = 46
prob_b1=0.6
prob_b2=0.3
prob_b3=0.1
prob_a_given_b1=0.09
prob_a_given_b2=0.2
prob_a_given_b3= 0.06
prob_a= prob_b1*prob_a_given_b1+prob_b2*prob_a_given
    _b2+prob_b3*prob_a_given_b3
print(prob_a)
```

R code Exa 2.27 rental agency 2

```
# page number 47
prob_b1=0.6
prob_b2=0.3
prob_b3=0.1
prob_a_given_b1=0.09
prob_a_given_b2=0.2
prob_a_given_b3= 0.06
prob_b2_a= prob_b2*prob_a_given_b2/(prob_b1*prob_a_
    given_b1+prob_b2*prob_a_given_b2+prob_b3*prob_a_
    given_b3)
print(prob_b2_a)
```

R code Exa 2.28 disease

```
# page number = 48
prod_d=0.01
prod_p_d=0.98
prod_p_dcom=0.03
prod_dcom_p= (1-prod_d)*prod_p_dcom/(prod_d*prod_d
   +(1-prod_d)*prod_p_dcom)
print(round(prod_dcom_p,3))
```

R code Exa 2.29 reliability of the system

```
# page number = 51
relibility_CDE= 1-(1-0.70)^3
relibility_FG= 1-(1-0.75)^2
relibility_H= 0.90
relibility_a=0.95
relibility_b=0.99
result= relibility_a*relibility_b*relibility_CDE*
   relibility_FG*relibility_H
print(round(result,3))
```

Chapter 3

Probability Distributions and Probability Densities

R code Exa 3.1 brown socks selected

```
# page number 63
library(MASS)
total_brown <- 5
total_green <- 3

possible_outcomes <- expand.grid(sock1 = c("B", "G"),
                                 sock2 = c("B", "G"))

possible_outcomes$brown <- rowSums(possible_outcomes == "B")

probabilities <- table(possible_outcomes$brown) / nrow(possible_outcomes)

prob <- function(n) {
  (choose(total_brown, n)*factorial(n) * choose(total_green, 2 - n)*factorial(2-n) )/ (choose(
```

```
      total_brown + total_green, 2)*factorial(2))
}

print(paste("P(BB)=",fractions(prob(2))))
print(paste("P(BG)=",fractions(prob(1))))
print(paste("P(GB)=",fractions(prob(1))))
print(paste("P(GG)=",fractions(prob(0))))
```

R code Exa 3.2 number of heads

```
#page number= 63
library(MASS)
coin_tossed <- 4
possible_outcomes <- expand.grid(
  coin1 = c("H", "T"),
  coin2 = c("H", "T"),
  coin3 = c("H", "T"),
  coin4 = c("H", "T")
)
possible_outcomes$combined <- paste(
  possible_outcomes$coin1,
  possible_outcomes$coin2,
  possible_outcomes$coin3,
  possible_outcomes$coin4,
  sep = ""
)
possible_outcomes$sum_H <- rowSums(possible_outcomes
    == "H")
possible_outcomes$probability <- (1 / 16)
possible_outcomes$fraction_probability <- as.
   character(MASS::fractions(possible_outcomes$
   probability))
colnames(possible_outcomes)[5] <- "element of Sample
    Space"
colnames(possible_outcomes)[8] <- "Probability"
```

```
colnames(possible_outcomes)[6] <- "x"
print(possible_outcomes[, c(5, 8, 6)])
```

R code Exa 3.3 number of heads

```
# page number = 66
library(MASS)
coin_tossed <- 4
for( i in 0:coin_tossed)
{
  print(paste("P(X=",i,")=",fractions(choose(coin_tossed,i)/2^coin_tossed)))
  cat("\n")
}
```

R code Exa 3.4 probability distribution

```
# page number = 66

x=c(1,2,3,4,5)
fun= function(n)
{
  return ((n+2)/25)
}
result=fun(x[1])+fun(x[2])+fun(x[3])+fun(x[4])+fun(x[5])
print(result)
```

R code Exa 3.5 number of heads

```
# page number =69
library(MASS)
pdf=c(1/16,4/16,6/16,4/16,1/16)
sum=0
cdf=c()
for(i in pdf){
  cdf=c(cdf,sum)
  sum=sum+i

}
cdf=c(cdf,sum)
print(paste(fractions(cdf)))
```

R code Exa 3.6 distribution function

```
# page number 70
library(MASS)
f = c(3/28, 15/28, 5/14)
cdf = cumsum(f)
for (i in 1:3) {
  print(paste("F(X=", i-1, ")=", fractions(cdf[i])))
}
plot(x = c(0, 1), y = c(cdf[1], cdf[1]), type = "l",
    col = "black", xlim = c(0, 3), ylim = c(0, 1),
     main = "Cumulative Distribution Function", xlab
         = "X", ylab = "F(X)")
lines(x = c(1, 2), y = c(cdf[2], cdf[2]), type = "l"
   , col = "black")
lines(x = c(2, 3), y = c(cdf[3], cdf[3]), type = "l"
   , col = "black")
```

R code Exa 3.7 probability distribution

```r
# page number = 71
library(MASS)
f=c(0,1/36,3/36,6/36,10/36,15/36,21/36,26/36,30/36,33/36,35/36,1)
f1=c(f[1])
for (i in 2:length(f))
{
  sum=f[i]-f[i-1]
  f1=c(f1,sum)
}

for( i in 2:(length(f1)))
{
  print(paste("f(",i,")=",fractions(f1[i])))
}
```

R code Exa 3.9 Probability

```r
# page number 76

fun <- function(x) {
  return(exp(-3*x))
}

result <- integrate(fun, lower = 0, upper = Inf)

k = 1 / as.numeric(result$value)


print(k)

result<- integrate(fun,lower=0.5, upper= 1)
result=k*result$value
print(round(result,3))
```

R code Exa 3.10 distribution function

```
# page number = 78
f <- function(x) {
  exp(-3*x)
}

result <- integrate(f, lower = 0, upper = Inf)

k = 1 / as.numeric(result$value)


print(k)

result1<- integrate(f,lower=0, upper= 1)
result2<- integrate(f,lower=0,upper=0.5)
result=k*(result1$value-result2$value)
print(round(result,3))
```

R code Exa 3.12 Two caplets are selected

```
# page number = 82

caplets <- c(rep("Aspirin", 3), rep("Sedative", 2),
    rep("Laxative", 4))


combinations <- combn(caplets, 2)

count_table <- matrix(0, nrow = 3, ncol = 3,
    dimnames = list(0:2, 0:2))

```

```
for (i in 1:ncol(combinations)) {
  combination <- combinations[,i]
  X <- sum(combination=="Aspirin")
  Y <- sum(combination=="Sedative")
  count_table[X+1,Y+1]<-count_table[X+1,Y+1]+1
}

total_combinations <- ncol(combinations)
prob_table <- count_table / total_combinations
prob_table<- t(prob_table)

print(fractions(prob_table))
```

R code Exa 3.13 a joint probability distribution

```
# page number 83
library(MASS)
fun= function(x,y){
  return (x*y)}
var <- expand.grid(1:3,1:3)
sum=sum(fun(var[1],var[2]))
k=fractions(1/sum)
print(k)
```

R code Exa 3.14 find F

