1. 연립방정식, 가우스 소거법

```
A <-matrix(c(6,2,2,2,2,0,2,0,2),byrow=TRUE,nr=3)

E1 <- diag(3)
E1[2,1] <- -1/3
E1[3,1] <- -1/3
E1A <- E1%*%A

cbind(E1,A,E1A)
```

```
##            [,1] [,2] [,3] [,4] [,5] [,6] [,7]       [,8]       [,9]
## [1,]  1.0000000    0    0    6    2    2    6  2.0000000  2.0000000
## [2,] -0.3333333    1    0    2    2    0    0  1.3333333 -0.6666667
## [3,] -0.3333333    0    1    2    0    2    0 -0.6666667  1.3333333
```

```
E2 <- diag(3)
E2[3,2] <- 1/2

E2E1A <- E2%*%E1A

cbind(E2,E1A,E2E1A)
```

```
##      [,1] [,2] [,3] [,4]       [,5]       [,6] [,7]         [,8]       [,9]
## [1,]    1  0.0    0    6  2.0000000  2.0000000    6 2.000000e+00  2.0000000
## [2,]    0  1.0    0    0  1.3333333 -0.6666667    0 1.333333e+00 -0.6666667
## [3,]    0  0.5    1    0 -0.6666667  1.3333333    0 1.110223e-16  1.0000000
```

```
L <- solve(E1)%*%solve(E2)
U <- E2E1A

LU <- L%*%U

cbind(L,U,LU)
```

```
##           [,1] [,2] [,3] [,4]         [,5]       [,6] [,7] [,8] [,9]
## [1,] 1.0000000  0.0    0    6 2.000000e+00  2.0000000    6    2    2
## [2,] 0.3333333  1.0    0    0 1.333333e+00 -0.6666667    2    2    0
## [3,] 0.3333333 -0.5    1    0 1.110223e-16  1.0000000    2    0    2
```

```
solve(A,c(0,0,0))
```

```
## [1] 0 0 0
```

2. 연립방정식의 답

```
A <- matrix(c(6,2,2,2,2,0,2,0,2),byrow = TRUE,nr=3)
b <- c(60,0,20)

X1 <- b/A
cbind(A,X1,b)
```

```
##                         b
## [1,] 6 2 2 10  30  30 60
## [2,] 2 2 0  0   0 NaN  0
## [3,] 2 0 2 10 Inf  10 20
```

```
solve(A,b)
```

```
## [1]  20 -20 -10
```

(6,2,2)x + (2,2,0)y + (2,0,2)z = (6x+2y+2z,2x+2y,2x+2z)=(60,0,20)

위의 연립방정식을 손으로 풀면 x= 20, y= -20, z= -10이다.

