1b.

comparisons\_col1<-c(rep("27\_7\_1", times =7), rep("47\_7\_1", times =7), rep("57\_5\_1", times=7),

rep("12\_8\_1", times=7), rep("76\_7\_1", times=7) )

comparisons\_col2<-c("27\_7\_2", "27\_7\_3", "27\_7\_4", "27\_7\_5", "27\_7\_6", "27\_7\_7", "27\_7\_8",

"47\_7\_2", "47\_7\_3", "47\_7\_4", "47\_7\_5", "47\_7\_6", "47\_7\_7", "47\_7\_8", "57\_5\_2", "57\_5\_3",

"57\_5\_4", "57\_5\_5", "57\_5\_6", "57\_5\_7", "57\_5\_8", "12\_8\_2", "12\_8\_3", "12\_8\_4", "12\_8\_5","12\_8\_6","12\_8\_7",

"12\_8\_8","76\_7\_2","76\_7\_3","76\_7\_4","76\_7\_5","76\_7\_6","76\_7\_7","76\_7\_8")

comparisons\_score<-c(249, 279, 223,352,263,285,190, 288, 302, 264,289,470,206,334,382,

259, 314,417,263,272,351, 386, 413, 363, 333, 379, 387, 376, 279, 287, 250, 319, 264, 196, 181 )

mated\_database<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

mated\_database

1d.

comparisons\_col1<- c(rep("27\_7\_1", times =7), rep("47\_7\_1", times =7), rep("57\_5\_1", times=7),

rep("12\_8\_1", times=7), rep("76\_7\_1", times=7) )

comparisons\_col2<- c("27\_6\_1", "27\_6\_2","27\_6\_3","27\_6\_4","27\_6\_5","27\_6\_6","27\_6\_7","47\_6\_1","47\_6\_2"

, "47\_6\_3","47\_6\_4","47\_6\_5","47\_6\_6","47\_6\_7","57\_3\_1","57\_3\_2","57\_3\_3","57\_3\_4","57\_3\_5","57\_3\_6","57\_3\_7",

"12\_3\_1","12\_3\_2","12\_3\_3","12\_3\_4","12\_3\_5","12\_3\_6","12\_3\_7","76\_8\_1","76\_8\_2","76\_8\_3","76\_8\_4",

"76\_8\_5","76\_8\_6","76\_8\_7")

comparisons\_score<-round(rnorm(35, mean = 175, sd=50),0) # change the number of generated outputs based on your non mated data

non\_mated\_database<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

non\_mated\_database

1e.

# Copy the code for your mated and non mated database generation here.

comparisons\_col1<-c(rep("27\_7\_1", times =7), rep("47\_7\_1", times =7), rep("57\_5\_1", times=7),

rep("12\_8\_1", times=7), rep("76\_7\_1", times=7) )

comparisons\_col2<-c("27\_7\_2", "27\_7\_3", "27\_7\_4", "27\_7\_5", "27\_7\_6", "27\_7\_7", "27\_7\_8",

"47\_7\_2", "47\_7\_3", "47\_7\_4", "47\_7\_5", "47\_7\_6", "47\_7\_7", "47\_7\_8", "57\_5\_2", "57\_5\_3",

"57\_5\_4", "57\_5\_5", "57\_5\_6", "57\_5\_7", "57\_5\_8", "12\_8\_2", "12\_8\_3", "12\_8\_4", "12\_8\_5","12\_8\_6","12\_8\_7",

"12\_8\_8","76\_7\_2","76\_7\_3","76\_7\_4","76\_7\_5","76\_7\_6","76\_7\_7","76\_7\_8")

comparisons\_score<-c(249, 279, 223,352,263,285,190, 288, 302, 264,289,470,206,334,382,

259, 314,417,263,272,351, 386, 413, 363, 333, 379, 387, 376, 279, 287, 250, 319, 264, 196, 181 )

mated\_database<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

mated\_database

comparisons\_col1<- c(rep("27\_7\_1", times =7), rep("47\_7\_1", times =7), rep("57\_5\_1", times=7),

rep("12\_8\_1", times=7), rep("76\_7\_1", times=7) )

comparisons\_col2<- c("27\_6\_1", "27\_6\_2","27\_6\_3","27\_6\_4","27\_6\_5","27\_6\_6","27\_6\_7","47\_6\_1","47\_6\_2"