```
# page number = 84
library(MASS)
f=c(1/6,2/9,1/3,1/6)
print(fractions(sum(f)))
```

R code Exa 3.15 Probability

```
# page number= 85
library(MASS)
fun= function(x,y){
  return ((3/5)*x*(x+y))
}
result <-integrate(function(x) {sapply(x,function(x)
   {
    integrate(function(y) {
      fun(x,y)
    }, 0, 1-x)$value
  })}, 0, 1)$value
print(round(result,3))
print(fractions(result))
```

R code Exa 3.17 Probability

```
# page number= 87

f <- function(x, y) {
  return(exp(-x) * exp(-y))
}

x_lower <- 1
x_upper <- 3
y_lower <- 1
y_upper <- 2

P <- integrate(function(y) {
  sapply(y, function(y_val) {
```

```
      integrate(function(x) f(x, y_val), x_lower, x_upper)$value
    })
}, y_lower, y_upper)$value
print(round(P,4))
```

R code Exa 3.18 Probability

```
# page nummber =89
f <- function(x, y, z) {
  return((x + y) * z / 63)
}

P <- f(2, 1, 1) + f(2, 1, 2) + f(2, 2, 1)
print(fractions(P))
```

R code Exa 3.19 trivariate probability density

```
# page number 90
f <- function(x1, x2, x3) {
  return((x1 + x2) * exp(-x3))
}
result <- integrate(function(x3) {sapply(x3, function(x3){
  integrate(function(x2) {sapply(x2,function(x2){
    integrate(function(x1) {
      f(x1, x2, x3)
    }, 0, 1/2)$value
  })}, 1/2, 1)$value
})}, 0, 1)$value
cat(round(result,3))
```

R code Exa 3.23 conditional distribution

```
# page number = 95
f_0_1= 2/9
h_1=7/18
f_1_1=1/6
f_2_2=0

f0by1=f_0_1/h_1
f1by1=f_1_1/h_1
f2by2=f_2_2/h_1
print(fractions(f0by1))
print(fractions(f1by1))
print(fractions(f2by2))
```

R code Exa 3.24 conditional density

```
# page number = 96
fun_at_y= function(x){
  return ((2*x+2)/3)
}

result= integrate(fun_at_y,0,1/2)$value
fractions(result)
```

R code Exa 3.27 r joint probability density

```
# page number = 99

```

```
fun = function(x1,x2,x3){
  return (6*exp(-x1-2*x2-3*x3))
}
  result <- integrate(function(x3) {sapply(x3, function(x3){
    integrate(function(x2) {sapply(x2,function(x2){
      integrate(function(x1) {
        fun(x1, x2, x3)
      }, 0, 1-x2)$value
    })}, 0, 1)$value
  })}, 1, Inf)$value
print(round(result,3))
```

R code Exa 3.28 Construct a frequency distribution

```
#page number = 103

data <- c(4890, 4830, 5490, 4820, 5230, 4860, 5040, 5060, 4500, 5260,
          4610, 5100, 4730, 5250, 5540, 4910, 4430, 4850, 5040, 5000,
          4600, 4630, 5330, 5160, 4950, 4480, 5310, 4730, 4700, 4390,
          4710, 5160, 4970, 4710, 4430, 4260, 4890, 5110, 5030, 4850,
          4820, 4550, 4970, 4740, 4840, 4910, 5200, 4880, 5150, 4890,
          4900, 4990, 4570, 4790, 4480, 5060, 4340, 4830, 4670, 4750)

class_intervals <- seq(4200, 5600, by = 200)

binned_data <- cut(data, breaks = class_intervals, right = FALSE)

```

```r
frequency_table <- table(t(binned_data))
for (i in 1:length(frequency_table))
print(frequency_table[[i]])
print(sum(frequency_table))
```

R code Exa 3.29 frequency distribution

```r
#page number 104
# Given data
data <- c(5771, 5839, 5840, 5864, 5880, 5890, 5892,
   5902, 5908, 5912, 5914, 5918, 5924, 5926, 5928,
   5932, 5933, 5934, 5936, 5938, 5942, 5944, 5946,
   5948, 5950, 5952, 5954, 5956, 5958, 5960)

upper_limit= 4400
lower_limit= 4200
class_interval= upper_limit-lower_limit
print(class_interval)
```

R code Exa 3.30 a histogram

```r
#page number= 104
compressive_strengths <- c(19.8, 13.9, 30.4, 16.4,
   11.6, 36.9, 14.8, 21.1, 13.5, 5.8,
                            10.0, 17.1, 14.1, 16.6,
                               23.3, 12.1, 18.8,
                               10.4, 9.4, 23.8,
                            14.2, 26.7, 7.8, 22.9,
                               12.6, 6.8, 13.5, 10.7,
                                12.2, 27.7,
                            9.0, 14.9, 24.0, 12.0,
                               7.1, 12.8, 18.6, 26.0,
                                37.4, 13.3)
```

```


hist(compressive_strengths,
     xlab = "Histogram of solder-bond strengths",
     ylab = "Frequency",
     border = "black",
     breaks = 10)  # Adjust the number of breaks as
        needed
```

Chapter 4

Mathematical Expectation

R code Exa 4.1 expect

```
#page number= 114
library(MASS)
N <- 12
W <- 2
k <- 3
probs <- dhyper(0:2, W, N - W, k)
expected_value <- sum(0:2 * probs)
print(fractions(expected_value))
```

R code Exa 4.2 expected value

```
# page number= 115
fun <- function(x) {
  return (4*x / (pi * (1 + x^2)))
}
result <- integrate(fun, 0, 1)
print(round(result$value,4))
```

R code Exa 4.3 expected value

```
# page number=116
library(MASS)
fun <- function(x) {return ((2 * x * x + 1) / 6)}
sum <- sum(sapply(1:6, fun))
print(fractions(sum))
```

R code Exa 4.4 expected value

```
# page number = 116
fun= function(x){
  return (exp(3*x/4)*exp(-x))
}
result= integrate(fun,lower= 0,upper=100)
fractions(result$value)
```

R code Exa 4.5 expected value

```
# page number= 118
library(MASS)
e_x_square=91/6
sum=2*e_x_square+1
print(fractions(sum))
```

R code Exa 4.6 expected value

```r
# page number = 118
library(MASS)
fun <- function(r) {return (2 / ((r + 2) * (r + 1)))}
sum <- sum(4 * fun(c(2, 1))) + 1
print(fractions(sum))
```

R code Exa 4.8 expected value

```r
# page numeber = 120
library(MASS)
fun <- function(x, y) {return (x + y)}
f <- c(1/6, 2/9, 1/36, 1/3, 1/6, 1/12)
xy <- matrix(c(0, 0, 0, 1, 0, 2, 1, 0, 1, 1, 2, 0), ncol = 2, byrow = TRUE)
sum <- sum(apply(xy, 1, function(v) fun(v[1], v[2])) * f)
print(fractions(sum))
```

R code Exa 4.9 expected value