답: x= 20, y= -20, z= -10

3. 연립방정식, 정규방정식

1. 미지수의 수: 3개
2. 방정식의 수: 6개
3. 연립방정식의 답은 존재하지 않는다.

```
x <- matrix(c(1,1,0,1,1,0,1,0,1,1,0,1,1,0,0,1,0,0),byrow = TRUE,nc=3)
y <- c(-1,1,9,11,19,21)
cbind(x,y)
```

```
##             y
## [1,] 1 1 0 -1
## [2,] 1 1 0  1
## [3,] 1 0 1  9
## [4,] 1 0 1 11
## [5,] 1 0 0 19
## [6,] 1 0 0 21
```

```
XTX <- t(x)%*%x
XTY <- t(x)%*%y
NE <- cbind(XTX,XTY)
NE
```

```
##      [,1] [,2] [,3] [,4]
## [1,]    6    2    2   60
## [2,]    2    2    0    0
## [3,]    2    0    2   20
```

```
b <- solve(XTX,XTY)
b
```

```
##      [,1]
## [1,]   20
## [2,]  -20
## [3,]  -10
```

```
yh <- x%*%b
e <- y-yh
round(data.frame(y=y,yh=yh,e),4)
```

```
##    y yh  e
## 1 -1  0 -1
## 2  1  0  1
## 3  9 10 -1
## 4 11 10  1
## 5 19 20 -1
## 6 21 20  1
```

```
e
```

```
##      [,1]
## [1,]   -1
## [2,]    1
## [3,]   -1
## [4,]    1
## [5,]   -1
## [6,]    1
```

```
sum(e*e)
```

```
## [1] 6
```

```
invXTX <- solve(XTX)
H <- x%*%invXTX%*%t(x)
round(H,5)
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]  0.5  0.5  0.0  0.0  0.0  0.0
## [2,]  0.5  0.5  0.0  0.0  0.0  0.0
## [3,]  0.0  0.0  0.5  0.5  0.0  0.0
## [4,]  0.0  0.0  0.5  0.5  0.0  0.0
## [5,]  0.0  0.0  0.0  0.0  0.5  0.5
## [6,]  0.0  0.0  0.0  0.0  0.5  0.5
```

```
round(H%*%H,5)
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]  0.5  0.5  0.0  0.0  0.0  0.0
## [2,]  0.5  0.5  0.0  0.0  0.0  0.0
## [3,]  0.0  0.0  0.5  0.5  0.0  0.0
## [4,]  0.0  0.0  0.5  0.5  0.0  0.0
## [5,]  0.0  0.0  0.0  0.0  0.5  0.5
## [6,]  0.0  0.0  0.0  0.0  0.5  0.5
```

```
sum(diag(H))
```

```
## [1] 3
```

4. 기초통계량 계산

```
x <- matrix(c(2,3,3,2,7,1),byrow = TRUE,nc=2)
x
```

```
##      [,1] [,2]
## [1,]    2    3
## [2,]    3    2
## [3,]    7    1
```

```
scale(x,center = TRUE,scale = FALSE)
```

```
##      [,1] [,2]
## [1,]   -2    1
## [2,]   -1    0
## [3,]    3   -1
## attr(,"scaled:center")
## [1] 4 2
```

```
scale(x,center = TRUE,scale = TRUE)
```

```
##            [,1] [,2]
## [1,] -0.7559289    1
## [2,] -0.3779645    0
## [3,]  1.1338934   -1
## attr(,"scaled:center")
## [1] 4 2
## attr(,"scaled:scale")
## [1] 2.645751 1.000000
```

```
t(x)%*%x
```

```
##      [,1] [,2]
## [1,]   62   19
## [2,]   19   14
```

```
I3 <- diag(3)
J3 <- matrix(1/nrow(x),nr=nrow(x),nc=nrow(x))
C3 <- I3-J3

CX <- C3%*%x
t(CX)%*%CX
```

```
##      [,1] [,2]
## [1,]   14   -5
## [2,]   -5    2
```

```
S <- cov(x)
S
```

```
##      [,1] [,2]
## [1,]  7.0 -2.5
## [2,] -2.5  1.0
```

```
R <- cor(x)
R
```

```
##            [,1]       [,2]
## [1,]  1.0000000 -0.9449112
## [2,] -0.9449112  1.0000000
```

