MAST30025 Week 8 Lab Q5 R Code

#Question 5

#Part a: Use the read.csv function to read the data. Then convert the type component into a factor

setwd("~/Desktop/UNIMELB 2021 Material/UNIMELB S1 2021 (Currently)/MAST30025/Tutorials /Tutorials/Rfile/data")  
filters = read.csv("filters.csv")  
  
#More to add how to convert into a factor! #Slide 63 Less than full rank model!  
filters$type = factor(filters$type)

#Part b: Construct X and y matrices for this linear model!

#Attempt 1  
  
#y matrix  
y = filters$life  
  
#X matrix  
n = dim(filters)  
k = length(levels(filters$type))  
X = matrix(0,n,k+1)  
#Add all ones in the first column  
X[,1] = 1  
#Add all ones for each tao factor  
  
#2nd column  
X[filters$type==1,2] = 1  
#3rd column  
X[filters$type==2,3] = 1  
#4th column  
X[filters$type==3,4] = 1  
#5th column  
X[filters$type==4,5] = 1  
#6th column  
X[filters$type==5,6] = 1

y

## [1] 261 186 239 243 296 270 221 188 167 224 178 147 201 146 96 173 280 100 600  
## [20] 301 608 283 193 159 160 135 455 402 457 559

X

## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 1 1 0 0 0 0  
## [2,] 1 1 0 0 0 0  
## [3,] 1 1 0 0 0 0  
## [4,] 1 1 0 0 0 0  
## [5,] 1 1 0 0 0 0  
## [6,] 1 1 0 0 0 0  
## [7,] 1 0 1 0 0 0  
## [8,] 1 0 1 0 0 0  
## [9,] 1 0 1 0 0 0  
## [10,] 1 0 1 0 0 0  
## [11,] 1 0 1 0 0 0  
## [12,] 1 0 1 0 0 0  
## [13,] 1 0 0 1 0 0  
## [14,] 1 0 0 1 0 0  
## [15,] 1 0 0 1 0 0  
## [16,] 1 0 0 1 0 0  
## [17,] 1 0 0 1 0 0  
## [18,] 1 0 0 1 0 0  
## [19,] 1 0 0 0 1 0  
## [20,] 1 0 0 0 1 0  
## [21,] 1 0 0 0 1 0  
## [22,] 1 0 0 0 1 0  
## [23,] 1 0 0 0 1 0  
## [24,] 1 0 0 0 1 0  
## [25,] 1 0 0 0 0 1  
## [26,] 1 0 0 0 0 1  
## [27,] 1 0 0 0 0 1  
## [28,] 1 0 0 0 0 1  
## [29,] 1 0 0 0 0 1  
## [30,] 1 0 0 0 0 1

#Actual X matrix should works out exactly above  
X1 = matrix(0,30,6)  
X1[,1] = 1  
for (i in 1:5){X1[filters$type==i,i+1] = 1}  
X1

## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 1 1 0 0 0 0  
## [2,] 1 1 0 0 0 0  
## [3,] 1 1 0 0 0 0  
## [4,] 1 1 0 0 0 0  
## [5,] 1 1 0 0 0 0  
## [6,] 1 1 0 0 0 0  
## [7,] 1 0 1 0 0 0  
## [8,] 1 0 1 0 0 0  
## [9,] 1 0 1 0 0 0  
## [10,] 1 0 1 0 0 0  
## [11,] 1 0 1 0 0 0  
## [12,] 1 0 1 0 0 0  
## [13,] 1 0 0 1 0 0  
## [14,] 1 0 0 1 0 0  
## [15,] 1 0 0 1 0 0  
## [16,] 1 0 0 1 0 0  
## [17,] 1 0 0 1 0 0  
## [18,] 1 0 0 1 0 0  
## [19,] 1 0 0 0 1 0  
## [20,] 1 0 0 0 1 0  
## [21,] 1 0 0 0 1 0  
## [22,] 1 0 0 0 1 0  
## [23,] 1 0 0 0 1 0  
## [24,] 1 0 0 0 1 0  
## [25,] 1 0 0 0 0 1  
## [26,] 1 0 0 0 0 1  
## [27,] 1 0 0 0 0 1  
## [28,] 1 0 0 0 0 1  
## [29,] 1 0 0 0 0 1  
## [30,] 1 0 0 0 0 1

#Part c: Using the algorithm given in the lecture slides, find a conditional inverse for t(X)%\*%X!