```r
# page number= 120
library(MASS)
fun <- function(x, y) {
  return ((2*x/(7*y^3)) * (x + 2 * y))
}

result <- integrate(function(y) {sapply(y, function(y) {
  integrate(function(x) {
    fun(x, y)
  }, 0, 1)$value
})}, 1, 2)$value
```

```
print(fractions(result))
```

R code Exa 4.10 calculate the variance

```
#page number =124
library(MASS)
prob_each_dice=1/6
x=c(1,2,3,4,5,6)
expect_x=prob_each_dice*(sum(x))
expect_x_square=prob_each_dice*sum(x^2)
var=expect_x_square-(expect_x)^2
fractions(var)
```

R code Exa 4.11 standard deviation

```
# page number= 124

expect_x=0.4413
fun <- function(x) {
  return ((4*x^2 / (pi * (1 + x^2))))
}
result <- integrate(fun, 0, 1)

result=round(result$value,4)
var=result-expect_x^2
var=round(var,4)
sd=sqrt(var)
print(round(sd,4))
```

R code Exa 4.12 Chebyshev theorem

```r
# page number 127
library(stats)
library(MASS)

f <- function(x) {
  ifelse(x > 0 & x < 1, 630 * x^4 * (1 - x)^4, 0)
}
mean_val <- integrate(function(x) x * f(x), 0, 1)$
   value
var_val <- integrate(function(x) (x - mean_val)^2 *
   f(x), 0, 1)$value
sd_val <- sqrt(var_val)
lower_bound <- mean_val - 2 * sd_val
upper_bound <- mean_val + 2 * sd_val
prob_within_interval <- integrate(f, lower_bound,
   upper_bound)$value
chebyshev_bound <- 1 - 1 / (2^2)
sprintf(paste(round(prob_within_interval,2)))
```

R code Exa 4.14 moment generating function

```r
# page number 129
library(MASS)
fun= function(x){
  return ((3*(1+exp(x))^2*exp(x))/8)
}
fun1= function(x){
  return ((3*(1+exp(x))*exp(2*x))/4)
}
moment1=fractions(fun(0))
moment2=fractions(fun1(0))+fractions(fun(0))
print(moment1)
print(moment2)
```

R code Exa 4.15 covariance of X and Y

```
# page number= 133
library(MASS)
p=matrix(c(1/6,1/3,1/12,2/9,1/6,0,1/36,0,0),nrow=3,
    ncol=3,byrow=TRUE)
fractions(colSums(p))
mu1_1=0
x_values=0:2
y_values=0:2
for (x in x_values) {
  for (y in y_values) {
    mu1_1 <- mu1_1 + x * y * p[x+1, y+1]
  }
}
print(fractions(mu1_1))
mu_x=fractions(sum(c(0:2)*colSums(p)))
mu_y=fractions(sum(c(0:2)*rowSums(p)))
print(mu_x)
print(mu_y)
sigma_xy=mu1_1-mu_x*mu_y
print(sigma_xy)
```

R code Exa 4.16 covariance

```
# page number = 133
library(cubature)
library(MASS)
nested_integrate <- function(outer_fun, inner_fun,
    lower_limit, upper_limit) {
  adaptIntegrate(function(x) {
```

```
    sapply(x, function(x_val) {
      adaptIntegrate(function(y) {
        inner_fun(x_val, y)
      }, lowerLimit = lower_limit(y), upperLimit =
         upper_limit(x_val))$integral
    })
  }, lowerLimit = lower_limit, upperLimit = upper_
     limit)$integral
}
fun1 <- function(x, y) { 2 * y }
fun2 <- function(x, y) { 2 * x }
fun3 <- function(x, y) { 2 * x * y }
lower_limit <- function(x) 0
upper_limit <- function(x) 1 - x
result1 <- nested_integrate(fun1, fun1, 0, 1)
result2 <- nested_integrate(fun2, fun2, 0, 1)
result3 <- nested_integrate(fun3, fun3, 0, 1)
print(fractions(result1))
print(fractions(result2))
print(fractions(result3))
final <- result3 - result1 * result2
print(fractions(final))
```

R code Exa 4.17 covariance

```
# page number = 135
joint_dist <- matrix(c(1/6, 1/3, 1/6, 0, 0, 0, 1/6,
   0, 1/6), nrow = 3, ncol = 3, byrow = TRUE)
sum <- sum(sapply(c(-1, 0, 1), function(i) {sum(
   sapply(c(-1, 0, 1), function(j) {(i * j) * joint_
   dist[i + 2, j + 2]}))}))
print(sum)
```

R code Exa 4.18 mean and the variance

```
# page number= 137
mu <- c(2, -3, 4)
var <- c(1, 5, 2)
cov <- c(-2, -1, 1)
expect <- sum(c(3, -1, 2) * mu)
variance <- sum(c(9, 1, 4) * var) + sum(c(-6, 12,
   -4) * cov)
print(expect)
print(variance)
```

R code Exa 4.19 covariance

```
# page number = 138
mu <- c(3, 5, 2)
var <- c(8, 12, 18)
cov <- c(1, -3, 2)
covariance <- sum(c(3, -4, -2) * var) + sum(c(11, 5,
    -6) * cov)
print(covariance)
```

R code Exa 4.20 conditional mean and the conditional variance

```
# page number  = 139
cond_x=function(x){
  return ((2/3)*x*(x+1))
}

cond_x_sq=function(x){
  return ((2/3)*x*x*(x+1))
}

```

```
expect_x=integrate(cond_x,0,1)$value
expect_x_sq=integrate(cond_x_sq,0,1)$value
var= expect_x_sq-expect_x^2
print(fractions(var))
```

R code Exa 4.21 mean length and its standard deviation

```
# page nummber = 142
obs= c
   (11.8,12.1,12.5,11.7,11.9,12.0,12.2,11.5,11.9,12.2)

s=sum(obs)
mean= mean(obs)
var=round(var(obs),3)
print(var)
print(round(var^(1/2),2))
print(mean)
```

Chapter 5

Special Probability Distributions

R code Exa 5.1 binomial distribution

```
# page number= 147
x=5
n=12
thita=1/2
result=dbinom(x, size=n, prob=thita)
print(round(result,2))
```

R code Exa 5.2 binomial distribution

```
# page number = 147
x=7
n=10
thita=0.8
result=dbinom(x, size=n, prob=thita)
print(round(result,2))
```

R code Exa 5.3 negative binomial distribution

```
# page number = 154
size <- 3
prob <- 0.40
failures <- 7
probability <- dnbinom(failures, size = size, prob =
    prob)
print(round(probability,4))
```

R code Exa 5.4 negative binomial distribution

```
# page number = 154
x <- 10
k <- 3
theta <- 0.40
binom_prob <- dbinom(k, size = x, prob = theta)
b_star <- (k / x) * binom_prob
print(round(b_star,4))
```

R code Exa 5.5 geometric distribution

```
#page number = 155
p <- 0.75
k <- 4
probability <- dgeom(k - 1, prob = p)
print(round(probability,4))
```

R code Exa 5.6 hypergeometric distribution

```
# page number = 156
x <- 0
m <- 4
n <- 20
k <- 6
probability <- dhyper(x, m, n, k)
print(round(probability,4))
```

R code Exa 5.7 hyper and binomial