5. 분광분해/SVD

```
read.csv(file = "C:/Users/Administrator/Desktop/htwtage4.csv",header=T)
```

```
##    ht wt age
## 1 166 65  45
## 2 168 60  42
## 3 172 75  35
## 4 174 80  38
```

```
eigS <- eigen(S)
V <- eigS$vector
L <- eigS$value
cbind(V,diag(L),t(V),V%*%diag(L)%*%t(V))
```

```
##            [,1]       [,2]     [,3]       [,4]       [,5]       [,6] [,7] [,8]
## [1,] -0.9402716 -0.3404253 7.905125 0.00000000 -0.9402716  0.3404253  7.0 -2.5
## [2,]  0.3404253 -0.9402716 0.000000 0.09487516 -0.3404253 -0.9402716 -2.5  1.0
```

```
S1 <- L[1]*V[,1]%*%t(V[,1])
S2 <- L[2]*V[,2]%*%t(V[,2])
cbind(S,S1,S1+S2)
```

```
##      [,1] [,2]      [,3]       [,4] [,5] [,6]
## [1,]  7.0 -2.5  6.989005 -2.5303688  7.0 -2.5
## [2,] -2.5  1.0 -2.530369  0.9161199 -2.5  1.0
```

```
eigR <- eigen(R)
V <- eigR$vector
L <- eigR$value
cbind(V,diag(L),t(V),V%*%diag(L)%*%t(V))
```

```
##            [,1]       [,2]     [,3]       [,4]       [,5]       [,6]       [,7]
## [1,] -0.7071068 -0.7071068 1.944911 0.00000000 -0.7071068  0.7071068  1.0000000
## [2,]  0.7071068 -0.7071068 0.000000 0.05508882 -0.7071068 -0.7071068 -0.9449112
##            [,8]
## [1,] -0.9449112
## [2,]  1.0000000
```

```
R1 <- L[1]*V[,1]%*%t(V[,1])
R2 <- L[2]*V[,2]%*%t(V[,2])
cbind(R,R1,R1+R2)
```

```
##            [,1]       [,2]       [,3]       [,4]       [,5]       [,6]
## [1,]  1.0000000 -0.9449112  0.9724556 -0.9724556  1.0000000 -0.9449112
## [2,] -0.9449112  1.0000000 -0.9724556  0.9724556 -0.9449112  1.0000000
```

```
svdCX<- svd(CX)
svdCX
```

```
## $d
## [1] 3.9762105 0.4356034
##
## $u
##            [,1]       [,2]
## [1,] -0.5585641  0.5955441
## [2,] -0.2364743 -0.7815028
## [3,]  0.7950384  0.1859586
##
## $v
##            [,1]      [,2]
## [1,]  0.9402716 0.3404253
## [2,] -0.3404253 0.9402716
```

```
U <- svdCX$u
D <- svdCX$d
V <- svdCX$v
round(cbind(CX,U%*%diag(D)%*%t(V)),4)
```

```
##      [,1] [,2] [,3] [,4]
## [1,]   -2    1   -2    1
## [2,]   -1    0   -1    0
## [3,]    3   -1    3   -1
```

```
CX1 <- D[1]*U[,1]%*%t(V[,1])
CX2 <- D[2]*U[,2]%*%t(V[,2])
round(cbind(CX,CX1,CX1+CX2),4)
```

```
##      [,1] [,2]    [,3]    [,4] [,5] [,6]
## [1,]   -2    1 -2.0883  0.7561   -2    1
## [2,]   -1    0 -0.8841  0.3201   -1    0
## [3,]    3   -1  2.9724 -1.0762    3   -1
```

```
s <- apply(x, 2, sd)
Z <- C3%*%x%*%diag(1/s)

svdZ<- svd(Z)
svdZ
```

```
## $d
## [1] 1.9722633 0.3319302
##
## $u
##            [,1]       [,2]
## [1,] -0.6295454  0.5199416
## [2,] -0.1355099 -0.8051731
## [3,]  0.7650553  0.2852315
##
## $v
##            [,1]      [,2]
## [1,]  0.7071068 0.7071068
## [2,] -0.7071068 0.7071068
```

```
U <- svdZ$u
D <- svdZ$d
V <- svdZ$v
round(cbind(CX,U%*%diag(D)%*%t(V)),4)
```

```
##      [,1] [,2]    [,3] [,4]
## [1,]   -2    1 -0.7559    1
## [2,]   -1    0 -0.3780    0
## [3,]    3   -1  1.1339   -1
```

```
Z1 <- D[1]*U[,1]%*%t(V[,1])
Z2 <- D[2]*U[,2]%*%t(V[,2])
round(cbind(Z,Z1,Z1+Z2),4)
```

```
##         [,1] [,2]    [,3]    [,4]    [,5] [,6]
## [1,] -0.7559    1 -0.8780  0.8780 -0.7559    1
## [2,] -0.3780    0 -0.1890  0.1890 -0.3780    0
## [3,]  1.1339   -1  1.0669 -1.0669  1.1339   -1
```