, "47\_6\_3","47\_6\_4","47\_6\_5","47\_6\_6","47\_6\_7","57\_3\_1","57\_3\_2","57\_3\_3","57\_3\_4","57\_3\_5","57\_3\_6","57\_3\_7",

"12\_3\_1","12\_3\_2","12\_3\_3","12\_3\_4","12\_3\_5","12\_3\_6","12\_3\_7","76\_8\_1","76\_8\_2","76\_8\_3","76\_8\_4",

"76\_8\_5","76\_8\_6","76\_8\_7")

comparisons\_score<-c(161, 131, 162,211,262,165,253, 121,64,148,70,277,216,250,139,201,162,248,165,166,102,248,84,117,155,213,109,183,190,83,229,156,95,224,229)

nonmated\_database<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

nonmated\_database

#observe the score distribution

mated\_scores<-as.numeric(mated\_database[,3])

nonmated\_scores<-as.numeric(nonmated\_database[,3])

mated\_hist<-hist(mated\_scores, plot=TRUE, breaks = seq(from=0, to=600, by=25))

nonmated\_hist<-hist(nonmated\_scores, plot=TRUE, breaks = seq(from=0, to=400, by=20))

mated\_hist

nonmated\_hist

plot(mated\_hist$mids, mated\_hist$counts, type='l', lwd=2, col=3, xlab = "mated scores", ylab = "Counts" )

lines(nonmated\_hist$mids, nonmated\_hist$counts, lwd=2, col=2)

title("Mated and Non Mated score distribution")

1g – 1i.

comparisons\_score\_mated<-c(249, 279, 223,352,263,285,190, 288, 302, 264,289,470,206,334,382,

259, 314,417,263,272,351, 386, 413, 363, 333, 379, 387, 376, 279, 287, 250, 319, 264, 196, 181 )

comparisons\_score\_nonmated<-c(161, 131, 162,211,262,165,253, 121,64,148,70,277,216,250,139,201,162,248,165,166,102,248,84,117,155,213,109,183,190,83,229,156,95,224,229)

mean\_mated <- mean(comparisons\_score\_mated)

mean\_mated

sd\_mated <- sd(comparisons\_score\_mated)

sd\_mated

mean\_nonmated <- mean(comparisons\_score\_nonmated)

mean\_nonmated

sd\_nonmated <- sd(comparisons\_score\_nonmated)

sd\_nonmated

test\_mated\_scores<-round(rnorm(200, mean = mean\_mated, sd= sd\_mated),0)

test\_mated\_scores

test\_nonmated\_scores<-round(rnorm(200, mean = mean\_nonmated, sd= sd\_nonmated),0)

test\_nonmated\_scores

NumberMatched <- length(test\_mated\_scores[test\_mated\_scores >= 250])

NumberFalseMatched <- length(test\_nonmated\_scores[test\_nonmated\_scores >= 250])

percentageGenuineAccepted <- NumberMatched/2

percentageGenuineAccepted

percentageFalseMatchRate <- NumberFalseMatched/2

percentageFalseMatchRate

2c.

comparisons\_col1<-c(rep("0001\_L\_000", times =4), rep("0001\_R\_000", times =4), rep("0002\_L\_000", times=2),

rep("0002\_R\_000", times=2), rep("0004\_L\_000", times=2), rep("0004\_R\_000", times=2), rep("0007\_L\_000", times=1),

rep("0007\_R\_000", times=1), rep("0008\_L\_000", times=1), rep("0008\_R\_000", times=1) )

comparisons\_col2<-c("0001\_L\_001", "0001\_L\_002", "0001\_L\_003", "0001\_L\_004", "0001\_R\_001", "0001\_R\_002",

"0001\_R\_003", "0001\_R\_004", "0002\_L\_001", "0002\_L\_002", "0002\_R\_001", "0002\_R\_002", "0004\_L\_001", "0004\_L\_002", "0004\_R\_001",