```
# page number = 158
x_hyper <- 2
m_hyper <- 80
n_hyper <- 40
k_hyper <- 5
probability_hyper <- dhyper(x_hyper, m_hyper, n_
   hyper, k_hyper)
print(round(probability_hyper,3))
x_binom <- 2
n_binom <- 5
theta_binom <- 2/3
probability_binom <- dbinom(x_binom, size = n_binom,
    prob = theta_binom)
print(round(probability_binom,3))
```

R code Exa 5.8 Poisson distribution

```
# page number = 160
n <- 150
theta <- 0.05
lambda <- n * theta
```

```r
x_values <- 5:15
poisson_probs <- dpois(x_values, lambda)
binomial_probs <- dbinom(x_values, size = n, prob = theta)
errors <- poisson_probs - binomial_probs
max_error_index <- which.max(abs(errors))
x_max_error <- x_values[max_error_index]
max_error <- errors[max_error_index]
cat(round(max_error,4))
cat(x_max_error)
```

R code Exa 5.9 Poisson distribution

```r
# page number = 160

n <- 400
theta <- 0.02
lambda <- n * theta
x_values <- 5
poisson_probs <- dpois(x_values, lambda)
print(round(poisson_probs,3))
#- The answer may slightly vary due to rounding off values.
```

R code Exa 5.10 binomial probabilities

```r
# page number = 160
n <- 10000
theta <- 0.00005
lambda <- n * theta
x_a <- 2
prob_a <- dpois(x_a, lambda)
cat(round(prob_a,4))
```

```r
x_b <- c(0:2)
prob_b <- dpois(x_b, lambda)
print(sum(round( prob_b,4)))
```

R code Exa 5.11 Poisson distribution

```r
# page number = 162
cumulative_probs <- c
   (0.6065,0.3033,0.0758,0.0126,0.0016,0.0002)
print(cumulative_probs[3])
print(sum(cumulative_probs[c(1:3)]))
```

R code Exa 5.12 Poisson distribution

```r
# page number = 163
lambda <- 12
prob_less_than_9 <- ppois(8, lambda)
print(round(prob_less_than_9,4))
```

R code Exa 5.13 a Poisson distribution

```r
# page number = 164
lambda <- 7.5
x <- 5
prob_at_most_5 <- ppois(x, lambda)
prob_at_least_6 <- 1 - prob_at_most_5
cat(round(prob_at_least_6,4))
```

R code Exa 5.14 MULTINOMIAL DISTRIBUTION

```
# page number = 166
n <- 8
k <- c(5, 2, 1)
p <- c(0.50, 0.30, 0.20)
prob_multinomial <- factorial(n) / prod(factorial(k)
   ) * prod(p^k)
cat(prob_multinomial)
```

R code Exa 5.15 MULTINOMIAL DISTRIBUTION

```
# page number = 168
N1 <- c(6,3,7,4)
N <- sum(N1)
n <- 12
k <- c(4, 1, 5, 2)
result <- prod(choose(N1, k)) / choose(N, n)
print(round(result, 4))
```

R code Exa 5.16 producer and consumer risks

```
# page number = 171
p_AQL <- 0.05
p_LTPD <- 0.20
L_AQL <- 0.7358
L_LTPD <- 0.0692
producer_risk <- 1 - L_AQL
consumer_risk <- L_LTPD
cat(producer_risk)
cat(consumer_risk)

```

```
p <- c(0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35,
    0.40, 0.45)
L_p <- c(0.7358, 0.3917, 0.1756, 0.0692, 0.0243,
    0.0076, 0.0021, 0.0005, 0.0001)

plot(p, L_p, type = "o", col = "blue", xlab = "p",
    ylab = "L(p)",
     main = "Oc curve for example 16")
```

Chapter 6

Special Probability Densities

R code Exa 6.1 a Poisson distribution

```
# page number = 181
lambda <- 8.4
exponential_density <- function(x) {
  lambda * exp(-lambda * x)
}
upper_limit <- 5 / 30
result <- integrate(exponential_density, lower = 0,
   upper = upper_limit)
probability <- result$value
print(round(probability,2))
```

R code Exa 6.2 standard normal distribution

```
#page number = 188
prob_a <- pnorm(1.72)
prob_b <- pnorm(-0.88)
prob_c <- pnorm(1.75) - pnorm(1.30)
prob_d <- pnorm(0.45) - pnorm(-0.25)
```

```
cat("(a) P(Z < 1.72) =", round(prob_a,4), "\n")
cat("(b) P(Z < -0.88) =", round(prob_b,4), "\n")
cat("(c) P(1.30 < Z < 1.75) =", round(prob_c,4), "\n")
cat("(d) P(-0.25 < Z < 0.45) =", round(prob_d,4), "\n")
```

R code Exa 6.4 cosmic radiation

```
# page number = 190
mean_radiation <- 4.35
sd_radiation <- 0.59
threshold <- 5.20
z_score <- (threshold - mean_radiation) / sd_radiation
prob_more_than_threshold <- 1 - pnorm(z_score)
cat(round(prob_more_than_threshold,4))
#- The answer may slightly vary due to rounding off values.
```

R code Exa 6.5 chisquare distribution

```
# page number = 191
df <- 25
threshold <- 30
prob_chi_square <- 1 - pchisq(threshold, df)
cat(round(prob_chi_square,4))

mean_normal <- 18.7
sd_normal <- 9.1
lower <- 10.6
upper <- 24.8
```

```r
prob_normal_lower <- pnorm(lower, mean_normal, sd_normal)
prob_normal_upper <- pnorm(upper, mean_normal, sd_normal)
prob_normal_between <- prob_normal_upper - prob_normal_lower
cat(round(prob_normal_between,4))
```

R code Exa 6.6 binomial distribution

```r
# page number = 193
n <- 16
p <- 0.5
k <- 6
mean_binomial <- n * p
sd_binomial <- sqrt(n * p * (1 - p))
z_lower <- (k-(1/2) - mean_binomial) / sd_binomial
z_upper <- ((k + (1/2)) - mean_binomial) / sd_binomial
prob_normal_approx <- pnorm(z_upper) - pnorm(z_lower)
cat(round(prob_normal_approx,4))
```

R code Exa 6.7 normal scores

```r
# page number = 199

observations <- c(3, 2, 7, 4, 3, 5)
ordered_observations <- sort(observations)
n <- length(ordered_observations)
normal_scores <- round(qnorm((1:n) / (n + 1)),2)
data <- data.frame(Ordered_Observations = ordered_observations, Normal_Scores = normal_scores)
```

```r
print(data)
#-- The answer may slightly vary due to rounding off values.
```

R code Exa 6.8 normality

```r
# page number = 200
original_data <- c(54.9, 8.3, 5.2, 32.4, 15.5)
print(original_data)
normal_scores <- c(-0.95, -0.44, 0, 0.44, 0.95)
ordered_original_data <- sort(original_data)
plot(normal_scores, ordered_original_data, xlab = "Normal Scores", ylab = "Ordered Observations", main = "Normal-Scores Plot for Original Data")
abline(lm(ordered_original_data ~ normal_scores), col = "red")
shapiro_test_original <- shapiro.test(original_data)
shapiro_test_original
transformed_data <- log10(original_data)
ordered_transformed_data <- sort(transformed_data)
plot(normal_scores, ordered_transformed_data, xlab = "Normal Scores", ylab = "Ordered Log-Transformed Observations", main = "Normal-Scores Plot for Transformed Data")
abline(lm(ordered_transformed_data ~ normal_scores), col = "red")
shapiro_test_transformed <- shapiro.test(transformed_data)
shapiro_test_transformed
```

Chapter 7

Functions of Random Variables

R code Exa 7.4 probability distribution