6. 분광분해/SVD (설문)

```
X <- matrix(c(5,1,2,3,2,1,2,1,5,1,4,2,2,2,3,3,3,1,4,2,3),byrow = TRUE, nr=7)
colnames(X) <-
c("x1ab(능력)","x2ap(용모)","x3ch(성품)")
X
```

```
##      x1ab(능력) x2ap(용모) x3ch(성품)
## [1,]          5          1          2
## [2,]          3          2          1
## [3,]          2          1          5
## [4,]          1          4          2
## [5,]          2          2          3
## [6,]          3          3          1
## [7,]          4          2          3
```

```
A <- as.data.frame(X)
A
```

```
##   x1ab(능력) x2ap(용모) x3ch(성품)
## 1          5          1          2
## 2          3          2          1
## 3          2          1          5
## 4          1          4          2
## 5          2          2          3
## 6          3          3          1
## 7          4          2          3
```

```
library(fmsb)
```

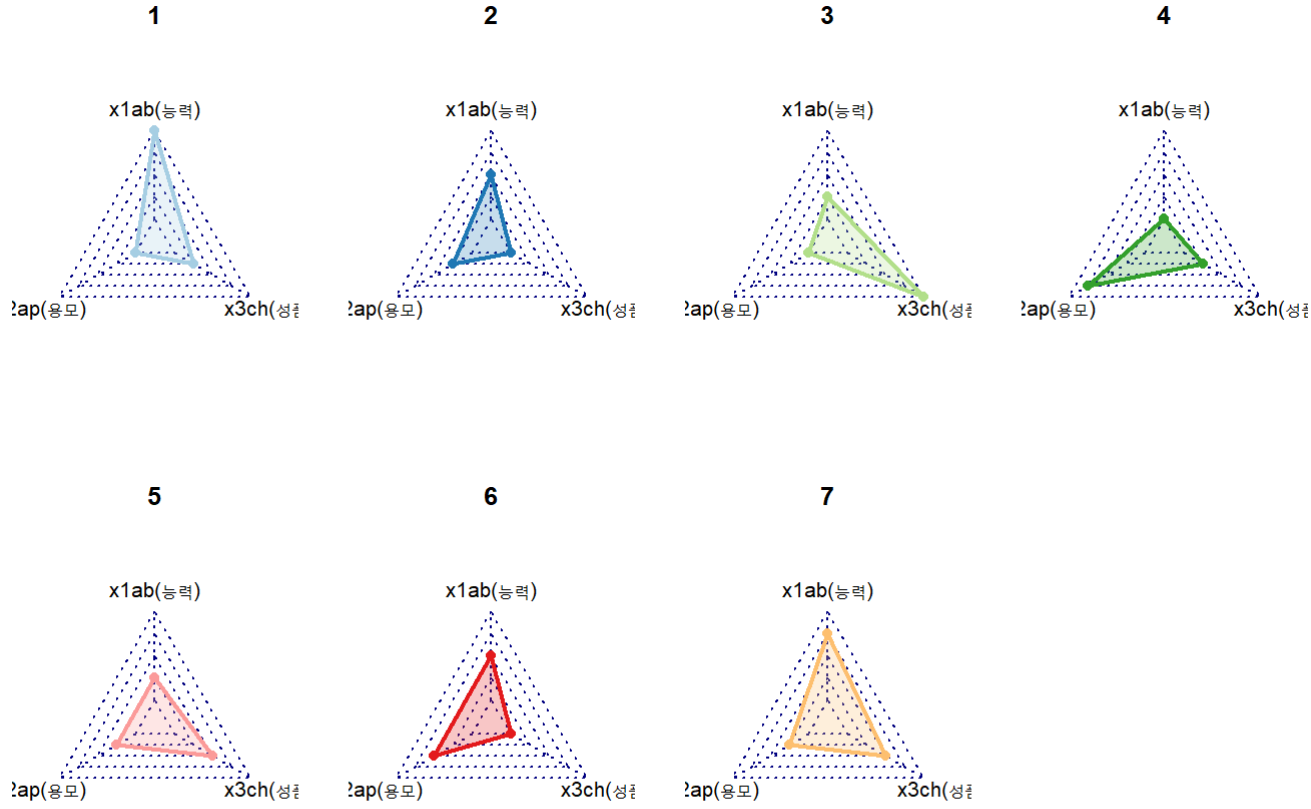
```
## Warning: 패키지 'fmsb'는 R 버전 4.1.1에서 작성되었습니다
```

```
library(RColorBrewer)
```

```
## Warning: 패키지 'RColorBrewer'는 R 버전 4.1.1에서 작성되었습니다
```

```
op <- par(no.readonly = TRUE)
par(mfrow=c(2,4),mar=c(1,1,1,1),oma=rep(0,4))
XX <- rbind(rep(5,3),rep(1,3),A)
col7= brewer.pal(7,'Paired')
for( i in 3:9){
radarchart(XX[c(1,2,i),],
           title= i-2,
           plwd=2,plty=1,
           pcol=col7[i-2],
           pfcol=scales::alpha(col7[i-2],0.25),
           axistype=0,
           calcex=0.75,
           vlabels=c("x1ab(능력)","x2ap(용모)","x3ch(성품)"))}

par(mfrow=c(1,1))
```




```
Z <- scale(X,center=TRUE,scale=TRUE)
Z
```

```
##      x1ab(능력) x2ap(용모) x3ch(성품)
## [1,]  1.5929827 -1.0690450 -0.3067192
## [2,]  0.1061988 -0.1336306 -1.0223973
## [3,] -0.6371931 -1.0690450  1.8403151
## [4,] -1.3805850  1.7371981 -0.3067192
## [5,] -0.6371931 -0.1336306  0.4089589
## [6,]  0.1061988  0.8017837 -1.0223973
## [7,]  0.8495908 -0.1336306  0.4089589
## attr(,"scaled:center")
## x1ab(능력) x2ap(용모) x3ch(성품)
##   2.857143   2.142857   2.428571
## attr(,"scaled:scale")
## x1ab(능력) x2ap(용모) x3ch(성품)
##   1.345185   1.069045   1.397276
```

```
R=cor(X)
R
```