#Actual X matrix should works out exactly above  
t(X)%\*%X

## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 30 6 6 6 6 6  
## [2,] 6 6 0 0 0 0  
## [3,] 6 0 6 0 0 0  
## [4,] 6 0 0 6 0 0  
## [5,] 6 0 0 0 6 0  
## [6,] 6 0 0 0 0 6

#finding the rank in t(X)%\*%X which is 5   
#Using Theorem 6.2 it is a 5 by 5 matrix and it has to be full rank and it is invertiable   
M = 6\*diag(5)  
M

## [,1] [,2] [,3] [,4] [,5]  
## [1,] 6 0 0 0 0  
## [2,] 0 6 0 0 0  
## [3,] 0 0 6 0 0  
## [4,] 0 0 0 6 0  
## [5,] 0 0 0 0 6

#finding the inverse  
U = solve(M)  
  
#then getting the conditional inverse  
CI = data.frame(U)  
R = rbind(c(0,0,0,0,0,0),CI)  
C = cbind(X0= 0, R)  
C

## X0 X1 X2 X3 X4 X5  
## 1 0 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## 2 0 0.1666667 0.0000000 0.0000000 0.0000000 0.0000000  
## 3 0 0.0000000 0.1666667 0.0000000 0.0000000 0.0000000  
## 4 0 0.0000000 0.0000000 0.1666667 0.0000000 0.0000000  
## 5 0 0.0000000 0.0000000 0.0000000 0.1666667 0.0000000  
## 6 0 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667

#If you want it to convert into a matrix form!  
#finding the inverse  
XtXc = matrix(0,6,6)  
XtXc[2:6,2:6] = solve((t(X)%\*%X)[2:6,2:6])  
XtXc

## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [2,] 0 0.1666667 0.0000000 0.0000000 0.0000000 0.0000000  
## [3,] 0 0.0000000 0.1666667 0.0000000 0.0000000 0.0000000  
## [4,] 0 0.0000000 0.0000000 0.1666667 0.0000000 0.0000000  
## [5,] 0 0.0000000 0.0000000 0.0000000 0.1666667 0.0000000  
## [6,] 0 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667

#Part d: Use ginv to find another conditional inverse for t(X)%\*%X

#Finding another conditional inverse (Open the MASS Package)  
library(MASS)  
XtXc2 = ginv(t(X)%\*%X)  
XtXc2

## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.02314815 0.00462963 0.00462963 0.00462963 0.00462963 0.00462963  
## [2,] 0.00462963 0.13425926 -0.03240741 -0.03240741 -0.03240741 -0.03240741  
## [3,] 0.00462963 -0.03240741 0.13425926 -0.03240741 -0.03240741 -0.03240741  
## [4,] 0.00462963 -0.03240741 -0.03240741 0.13425926 -0.03240741 -0.03240741  
## [5,] 0.00462963 -0.03240741 -0.03240741 -0.03240741 0.13425926 -0.03240741  
## [6,] 0.00462963 -0.03240741 -0.03240741 -0.03240741 -0.03240741 0.13425926

#Part e: Verify that X(t(X)%*%X)^c%*%t(X) is the same for your two conditional inverses

#Attempt 1  
#Case 1 from Part c!  
X%\*%XtXc%\*%t(X)

## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000  
## [2,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000  
## [3,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000  
## [4,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000  
## [5,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000  
## [6,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667  
## [9,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667  
## [10,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667  
## [11,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667  
## [12,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1666667  
## [13,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [14,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [15,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [16,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [17,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [18,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [19,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [20,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [21,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [22,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [23,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [24,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [25,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [26,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [27,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [28,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [29,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [30,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [,8] [,9] [,10] [,11] [,12] [,13] [,14]  
## [1,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [2,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [3,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [4,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [10,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000  
## [11,] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000  
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## [19,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [20,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [21,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [23,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [27,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [28,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [29,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [30,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [,15] [,16] [,17] [,18] [,19] [,20] [,21]  
## [1,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [9,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [10,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [11,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [12,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [13,] 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000 0.0000000  
## [14,] 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000 0.0000000  
## [15,] 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000 0.0000000  
## [16,] 0.1666667 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000 0.0000000  
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## [,22] [,23] [,24] [,25] [,26] [,27] [,28]  
## [1,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [13,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [15,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [16,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [17,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
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## [19,] 0.1666667 0.1666667 0.1666667 0.0000000 0.0000000 0.0000000 0.0000000  
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## [26,] 0.0000000 0.0000000 0.0000000 0.1666667 0.1666667 0.1666667 0.1666667  
## [27,] 0.0000000 0.0000000 0.0000000 0.1666667 0.1666667 0.1666667 0.1666667  
## [28,] 0.0000000 0.0000000 0.0000000 0.1666667 0.1666667 0.1666667 0.1666667  
## [29,] 0.0000000 0.0000000 0.0000000 0.1666667 0.1666667 0.1666667 0.1666667  
## [30,] 0.0000000 0.0000000 0.0000000 0.1666667 0.1666667 0.1666667 0.1666667  
## [,29] [,30]  
## [1,] 0.0000000 0.0000000  
## [2,] 0.0000000 0.0000000  
## [3,] 0.0000000 0.0000000  
## [4,] 0.0000000 0.0000000  
## [5,] 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000  
## [7,] 0.0000000 0.0000000  
## [8,] 0.0000000 0.0000000  
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## [10,] 0.0000000 0.0000000  
## [11,] 0.0000000 0.0000000  
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## [23,] 0.0000000 0.0000000  
## [24,] 0.0000000 0.0000000  
## [25,] 0.1666667 0.1666667  
## [26,] 0.1666667 0.1666667  
## [27,] 0.1666667 0.1666667  
## [28,] 0.1666667 0.1666667  
## [29,] 0.1666667 0.1666667  
## [30,] 0.1666667 0.1666667

#Attempt 1  
#Case 2 from Part c!  
X%\*%XtXc2%\*%t(X)