```
# page number = 211
library(MASS)
n <- 4
p <- 0.5
x_values <- 0:n
x_probabilities <- dbinom(x_values, size = n, prob =
    p)
x_probabilities=fractions(x_probabilities)
y_values <- 1 / (1 + x_values)
probability_distribution <- data.frame(
  X = fractions(x_values),
  P_X = fractions(x_probabilities),
  Y = y_values
)
print((probability_distribution))
#— The answer may vary due to difference in
   representation
```

R code Exa 7.5 probability distribution

```
# page number = 212
n <- 4
p <- 0.5
x_values <- 0:n
x_probabilities <- dbinom(x_values, size = n, prob =
    p)
z_values <- (x_values - 2)^2
z_probabilities <- rep(0, max(z_values) + 1)
for (i in seq_along(z_values)) {
  z_probabilities[z_values[i] + 1] <- z_
     probabilities[z_values[i] + 1] + x_
     probabilities[i]
}
probability_distribution_Z <- data.frame(
  Z = seq_along(z_probabilities) - 1,
  P_Z = z_probabilities
)
print(probability_distribution_Z)
```

R code Exa 7.11 probability density

```
# page number = 219
fun = function(u){
  return ((u)*exp(-u))
}
result=integrate(fun,0,Inf )$value
print(result)
```

R code Exa 7.12 marginal density

```
# page number = 221
fun = function(y1){
  return ((y1)*exp(-y1))
```

```
}

result=integrate(fun,0,Inf )$value
print(result)
```

R code Exa 7.19 probability

```
# page number = 230
lambda <- 5
n <- 2
gamma_cdf <- function(x, alpha, beta) {
  pgamma(x, shape = alpha, rate = beta)
}
prob_T_leq_3 <- gamma_cdf(3, alpha = n, beta = 1/
    lambda)


cat("P(T <= 3) =", prob_T_leq_3, "\n")
#- The answer may vary due to difference in
    representation
```

Chapter 8

Sampling Distributions

R code Exa 8.1 central limit theorem

```
#page number = 238
mean_dispensed <- 200
sd_dispensed <- 15
sample_size <- 36
sample_mean_threshold <- 204
sd_sample_mean <- sd_dispensed / sqrt(sample_size)
z_score <- (sample_mean_threshold - mean_dispensed)
    / sd_sample_mean
cumulative_prob <- pnorm(z_score)
prob_at_least_threshold <- 1 - cumulative_prob
cat(round(prob_at_least_threshold,4))
```

R code Exa 8.2 Chisquare distribution

```
# page number = 245
n <- 20
sigma <- 0.60
s <- 0.84
```

```
alpha <- 0.01
test_statistic <- (n - 1) * (s^2) / (sigma^2)
cat(test_statistic)
critical_value <- qchisq(1 - alpha, df = n - 1)
cat(round(critical_value,3))
if (test_statistic > critical_value) {
  cat("The process is declared out of control.\n")
} else {
  cat("The process is in control.\n")
}
```

R code Exa 8.3 t distribution

```
# page number = 248
n <- 16
mu_hypothesis <- 12.0
x_bar <- 16.4
s <- 2.1
t_statistic <- (x_bar - mu_hypothesis) / (s / sqrt(n
  ))
df <- n - 1
p_value <- 1 - pt(t_statistic, df)
cat(round(t_statistic,2))
cat(df)
cat(p_value)
alpha <- 0.05
if (p_value < alpha) {
  cat("Reject the null hypothesis\n")
} else {
  cat("Fail to reject the null hypothesis: There is
      not enough evidence to conclude that the true
      average hourly gasoline consumption exceeds
      12.0 gallons.\n")
}
```

Chapter 9

Decision Theory

R code Exa 9.1 deciding

```
# page nummber =261
prob_recession <- 2 / 3
prob_good <- 1 / 3


profit_expand_good <- 164000
loss_expand_recession <- -40000
profit_wait_good <- 80000
profit_wait_recession <- 8000
expected_profit_expand <- (profit_expand_good * prob_good) + (loss_expand_recession * prob_recession)
expected_profit_wait <- (profit_wait_good * prob_good) + (profit_wait_recession * prob_recession)
cat(expected_profit_expand)
cat(expected_profit_wait)
if (expected_profit_expand > expected_profit_wait) {
  cat("Decision: Expand now\n")
} else {
  cat("Decision: Wait at least another year\n")
}
```

R code Exa 9.2 decide

```r
# page number = 262
profit_expand_good <- 164000
loss_expand_recession <- -40000
profit_wait_good <- 80000
profit_wait_recession <- 8000

min_profit_expand <- loss_expand_recession
min_profit_wait <- profit_wait_recession

cat(min_profit_expand, "\n")
cat(min_profit_wait, "\n")

if (min_profit_expand > min_profit_wait) {
  cat("Decision: Expand now\n")
} else {
  cat("Decision: Wait another year\n")
}
```

R code Exa 9.3 PAYOFF MATRIX

```r
# page number = 264
payoff_matrix <- matrix(c(7, -4, 8, 10), nrow = 2,
    byrow = TRUE)
rownames(payoff_matrix) <- c("A_I", "A_II")
colnames(payoff_matrix) <- c("B_1", "B_2")
print(payoff_matrix)

reduced_matrix <- payoff_matrix[, "B_2", drop =
    FALSE]
```

```
optimal_strategy_A <- rownames(reduced_matrix)[which.min(reduced_matrix)]
value_of_game <- min(reduced_matrix)

cat("Player A's optimal strategy:", optimal_strategy_A, "\n")
cat("Player B's optimal strategy: B_2\n")
cat("Value of the game:", value_of_game, "\n")
```

R code Exa 9.4 optimum strategies

```
# page number = 264
payoff_matrix <- matrix(c(-4, 1, 7, 4, 3, 5), nrow = 2, byrow = TRUE)
rownames(payoff_matrix) <- c("A_I", "A_II")
colnames(payoff_matrix) <- c("B_1", "B_2", "B_3")
reduced_matrix <- payoff_matrix[, c("B_1", "B_2")]
print("Reduced matrix after removing dominated strategies for Player A:")
print(reduced_matrix)
final_matrix <- reduced_matrix[, "B_2", drop = FALSE]
print("Final matrix after removing dominated strategies for Player B:")
print(final_matrix)
optimal_strategy_A <- rownames(final_matrix)[which.min(final_matrix)]
value_of_game <- min(final_matrix)
cat("Player A's optimal strategy:", optimal_strategy_A, "\n")
cat("Player B's optimal strategy: B_2\n")
cat("Value of the game:", value_of_game, "\n")
```

R code Exa 9.5 minimax strategies