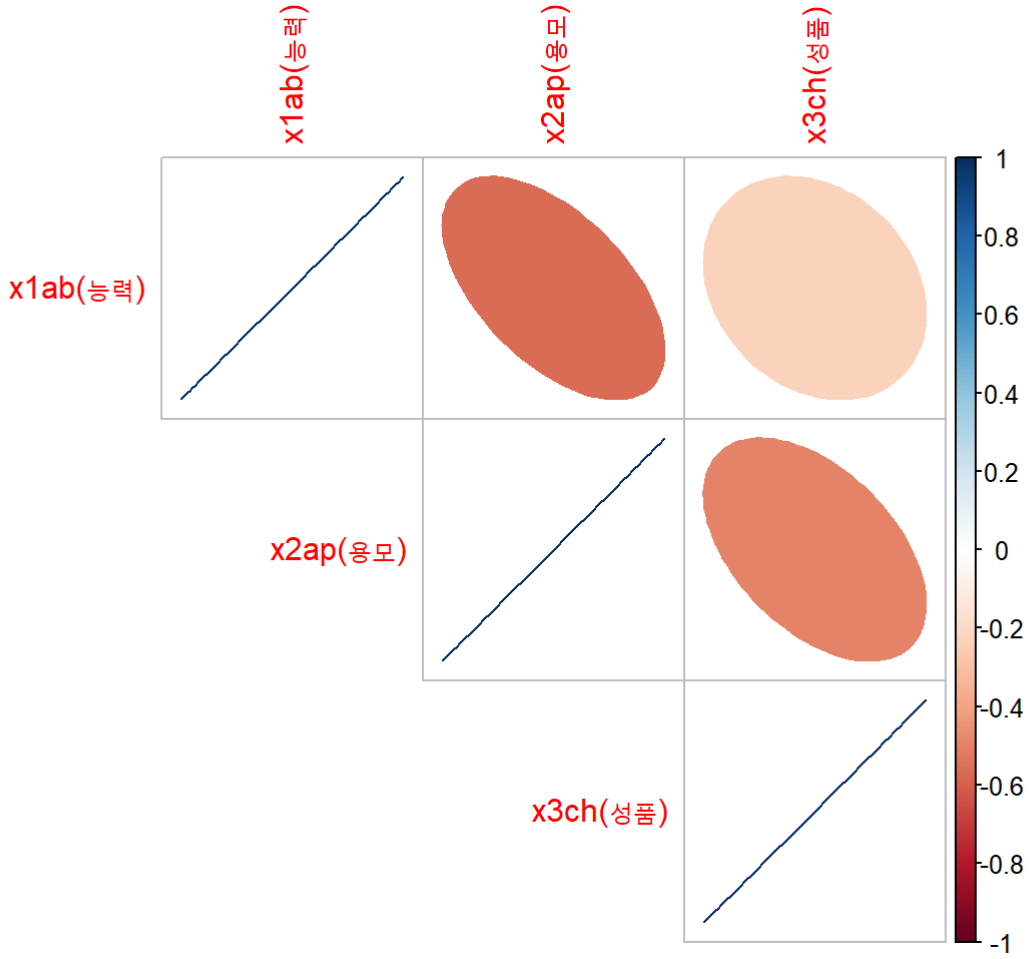
```
##            x1ab(능력) x2ap(용모) x3ch(성품)
## x1ab(능력)  1.0000000 -0.5629263 -0.2280126
## x2ap(용모) -0.5629263  1.0000000 -0.4941220
## x3ch(성품) -0.2280126 -0.4941220  1.0000000
```

```
library(corrplot)
```

```
## Warning: 패키지 'corrplot'는 R 버전 4.1.1에서 작성되었습니다
```

```
## corrplot 0.90 loaded
```

```
## corrplot 0.90 loaded
corrplot(R,method="ellipse",type="upper")
```




```
eigR <- eigen(R)
V <- eigR$vector
L <- eigR$value
cbind(V,diag(L),t(V),V%*%diag(L)%*%t(V))
```

```
##            [,1]        [,2]       [,3]     [,4]     [,5]      [,6]       [,7]
## [1,]  0.5203608  0.64794451 -0.5562307 1.645353 0.000000 0.0000000  0.5203608
## [2,] -0.7567895  0.04816289 -0.6518819 0.000000 1.225659 0.0000000  0.6479445
## [3,]  0.3955936 -0.76016330 -0.5154197 0.000000 0.000000 0.1289879 -0.5562307
##             [,8]       [,9]      [,10]       [,11]       [,12]
## [1,] -0.75678947  0.3955936  1.0000000 -0.5629263 -0.2280126
## [2,]  0.04816289 -0.7601633 -0.5629263  1.0000000 -0.4941220
## [3,] -0.65188191 -0.5154197 -0.2280126 -0.4941220  1.0000000
```