"0004\_R\_002", "0007\_L\_001", "0007\_R\_001", "0008\_L\_001", "0008\_R\_001")

comparisons\_score<-c(791, 566, 746, 618, 589, 541, 612, 638, 482, 522, 693, 737, 503, 551, 443, 881, 316, 427, 732, 777)

iris\_mated\_dataframe<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

iris\_mated\_dataframe

2d.

comparisons\_col1<- c(rep("0001\_L\_000", times =4), rep("0001\_R\_000", times =4), rep("0002\_L\_000", times=2),

rep("0002\_R\_000", times=2), rep("0004\_L\_000", times=2), rep("0004\_R\_000", times=2), rep("0007\_L\_000", times=1),

rep("0007\_R\_000", times=1), rep("0008\_L\_000", times=1), rep("0008\_R\_000", times=1) )

comparisons\_col2<- c("0011\_R\_002", "0011\_L\_001", "0010\_R\_002", "0010\_R\_001", "0010\_R\_000", "0010\_L\_002",

"0010\_L\_001", "0010\_L\_000","0009\_R\_001", "0009\_R\_000", "0009\_L\_001","0009\_L\_000", "0008\_R\_001", "0008\_R\_000",

"0008\_L\_001", "0008\_L\_000", "0007\_R\_001", "0000\_L\_000", "0000\_R\_000", "0001\_L\_001")

comparisons\_score<-round(rnorm(20, mean = 300, sd=50),0) # change the number of generated outputs based on your non mated data

iris\_nonmated\_dataframe<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

iris\_nonmated\_dataframe

2e.

# Copy the code for your mated and non mated database generation here.

comparisons\_col1<-c(rep("0001\_L\_000", times =4), rep("0001\_R\_000", times =4), rep("0002\_L\_000", times=2),

rep("0002\_R\_000", times=2), rep("0004\_L\_000", times=2), rep("0004\_R\_000", times=2), rep("0007\_L\_000", times=1),

rep("0007\_R\_000", times=1), rep("0008\_L\_000", times=1), rep("0008\_R\_000", times=1) )

comparisons\_col2<-c("0001\_L\_001", "0001\_L\_002", "0001\_L\_003", "0001\_L\_004", "0001\_R\_001", "0001\_R\_002",

"0001\_R\_003", "0001\_R\_004", "0002\_L\_001", "0002\_L\_002", "0002\_R\_001", "0002\_R\_002", "0004\_L\_001", "0004\_L\_002", "0004\_R\_001",

"0004\_R\_002", "0007\_L\_001", "0007\_R\_001", "0008\_L\_001", "0008\_R\_001")

comparisons\_score<-c(791, 566, 746, 618, 589, 541, 612, 638, 482, 522, 693, 737, 503, 551, 443, 881, 316, 427, 732, 777)

iris\_mated\_dataframe<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

iris\_mated\_dataframe

comparisons\_col1<- c(rep("0001\_L\_000", times =4), rep("0001\_R\_000", times =4), rep("0002\_L\_000", times=2),

rep("0002\_R\_000", times=2), rep("0004\_L\_000", times=2), rep("0004\_R\_000", times=2), rep("0007\_L\_000", times=1),

rep("0007\_R\_000", times=1), rep("0008\_L\_000", times=1), rep("0008\_R\_000", times=1) )

comparisons\_col2<- c("0011\_R\_002", "0011\_L\_001", "0010\_R\_002", "0010\_R\_001", "0010\_R\_000", "0010\_L\_002",

"0010\_L\_001", "0010\_L\_000","0009\_R\_001", "0009\_R\_000", "0009\_L\_001","0009\_L\_000", "0008\_R\_001", "0008\_R\_000",