```
payoff_matrix <- matrix(c(8, -5, 2, 6), nrow = 2, byrow = TRUE)
rownames(payoff_matrix) <- c("A_I", "A_II")
colnames(payoff_matrix) <- c("B_1", "B_2")

max_losses_A <- apply(payoff_matrix, 1, max)
minimax_strategy_A <- which.min(max_losses_A)

max_gains_B <- apply(payoff_matrix, 2, max)
minimax_strategy_B <- which.min(max_gains_B)

cat("Player A's minimax strategy:", rownames(payoff_matrix)[minimax_strategy_A], "\n")
cat("Player B's minimax strategy:", colnames(payoff_matrix)[minimax_strategy_B], "\n")

if (minimax_strategy_A == 2 && minimax_strategy_B == 2) {
  cat("Player A switches to Strategy I, reducing loss to 2.\n")
  cat("Player B switches to Strategy 1, increasing gain to 8.\n")
}
```

Chapter 10

Point Estimation

R code Exa 10.19 binomial trials

```
# page number = 308
x <- 42
n <- 120
alpha_prior <- 40
beta_prior <- 40
alpha_posterior <- alpha_prior + x
beta_posterior <- beta_prior + (n - x)
posterior_mean <- alpha_posterior / (alpha_posterior
    + beta_posterior)
cat(posterior_mean)
thita= x/n
print(thita)
```

R code Exa 10.20 soft drink vending machines

```
# page number = 309
mu1 <- 715
sigma1 <- 9.5
```

```
lower_bound <- 700
upper_bound <- 720
z_low <- (lower_bound - mu1) / sigma1
z_up <- (upper_bound - mu1) / sigma1
p_low <- pnorm(z_low)
p_up <- pnorm(z_up)
probability <- p_up - p_low
cat(mu1)
cat(sigma1)
cat(round(z_low,2))
cat(round(z_up,2))
cat(round(probability,3))
```

R code Exa 10.21 voters

```
# page number = 311
z_alpa_by_2=1.96
E=0.03

n= z_alpa_by_2^2/(4*E^2)
print(ceiling(n))
```

Chapter 11

Interval Estimation

R code Exa 11.1 efficiency experts

```
# page number=  318

n <- 150
sigma <- 6.2
z_value <- 2.575

max_error <- z_value * sigma / sqrt(n)

cat(round(max_error,2))
```

R code Exa 11.2 confidence interval

```
# page number= 319
n <- 20
x_bar <- 64.3
sigma <- 15
z_value <- 1.96
margin_of_error <- z_value * sigma / sqrt(n)
```

```
lower_bound <- x_bar - margin_of_error
upper_bound <- x_bar + margin_of_error

cat(round(lower_bound,1), "<    <",round(upper_bound
   ,1))
```

R code Exa 11.3 confidence interval

```
# page number = 320
data <- c(17, 13, 18, 19, 17, 21, 29, 22, 16, 28,
   21, 15,
          26, 23, 24, 20, 8, 17, 17, 21, 32, 18, 25,
              22,
          16, 10, 20, 22, 19, 14, 30, 22, 12, 24,
             28, 11)
conf_interval <- t.test(data)$conf.int
cat(round(conf_interval[1], 2))
cat(round(conf_interval[2], 2))

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

R code Exa 11.4 paint manufacturer

```
# page number = 321
x_bar <- 66.3
s <- 8.4
n <- 12
t_value <- 2.201
margin_of_error <- t_value * s / sqrt(n)
lower_bound <- x_bar - margin_of_error
upper_bound <- x_bar + margin_of_error
```

```
cat(round(lower_bound,1))
cat(round(upper_bound,1))
```

R code Exa 11.5 confidence interval

```
# page number = 322
x1_bar <- 418
x2_bar <- 402
n1 <- 40
n2 <- 50
sigma1 <- 26
sigma2 <- 22
z_value <- 1.88
se_diff <- sqrt((sigma1^2 / n1) + (sigma2^2 / n2))
margin_of_error <- z_value * se_diff
difference_means <- x1_bar - x2_bar
lower_bound <- difference_means - margin_of_error
upper_bound <- difference_means + margin_of_error
cat(round(lower_bound,1))
cat(round(upper_bound,1))
```

R code Exa 11.6 two brands of cigarettes

```
# page number= 324
n1 <- 10
n2 <- 8
x1_bar <- 3.1
x2_bar <- 2.7
s1 <- 0.5
s2 <- 0.7
t_value <- 2.120

se_diff <- sqrt(s1^2 / n1 + s2^2 / n2)
```

```
margin_of_error <- t_value * se_diff

cat(round(x1_bar - x2_bar - margin_of_error, 1), "\n
  ", round(x1_bar - x2_bar + margin_of_error, 1))
```

R code Exa 11.7 a flu vaccine experienced

```
# page number = 326
n <- 400
x <- 136
confidence_level <- 0.95

binom_result <- binom.test(x, n, conf.level =
  confidence_level)

cat( round(binom_result$conf.int[1], 2), "\n")
cat(round(binom_result$conf.int[2], 2))
```

R code Exa 11.8 voters

```
# page number = 327
n <- 400
x <- 140
confidence_level <- 0.99
binom_result <- binom.test(x, n, conf.level =
  confidence_level)
cat(round(binom_result$conf.int[2] - p_hat, 2))
```

R code Exa 11.9 running for governor of Illinois

```
# page number = 328

n1 <- 200
n2 <- 150
x1 <- 132
x2 <- 90
confidence_level <- 0.99
prop_result <- prop.test(c(x1, x2), c(n1, n2), conf.
   level = confidence_level)
cat("Confidence interval for (p1 - p2):", round(prop
   _result$conf.int[1], 3), "to", round(prop_result$
   conf.int[2], 3))
#- The answer may slightly vary due to rounding off
   values.
```

R code Exa 11.10 gasoline consumption

```
# page number = 330
n <- 16
s <- 2.2
chi_sq_low <- 4.601
chi_sq_high <- 32.801
lower_bound <- (n - 1) * (s^2) / chi_sq_high
upper_bound <- (n - 1) * (s^2) / chi_sq_low
cat(round(lower_bound,2), "<  2 < ", round(upper_
   bound,2))
```

R code Exa 11.11 confidence interval

```
# page number = 331
n1 <- 10
n2 <- 8
s1 <- 0.5
```

```r
s2 <- 0.7
f0.01_9_7 <- 6.72
f0.01_7_9 <- 5.61
lower_bound <- (s1^2 / s2^2) / f0.01_9_7
upper_bound <- (s1^2 / s2^2) * f0.01_7_9
cat(round(lower_bound,3), " <  2^2/ 2^2< ", round(
    upper_bound,3))
```

R code Exa 11.12 car crossings

```r
# page number = 332
car_crossings <- c(142600, 167800, 136500, 108300,
    126400, 133700, 162000, 149400)
sample_mean <- mean(car_crossings)
sample_sd <- sd(car_crossings)
n <- length(car_crossings)
confidence_level <- 0.95
t_critical <- qt((1 + confidence_level) / 2, df = n
    - 1)
standard_error <- sample_sd / sqrt(n)
margin_of_error <- t_critical * standard_error
lower_bound <- sample_mean - margin_of_error
upper_bound <- sample_mean + margin_of_error
cat((lower_bound), ", ", upper_bound)
#- The answer provided in the textbook is wrong.
```