```
R1 <- L[1]*V[,1]%*%t(V[,1])
R2 <- L[2]*V[,2]%*%t(V[,2])

cbind(R,R1,R1+R2)
```

```
##            x1ab(능력) x2ap(용모) x3ch(성품)
## x1ab(능력)  1.0000000 -0.5629263 -0.2280126  0.4455210 -0.6479459  0.3386982
## x2ap(용모) -0.5629263  1.0000000 -0.4941220 -0.6479459  0.9423435 -0.4925876
## x3ch(성품) -0.2280126 -0.4941220  1.0000000  0.3386982 -0.4925876  0.2574884
##
## x1ab(능력)  0.9600921 -0.6096969 -0.2649924
## x2ap(용모) -0.6096969  0.9451866 -0.5374610
## x3ch(성품) -0.2649924 -0.5374610  0.9657334
```

```
Y <- Z%*%V
Y
```

```
##             [,1]       [,2]        [,3]
## [1,]  1.51663160  1.2138328 -0.03108565
## [2,] -0.24806189  0.8395638  0.55500399
## [3,]  1.20548860 -1.8632940  0.10278283
## [4,] -2.15443171 -0.5777174 -0.20643520
## [5,] -0.06865852 -0.7301774  0.23075225
## [6,] -0.95597362  0.8846161 -0.05477571
## [7,]  0.70500554  0.2331761 -0.59624252
```

```
mean(Y)
```

```
## [1] -7.403036e-17
```