"0008\_L\_001", "0008\_L\_000", "0007\_R\_001", "0000\_L\_000", "0000\_R\_000", "0001\_L\_001")

comparisons\_score<-round(rnorm(20, mean = 300, sd=50),0) # change the number of generated outputs based on your non mated data

iris\_nonmated\_dataframe<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

iris\_nonmated\_dataframe

#observe the score distribution

mated\_scores<-as.numeric(iris\_mated\_dataframe[,3])

nonmated\_scores<-as.numeric(iris\_nonmated\_dataframe[,3])

mated\_hist<-hist(mated\_scores, plot=TRUE, breaks = seq(from=0, to=1000, by=30))

nonmated\_hist<-hist(nonmated\_scores, plot=TRUE, breaks = seq(from=0, to=1000, by=5))

mated\_hist

nonmated\_hist

plot(mated\_hist$mids, mated\_hist$counts, type='l', lwd=2, col=3, xlab = "mated scores", ylab = "Counts" )

lines(nonmated\_hist$mids, nonmated\_hist$counts, lwd=2, col=2)

title("Mated and Non Mated score distribution")

3a.

#copy the mated and non mated score distributions of the fingerprint system here

mated\_scores\_fp<-round(rnorm(20, mean=304.7143, sd=70.00948))

nonmated\_scores\_fp<-round(rnorm(20, mean=171.1143, sd=59.76019))

comparisons\_col1<-c(rep("27\_7\_1", times =7), rep("47\_7\_1", times =7), rep("57\_5\_1", times=7),

rep("12\_8\_1", times=7), rep("76\_7\_1", times=7) )

comparisons\_col2<-c("27\_7\_2", "27\_7\_3", "27\_7\_4", "27\_7\_5", "27\_7\_6", "27\_7\_7", "27\_7\_8",

"47\_7\_2", "47\_7\_3", "47\_7\_4", "47\_7\_5", "47\_7\_6", "47\_7\_7", "47\_7\_8", "57\_5\_2", "57\_5\_3",

"57\_5\_4", "57\_5\_5", "57\_5\_6", "57\_5\_7", "57\_5\_8", "12\_8\_2", "12\_8\_3", "12\_8\_4", "12\_8\_5","12\_8\_6","12\_8\_7",

"12\_8\_8","76\_7\_2","76\_7\_3","76\_7\_4","76\_7\_5","76\_7\_6","76\_7\_7","76\_7\_8")

comparisons\_score<-c(249, 279, 223,352,263,285,190, 288, 302, 264,289,470,206,334,382,

259, 314,417,263,272,351, 386, 413, 363, 333, 379, 387, 376, 279, 287, 250, 319, 264, 196, 181 )

mated\_database<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

mated\_database

comparisons\_col1<- c(rep("27\_7\_1", times =7), rep("47\_7\_1", times =7), rep("57\_5\_1", times=7),

rep("12\_8\_1", times=7), rep("76\_7\_1", times=7) )

comparisons\_col2<- c("27\_6\_1", "27\_6\_2","27\_6\_3","27\_6\_4","27\_6\_5","27\_6\_6","27\_6\_7","47\_6\_1","47\_6\_2"

, "47\_6\_3","47\_6\_4","47\_6\_5","47\_6\_6","47\_6\_7","57\_3\_1","57\_3\_2","57\_3\_3","57\_3\_4","57\_3\_5","57\_3\_6","57\_3\_7",

"12\_3\_1","12\_3\_2","12\_3\_3","12\_3\_4","12\_3\_5","12\_3\_6","12\_3\_7","76\_8\_1","76\_8\_2","76\_8\_3","76\_8\_4",

"76\_8\_5","76\_8\_6","76\_8\_7")

comparisons\_score<-c(161, 131, 162,211,262,165,253, 121,64,148,70,277,216,250,139,201,162,248,165,166,102,248,84,117,155,213,109,183,190,83,229,156,95,224,229)

nonmated\_database<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

nonmated\_database

#copy the mated and non mated score distributions of the iris system here

comparisons\_col1<-c(rep("0001\_L\_000", times =4), rep("0001\_R\_000", times =4), rep("0002\_L\_000", times=2),

rep("0002\_R\_000", times=2), rep("0004\_L\_000", times=2), rep("0004\_R\_000", times=2), rep("0007\_L\_000", times=1),

rep("0007\_R\_000", times=1), rep("0008\_L\_000", times=1), rep("0008\_R\_000", times=1) )

comparisons\_col2<-c("0001\_L\_001", "0001\_L\_002", "0001\_L\_003", "0001\_L\_004", "0001\_R\_001", "0001\_R\_002",