Chapter 12

Hypothesis Testing

R code Exa 12.1 new medication

```
# page number = 339
n <- 20
theta_0 <- 0.90
theta_1 <- 0.60
critical_value <- 14
alpha <- pbinom(critical_value, n, theta_0, lower.
    tail = TRUE)
beta <- pbinom(critical_value, n, theta_1, lower.
    tail = FALSE)
cat(round(alpha,4))
cat(round(beta,4))
#- The answer may slightly vary due to rounding off
    values.
```

R code Exa 12.7 likelihood ratio technique

```
# page number= 353
library(MASS)
```

```
f_x <- c(1/12, 1/12, 1/12, 1/4, 1/6, 1/6, 1/6)
g_x <- c(1/3, 1/3, 1/3, 2/3, 0, 0, 0)
x_values <- 1:7
lambda <- ifelse(g_x != 0, f_x / g_x, 1)
cat("Lambda values for each x:\n")
data.frame(x = x_values, lambda = lambda)
critical_region_lrt <- x_values[lambda == 1/4]
alpha_lrt <- sum(f_x[critical_region_lrt])
beta_lrt <- sum(g_x[c(4,5,6)])
print(fractions(beta_lrt))
critical_region_alt <- c(4)
cat(critical_region_alt)
alpha_alt <- sum(f_x[c(4)])
print(fractions(alpha_alt))
beta_alt <- sum(g_x[c(1,2,3)])
if(beta_lrt>alpha_lrt){
cat("null hypothesis is rejected")
}
```

Chapter 13

Tests of Hypothesis Involving Means Variances and Proportions

R code Exa 13.1 packages of cookies

```
# page number = 364
x_bar <- 8.091
mu_0 <- 8
sigma <- 0.16
n <- 25
alpha <- 0.01
z <- (x_bar - mu_0) / (sigma / sqrt(n))
z_critical_lower <- qnorm(alpha / 2)
z_critical_upper <- qnorm(1 - alpha / 2)
cat(round(z,2))
cat(round(z_critical_lower,3))
cat(round(z_critical_upper,3))
if (z < z_critical_lower || z > z_critical_upper) {
  cat(" the null hypothesis must be rejected \n")
} else {
  cat("Fail to reject the null hypothesis\n")
}
```

R code Exa 13.2 high performance tires

```r
# page number= 365
x_bar <- 21819
mu_0 <- 22000
sigma <- 1295
n <- 100
alpha <- 0.05
z <- (x_bar - mu_0) / (sigma / sqrt(n))
z_critical <- qnorm(alpha)
cat("Test Statistic (z):", round(z,1), "\n")
cat("Critical Value:", round(z_critical,3), "\n")
if (z < z_critical) {
  cat("Reject the null hypothesis.")
} else {
  cat("Fail to reject the null hypothesis.")
}
```

R code Exa 13.3 ribbon call

```r
# page number= 365
sample_data <- c(171.6, 191.8, 178.3, 184.9, 189.1)
    # sample breaking strengths
mu_0 <- 185
alpha <- 0.05
sample_mean <- mean(sample_data)
sample_sd <- sd(sample_data)
n <- length(sample_data)
t_statistic <- (sample_mean - mu_0) / (sample_sd /
   sqrt(n))
critical_value <- qt(alpha, df = n - 1)
```

```
p_value <- pt(t_statistic, df = n - 1)
cat(round(t_statistic,2))
if (t_statistic < critical_value) {
  cat("Reject the null hypothesis\n")
} else {
  cat("the null hypothesis cannot be rejected\n")
}
```

R code Exa 13.4 nicotine

```
# page number = 367
x <- c(2.61,2.38)
s <- c(0.12,0.14)
n <- c(50,40)
delta <- 0.20
z <- (x[1] - x[2] - delta) / sqrt((s[1]^2 / n[1]) + (s[2]^2 / n[2]))
p_value <- 1 - pnorm(z)
cat(round(z,2))
alpha <- 0.05
if (p_value < alpha) {
  cat("Reject the null hypothesis.\n")
} else {
  cat("Fail to reject the null hypothesis.\n")
}
```

R code Exa 13.5 consumer testing service

```
# page number = 368
x <- c(546,492)
s <- c(31,26)
n <- c(4,4)

```

```
sp <- sqrt(((n[1]- 1) * s[1]^2 + (n[2] - 1) * s
   [2]^2) / (n[1] + n[2] - 2))
t <- (x[1] - x[2]) / (sp * sqrt(1/n[1] + 1/n[2]))
critical_value <- qt(0.95, df = n[1] + n[2] - 2)
cat(round(sp,3))
cat(round(t,2))
if (t > critical_value) {
  "reject null hypothesis."
} else {
  "Fail to reject null hypothesis"
}
```

R code Exa 13.6 a semiconductor

```
# page number = 370
s2 <- 0.68
sigma0 <- 0.36
n <- 18
chi_square <- (n - 1) * s2 / sigma0
print(round(chi_square,2))
critical_value <- qchisq(0.05, df = n - 1)
if (chi_square > critical_value) {
  "Reject null hypothesis"
} else {
  "Fail to reject null hypothesis"
}
```

R code Exa 13.7 structural steel

```
# page numebr= 371
s_squared <- c(19.2,3.5)
alpha <- 0.02
F_statistic <- s_squared[1] / s_squared[2]
```

```r
critical_value <- qf(1 - alpha, df1 = 12, df2 = 15)
cat(round(F_statistic, 2))
if (F_statistic > critical_value) {
  "Reject null hypothesis"
} else {
  "Fail to Reject null hypothesis"
}
```

R code Exa 13.8 patients suffering

```r
# page number = 373
x <- 4
n <- 20
alpha <- 0.05
theta_hat <- x / n
p_value <- 2*pbinom(x, size = n, prob = 0.5, lower.tail = TRUE)
cat("P-value:", round(p_value,4), "\n")
if (p_value < alpha) {
  cat("Reject the null hypothesis")
} else {
  cat("Fail to reject the null hypothesis")
}
```

R code Exa 13.9 oil company claims

```r
# page number = 374
x <- 22
n <- 200
theta0 <- 0.20
alpha <- 0.01
theta_hat <- x / n
```

```
z <- (x - n * theta0) / sqrt(n * theta0 * (1 -
   theta0))
cat(round(z,2))
p_value <- pnorm(z, lower.tail = TRUE)
if (p_value < alpha) {
  cat("Reject the null hypothesis.\n")
} else {
  cat("Fail to reject the null hypothesis.\n")
}
```

R code Exa 13.10 shoppers favoring detergent

```
# page number= 376
observed <- matrix(c(232, 168, 260, 240, 197, 203),
   nrow = 3, byrow = TRUE,
                   dimnames = list(c("Los Angeles",
                     "San Diego", "Fresno"),
                                   c("Detergent A",
                                     "Detergent B")
                                     ))
chi_square_test <- chisq.test(observed)
cat(round(chi_square_test$statistic, 2), "\n")
cat(round(qchisq(0.95, chi_square_test$parameter),
   3), "\n")

if (chi_square_test$p.value < 0.05) {
  cat("Reject the null hypothesis\n")
} else {
  cat("Fail to reject the null hypothesis\n")
}
#- The answer may slightly vary due to rounding off
   values.
```