## [,1] [,2] [,3] [,4] [,5]  
## [1,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [2,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [3,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [4,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [5,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [6,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [7,] 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17  
## [8,] 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17  
## [9,] 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17  
## [10,] 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17  
## [11,] 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17  
## [12,] 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17 4.510281e-17  
## [13,] 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [14,] 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [15,] 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [16,] 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [17,] 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [18,] 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [19,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [20,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [21,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [22,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [23,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [24,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [25,] 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17  
## [26,] 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17  
## [27,] 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17  
## [28,] 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17  
## [29,] 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17  
## [30,] 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17 2.775558e-17  
## [,6] [,7] [,8] [,9] [,10]  
## [1,] 1.666667e-01 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [2,] 1.666667e-01 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [3,] 1.666667e-01 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [4,] 1.666667e-01 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [5,] 1.666667e-01 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [6,] 1.666667e-01 1.734723e-17 1.734723e-17 1.734723e-17 1.734723e-17  
## [7,] 4.510281e-17 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [8,] 4.510281e-17 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [9,] 4.510281e-17 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [10,] 4.510281e-17 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [11,] 4.510281e-17 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [12,] 4.510281e-17 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [13,] 1.734723e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [14,] 1.734723e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [15,] 1.734723e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [16,] 1.734723e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [17,] 1.734723e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [18,] 1.734723e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [19,] 2.428613e-17 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [20,] 2.428613e-17 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [21,] 2.428613e-17 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [22,] 2.428613e-17 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [23,] 2.428613e-17 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [24,] 2.428613e-17 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [25,] 2.775558e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17  
## [26,] 2.775558e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17  
## [27,] 2.775558e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17  
## [28,] 2.775558e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17 -1.734723e-17  
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## [,11] [,12] [,13] [,14] [,15]  
## [1,] 1.734723e-17 1.734723e-17 3.469447e-18 3.469447e-18 3.469447e-18  
## [2,] 1.734723e-17 1.734723e-17 3.469447e-18 3.469447e-18 3.469447e-18  
## [3,] 1.734723e-17 1.734723e-17 3.469447e-18 3.469447e-18 3.469447e-18  
## [4,] 1.734723e-17 1.734723e-17 3.469447e-18 3.469447e-18 3.469447e-18  
## [5,] 1.734723e-17 1.734723e-17 3.469447e-18 3.469447e-18 3.469447e-18  
## [6,] 1.734723e-17 1.734723e-17 3.469447e-18 3.469447e-18 3.469447e-18  
## [7,] 1.666667e-01 1.666667e-01 -5.551115e-17 -5.551115e-17 -5.551115e-17  
## [8,] 1.666667e-01 1.666667e-01 -5.551115e-17 -5.551115e-17 -5.551115e-17  
## [9,] 1.666667e-01 1.666667e-01 -5.551115e-17 -5.551115e-17 -5.551115e-17  
## [10,] 1.666667e-01 1.666667e-01 -5.551115e-17 -5.551115e-17 -5.551115e-17  
## [11,] 1.666667e-01 1.666667e-01 -5.551115e-17 -5.551115e-17 -5.551115e-17  
## [12,] 1.666667e-01 1.666667e-01 -5.551115e-17 -5.551115e-17 -5.551115e-17  
## [13,] -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01 1.666667e-01  
## [14,] -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01 1.666667e-01  
## [15,] -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01 1.666667e-01  
## [16,] -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01 1.666667e-01  
## [17,] -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01 1.666667e-01  
## [18,] -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01 1.666667e-01  
## [19,] 0.000000e+00 0.000000e+00 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [20,] 0.000000e+00 0.000000e+00 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [21,] 0.000000e+00 0.000000e+00 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [22,] 0.000000e+00 0.000000e+00 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [23,] 0.000000e+00 0.000000e+00 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [24,] 0.000000e+00 0.000000e+00 -2.775558e-17 -2.775558e-17 -2.775558e-17  
## [25,] -1.734723e-17 -1.734723e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [26,] -1.734723e-17 -1.734723e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [27,] -1.734723e-17 -1.734723e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [28,] -1.734723e-17 -1.734723e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [29,] -1.734723e-17 -1.734723e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [30,] -1.734723e-17 -1.734723e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [,16] [,17] [,18] [,19] [,20]  
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## [2,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18  
## [3,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18  
## [4,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18  
## [5,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18  
## [6,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18  
## [7,] -5.551115e-17 -5.551115e-17 -5.551115e-17 0.000000e+00 0.000000e+00  
## [8,] -5.551115e-17 -5.551115e-17 -5.551115e-17 0.000000e+00 0.000000e+00  
## [9,] -5.551115e-17 -5.551115e-17 -5.551115e-17 0.000000e+00 0.000000e+00  
## [10,] -5.551115e-17 -5.551115e-17 -5.551115e-17 0.000000e+00 0.000000e+00  
## [11,] -5.551115e-17 -5.551115e-17 -5.551115e-17 0.000000e+00 0.000000e+00  
## [12,] -5.551115e-17 -5.551115e-17 -5.551115e-17 0.000000e+00 0.000000e+00  
## [13,] 1.666667e-01 1.666667e-01 1.666667e-01 2.081668e-17 2.081668e-17  
## [14,] 1.666667e-01 1.666667e-01 1.666667e-01 2.081668e-17 2.081668e-17  
## [15,] 1.666667e-01 1.666667e-01 1.666667e-01 2.081668e-17 2.081668e-17  
## [16,] 1.666667e-01 1.666667e-01 1.666667e-01 2.081668e-17 2.081668e-17  
## [17,] 1.666667e-01 1.666667e-01 1.666667e-01 2.081668e-17 2.081668e-17  
## [18,] 1.666667e-01 1.666667e-01 1.666667e-01 2.081668e-17 2.081668e-17  
## [19,] -2.775558e-17 -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01  
## [20,] -2.775558e-17 -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01  
## [21,] -2.775558e-17 -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01  
## [22,] -2.775558e-17 -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01  
## [23,] -2.775558e-17 -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01  
## [24,] -2.775558e-17 -2.775558e-17 -2.775558e-17 1.666667e-01 1.666667e-01  
## [25,] 2.428613e-17 2.428613e-17 2.428613e-17 -3.122502e-17 -3.122502e-17  
## [26,] 2.428613e-17 2.428613e-17 2.428613e-17 -3.122502e-17 -3.122502e-17  
## [27,] 2.428613e-17 2.428613e-17 2.428613e-17 -3.122502e-17 -3.122502e-17  
## [28,] 2.428613e-17 2.428613e-17 2.428613e-17 -3.122502e-17 -3.122502e-17  
## [29,] 2.428613e-17 2.428613e-17 2.428613e-17 -3.122502e-17 -3.122502e-17  
## [30,] 2.428613e-17 2.428613e-17 2.428613e-17 -3.122502e-17 -3.122502e-17  
## [,21] [,22] [,23] [,24] [,25]  
## [1,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 6.938894e-18  
## [2,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 6.938894e-18  
## [3,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 6.938894e-18  
## [4,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 6.938894e-18  
## [5,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 6.938894e-18  
## [6,] 3.469447e-18 3.469447e-18 3.469447e-18 3.469447e-18 6.938894e-18  
## [7,] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 -2.428613e-17  
## [8,] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 -2.428613e-17  
## [9,] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 -2.428613e-17  
## [10,] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 -2.428613e-17  
## [11,] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 -2.428613e-17  
## [12,] 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 -2.428613e-17  
## [13,] 2.081668e-17 2.081668e-17 2.081668e-17 2.081668e-17 -3.122502e-17  
## [14,] 2.081668e-17 2.081668e-17 2.081668e-17 2.081668e-17 -3.122502e-17  
## [15,] 2.081668e-17 2.081668e-17 2.081668e-17 2.081668e-17 -3.122502e-17  
## [16,] 2.081668e-17 2.081668e-17 2.081668e-17 2.081668e-17 -3.122502e-17  
## [17,] 2.081668e-17 2.081668e-17 2.081668e-17 2.081668e-17 -3.122502e-17  
## [18,] 2.081668e-17 2.081668e-17 2.081668e-17 2.081668e-17 -3.122502e-17  
## [19,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 2.428613e-17  
## [20,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 2.428613e-17  
## [21,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 2.428613e-17  
## [22,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 2.428613e-17  
## [23,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 2.428613e-17  
## [24,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 2.428613e-17  
## [25,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 1.666667e-01  
## [26,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 1.666667e-01  
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## [28,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 1.666667e-01  
## [29,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 1.666667e-01  
## [30,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 1.666667e-01  
## [,26] [,27] [,28] [,29] [,30]  
## [1,] 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18  
## [2,] 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18  
## [3,] 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18  
## [4,] 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18  
## [5,] 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18  
## [6,] 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18 6.938894e-18  
## [7,] -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17  
## [8,] -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17  
## [9,] -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17  
## [10,] -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17  
## [11,] -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17  
## [12,] -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17 -2.428613e-17  
## [13,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17  
## [14,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17  
## [15,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17  
## [16,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17  
## [17,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17  
## [18,] -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17 -3.122502e-17  
## [19,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [20,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [21,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [22,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [23,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [24,] 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17 2.428613e-17  
## [25,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [26,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [27,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [28,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [29,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01  
## [30,] 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01 1.666667e-01