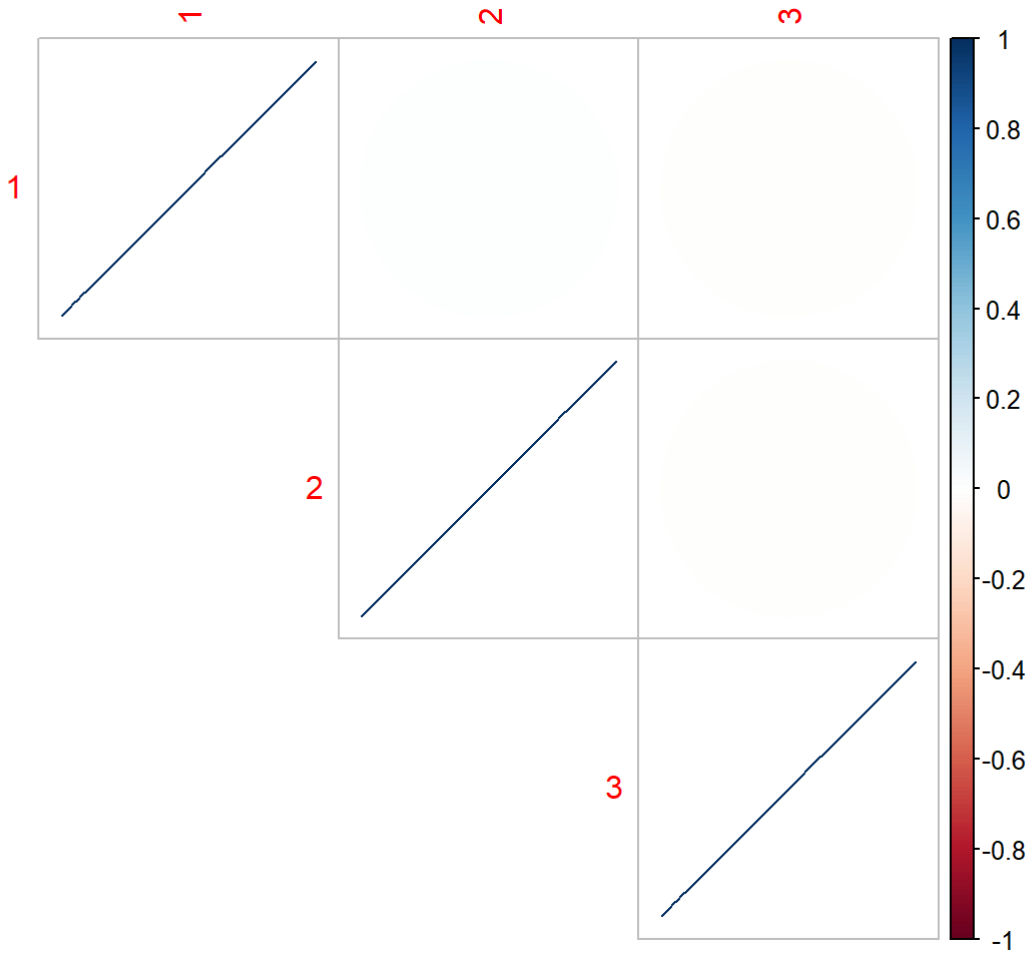
```
D <- cov(Y)
D
```

```
##              [,1]          [,2]          [,3]
## [1,]  1.645353e+00 -7.475122e-17 -1.979256e-16
## [2,] -7.475122e-17  1.225659e+00 -5.856521e-16
## [3,] -1.979256e-16 -5.856521e-16  1.289879e-01
```

```
E <- cor(Y)
E
```

```
##              [,1]          [,2]          [,3]
## [1,]  1.000000e+00 -5.263855e-17 -4.296333e-16
## [2,] -5.263855e-17  1.000000e+00 -1.472924e-15
## [3,] -4.296333e-16 -1.472924e-15  1.000000e+00
```

```
corrplot(E,method="ellipse",type="upper")
```


1
2
3
1
2
3
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1