R code Exa 13.11 persons ability

```
# page numeber= 380
observed <- matrix(c(63, 42, 15, 58, 61, 31, 14, 47,
    29), nrow = 3, byrow = TRUE,
                   dimnames = list(c("Low", "Average
                     ", "High"),
                                   c("Low", "Average
                                     ", "High")))
chi_square <- chisq.test(observed)$statistic
df <- chisq.test(observed)$parameter
critical_value <- qchisq(0.99, df)
cat(round(chi_square,2))
if (chi_square > critical_value) {
  cat("Reject the null hypothesis")
} else {
  cat("Fail to reject the null hypothesis")
}
```

R code Exa 13.12 a Poisson distribution

```
# page number = 382
observed <- c(18, 53, 103, 107, 82, 46, 18, 10, 3)
expected <- c(21.9, 65.7, 98.6, 98.6, 73.9, 44.4,
   22.2, 9.5, 5.3)
chi_square <- sum((observed - expected)^2 / expected
   )
df <- length(observed) - 2
critical_value <- qchisq(0.95, df)
cat(round(chi_square,2))
if (chi_square > critical_value) {
  cat("Reject the null hypothesis. \n")
} else {
  cat(" the null hypothesis cannot be rejected.\n")
}
```

R code Exa 13.13 measurements of the heat producing capacity

```
# page number = 382
mine1 <- c(8400, 8230, 8380, 7860, 7930)
mine2 <- c(7510, 7690, 7720, 8070, 7660)
t_test_result <- t.test(mine1, mine2, var.equal = TRUE)
print(t_test_result)
```

Chapter 14

Regression and Correlation

R code Exa 14.4 equation of the least squares line

```
# page number = 400
x <- c(4, 9, 10, 14, 4, 7, 12, 22, 1, 17)
y <- c(31, 58, 65, 73, 37, 44, 60, 91, 21, 84)
model <- lm(y ~ x)
alpha_hat <- coef(model)[1]
beta_hat <- coef(model)[2]
cat("y =", round(alpha_hat, 2), "+", round(beta_hat,
    3), "x\n")
x_new <- 14
y_hat <- predict(model, newdata = data.frame(x = x_
   new))
cat(floor(y_hat))
```

R code Exa 14.5 amount of time that 10 persons studied

```
# page number = 404

x <- c(4, 9, 10, 14, 4, 7, 12, 22, 1, 17)
```

```
y <- c(31, 58, 65, 73, 37, 44, 60, 91, 21, 84)
model <- lm(y ~ x)
summary_model <- summary(model)
beta_hat <- coef(model)[2]
se_beta_hat <- summary_model$coefficients[2, "Std. Error"]
beta_null <- 3
t_stat <- (beta_hat - beta_null) / se_beta_hat
alpha <- 0.01
df <- summary_model$df[2]
t_critical <- qt(1 - alpha, df)
cat(round(t_stat,2), "\n")
if (t_stat > t_critical) {
  cat("Reject the null hypothesis")
} else {
  cat("Fail to reject the null hypothesis")
}
```

R code Exa 14.6 confidence interval

```
# page number - 405
x <- c(4, 9, 10, 14, 4, 7, 12, 22, 1, 17)
y <- c(31, 58, 65, 73, 37, 44, 60, 91, 21, 84)
model <- lm(y ~ x)
conf_interval <- confint(model, level = 0.95)
lhs <- conf_interval["x", "2.5 %"]
rhs <- conf_interval["x", "97.5 %"]
cat(round(lhs, 2), "<   <", round(rhs, 2))
```

R code Exa 14.7 complete a certain form

```
# page number = 410

```

```
x <- c(8.2, 9.6, 7.0, 9.4, 10.9, 7.1, 9.0, 6.6, 8.4,
    10.5)
y <- c(8.7, 9.6, 6.9, 8.5, 11.3, 7.6, 9.2, 6.3, 8.4,
    12.3)
r <- cor(x, y)
cat(round(r, 3))
plot(x, y, xlim = c(0, 14), ylim = c(0, 14), xlab =
   "Morning", ylab = "Afternoon")
abline(a = 0, b = 1)  # Adds a line y = x to the
   plot
```

R code Exa 14.8 complete a certain form

```
# page number = 411
n=10
r=0.936
critical= 2.575
z=sqrt((n-3))/2*log((r+1)/(1-r))
cat(round(z,1))
if(z>critical)
{
  cat("null hypothesis rejected")
}
```

R code Exa 14.9 onefamily houses sold

```
# page number = 414
bedrooms <- c(3, 2, 4, 2, 3, 2, 5, 4)
baths <- c(2, 1, 3, 1, 2, 2, 3, 2)
price <- c(292000, 264600, 317500, 265500, 302000,
   275500, 333000, 307500)
housing_data <- data.frame(bedrooms, baths, price)
```

```
model <- lm(price ~ bedrooms + baths, data = housing_data)
coefficients <- coef(model)
intercept <- coefficients[1]
bedrooms_coef <- coefficients[2]
baths_coef <- coefficients[3]
cat("y^cap =", round(intercept,0), "+", round(bedrooms_coef,0), " x1 +", round(baths_coef,0)," x2\n")
```

R code Exa 14.10 sales price of a threebedroom

```
# page number= 414
intercept= 224929
bedroom_coef=15314
bathroom_coef= 10957
x1=3
x2=2
result= intercept+bedrooms_coef*x1+bathroom_coef*x2
cat(floor(result))
```

R code Exa 14.11 least squares estimates

```
# page number = 417
bedrooms <- c(3, 2, 4, 2, 3, 2, 5, 4)
baths <- c(2, 1, 3, 1, 2, 2, 3, 2)
price <- c(292000, 264600, 317500, 265500, 302000, 275500, 333000, 307500)
housing_data <- data.frame(bedrooms, baths, price)
model <- lm(price ~ bedrooms + baths, data = housing_data)
coefficients <- coef(model)
intercept <- coefficients[1]
```

```
bedrooms_coef <- coefficients[2]
baths_coef <- coefficients[3]
cat("y^cap =", round(intercept,0), "+", round(
    bedrooms_coef,0), " x1 +", round(baths_coef,0),"
    x2\n")
```

R code Exa 14.12 least squares estimates

```
# page number = 414
y <- c(292000, 264600, 317500, 265500, 302000,
    275500, 333000, 307500)
Y= sum(y^2)
x=matrix(c(224929,15314,10957),nrow=1)
y=matrix(c(637000,7558200,4835600),ncol=1)
dim(y)
result= x%*%y
sigma=sqrt((Y-result)/8)
cat(round(sigma,0))
#− The answer provided in the textbook is wrong.
```

R code Exa 14.13 least squares estimates using hypothesis

```
# page number =419
critical= 2.015
bita_cap= 15314
bita=9500
c11=32/84
n=8
sigma= 3546
t=(bita_cap-bita)/(sigma*sqrt(n*c11/5))
cat(round(t,3))
if(critical<t)
{
```

```
  cat("null hypothesis must be rejected")
}
#— The answer provided in the textbook is wrong.
```