#Actual Answer  
sum((X%\*%XtXc%\*%t(X)-X%\*%XtXc2%\*%t(X))^2)

## [1] 8.060017e-31

#Calculate the difference, in this case the difference here is very little. Safely assume that these computations are the same!

#Part f: Find two solutions for the normal equations

#Attempt 1 for the first conditional inverse  
b1 = XtXc%\*%t(X)%\*%y  
b1

## [,1]  
## [1,] 0.0000  
## [2,] 249.1667  
## [3,] 187.5000  
## [4,] 166.0000  
## [5,] 357.3333  
## [6,] 361.3333

#Attempt 1 for the second conditional inverse  
b2 = XtXc2%\*%t(X)%\*%y  
b2

## [,1]  
## [1,] 220.22222  
## [2,] 28.94444  
## [3,] -32.72222  
## [4,] -54.22222  
## [5,] 137.11111  
## [6,] 141.11111

#Part g: Express one of your solutions in terms of the other.

#From slide 72/137 Less than the full rank model  
#Sorry 1 step at a time  
b2 = diag(6) - XtXc%\*%t(X)%\*%X  
b2

## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 1 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] -1 1.110223e-16 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] -1 0.000000e+00 1.110223e-16 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] -1 0.000000e+00 0.000000e+00 1.110223e-16 0.000000e+00 0.000000e+00  
## [5,] -1 0.000000e+00 0.000000e+00 0.000000e+00 1.110223e-16 0.000000e+00  
## [6,] -1 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 1.110223e-16

#Part h: Write down a form for all solutions to the normal equations

#ASK ABOUT IT, #All solutions to the normal equation are of the form b + (I-(t(X)%\*%X)^c%\*%t(X)%\*%X)%\*%z for arbitary z!