"0001\_R\_003", "0001\_R\_004", "0002\_L\_001", "0002\_L\_002", "0002\_R\_001", "0002\_R\_002", "0004\_L\_001", "0004\_L\_002", "0004\_R\_001",

"0004\_R\_002", "0007\_L\_001", "0007\_R\_001", "0008\_L\_001", "0008\_R\_001")

comparisons\_score<-c(791, 566, 746, 618, 589, 541, 612, 638, 482, 522, 693, 737, 503, 551, 443, 881, 316, 427, 732, 777)

mated\_scores\_iris<-round(rnorm(20, mean= mean(comparisons\_score), sd=50))

nonmated\_scores\_iris<-round(rnorm(20, mean=300, sd=50))

iris\_mated\_dataframe<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

iris\_mated\_dataframe

comparisons\_col1<- c(rep("0001\_L\_000", times =4), rep("0001\_R\_000", times =4), rep("0002\_L\_000", times=2),

rep("0002\_R\_000", times=2), rep("0004\_L\_000", times=2), rep("0004\_R\_000", times=2), rep("0007\_L\_000", times=1),

rep("0007\_R\_000", times=1), rep("0008\_L\_000", times=1), rep("0008\_R\_000", times=1) )

comparisons\_col2<- c("0011\_R\_002", "0011\_L\_001", "0010\_R\_002", "0010\_R\_001", "0010\_R\_000", "0010\_L\_002",

"0010\_L\_001", "0010\_L\_000","0009\_R\_001", "0009\_R\_000", "0009\_L\_001","0009\_L\_000", "0008\_R\_001", "0008\_R\_000",

"0008\_L\_001", "0008\_L\_000", "0007\_R\_001", "0000\_L\_000", "0000\_R\_000", "0001\_L\_001")

comparisons\_score<-round(rnorm(20, mean = 300, sd=50),0) # change the number of generated outputs based on your non mated data

iris\_nonmated\_dataframe<-as.data.frame(cbind(comparisons\_col1,comparisons\_col2,comparisons\_score))

iris\_nonmated\_dataframe

#Assign variables to the chosen operating thresholds for fingerprint (T\_fp) and iris (T\_i)

T\_fp<-250

T\_i<- 450

N<-length(mated\_scores\_iris)

#take a random subset of N scores from the mated and non mated fingerprint score distributions

mated\_scores\_fp\_N<-mated\_scores\_fp[sample(1:length(mated\_scores\_fp), size=N, replace=FALSE)]

nonmated\_scores\_fp\_N<-nonmated\_scores\_fp[sample(1:length(nonmated\_scores\_fp), size=N, replace=FALSE)]

#Create a simulated bimodal system that takes a pair of fingerprint and iris scores. We will have 50 such genuine score pairs and 50 imposter score pairs

mated\_scores\_fp\_iris<-cbind(mated\_scores\_fp\_N,mated\_scores\_iris)

nonmated\_scores\_fp\_iris<-cbind(nonmated\_scores\_fp\_N,nonmated\_scores\_iris)

#Let us plot these scores

xlower<-range(c(mated\_scores\_fp\_N, nonmated\_scores\_fp\_N))[1]

xupper<-range(c(mated\_scores\_fp\_N, nonmated\_scores\_fp\_N))[2]

ylower<-range(c(mated\_scores\_iris, nonmated\_scores\_iris))[1]

yupper<-range(c(mated\_scores\_iris, nonmated\_scores\_iris))[2]

plot(mated\_scores\_fp\_iris, type='p', pch=18, col=3, xlim=c(xlower, xupper), ylim=c(ylower, yupper))

points(nonmated\_scores\_fp\_iris, pch=19, col=2)

abline(v=T\_fp, col=1)

abline(h=T\_i, col=1)

abline(a = 545, b = -0.38, col = 4)