Chapter 5 Lab

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```
## [1] "adjoint"  "cofactor" "minor"
```

5.

5.1

(a) $A = \begin{bmatrix} 6 & 13 \\ 5 & 12 \end{bmatrix}$

```
(A1 <- matrix(c(6, 5, 13, 12), 2))
```

```
##      [,1] [,2]
## [1,]    6   13
## [2,]    5   12
```

```
minor(A1, 1, 1)
```

```
## [1] 12
```

```
minor(A1, 2, 1)
```

```
## [1] 13
```

```
minor(A1, 1, 2)
```

```
## [1] 5
```

```
minor(A1, 2, 2)
```

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

```
cofactor(A1, 1, 1)
```

```
## [1] 12
```

```
cofactor(A1, 2, 1)
```

```
## [1] -13
```

```
cofactor(A1, 1, 2)
```

```
## [1] -5
```

```
cofactor(A1, 2, 2)
```

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

```
A1[1, 1]*cofactor(A1, 1, 1) + A1[2, 1]*cofactor(A1, 2, 1)
```

```
## [1] 7
```

```
A1[1, 2]*cofactor(A1, 1, 2) + A1[2, 2]*cofactor(A1, 2, 2)
```

```
## [1] 7
```

```
det(A1)
```

```
## [1] 7
```

```
adjoint(A1)
```

```
##      [,1] [,2]
## [1,]   12  -13
## [2,]   -5    6
```

```
1/det(A1) * adjoint(A1)
```

```
##            [,1]       [,2]
## [1,]  1.7142857 -1.8571429
## [2,] -0.7142857  0.8571429
```

```
solve(A1)
```

```
##            [,1]       [,2]
## [1,]  1.7142857 -1.8571429
## [2,] -0.7142857  0.8571429
```

```
A1 %*% solve(A1)
```

```
##      [,1] [,2]
## [1,]    1    0
## [2,]    0    1
```

```
solve(A1) %*% A1
```

```
##      [,1] [,2]
## [1,]    1    0
## [2,]    0    1
```

(b) $B = \begin{bmatrix} 3 & -4 \\ 7 & 14 \end{bmatrix}$

```
(B1 <- matrix(c(3, 7, -4, 14), 2))
```

```
##      [,1] [,2]
## [1,]    3   -4
## [2,]    7   14
```

```
minor(B1, 1, 1)
```

```
## [1] 14
```

```
minor(B1, 2, 1)
```

```
## [1] -4
```

```
minor(B1, 1, 2)
```

```
## [1] 7
```

```
minor(B1, 2, 2)
```

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

```
cofactor(B1, 1, 1)
```

```
## [1] 14
```

```
cofactor(B1, 2, 1)
```

```
## [1] 4
```

```
cofactor(B1, 1, 2)
```

```
## [1] -7
```

```
cofactor(B1, 2, 2)
```

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

```
B1[1, 1]*cofactor(B1, 1, 1) + B1[2, 1]*cofactor(B1, 2, 1)
```

```
## [1] 70
```

```
B1[1, 2]*cofactor(B1, 1, 2) + B1[2, 2]*cofactor(B1, 2, 2)
```

```
## [1] 70
```

```
det(B1)
```

```
## [1] 70
```

```
adjoint(B1)
```

```
##      [,1] [,2]
## [1,]   14    4
## [2,]   -7    3
```

```
1/det(B1) * adjoint(B1)
```

```
##      [,1]       [,2]
## [1,]  0.2 0.05714286
## [2,] -0.1 0.04285714
```

```
solve(B1)
```

```
##      [,1]       [,2]
## [1,]  0.2 0.05714286
## [2,] -0.1 0.04285714
```

```
B1 %*% solve(B1)
```

```
##      [,1] [,2]
## [1,]    1    0
## [2,]    0    1
```

```
solve(B1) %*% B1
```

```
##               [,1] [,2]
## [1,]  1.000000e+00    0
## [2,] -5.551115e-17    1
```

```
round(solve(B1) %*% B1, digits = 2)
```

```
##      [,1] [,2]
## [1,]    1    0
## [2,]    0    1
```

5.2

```
A1 %*% B1
```

```
##      [,1] [,2]
## [1,]  109  158
## [2,]   99  148
```

```
solve(A1 %*% B1)
```

```
##            [,1]      [,2]
## [1,]  0.3020408 -0.322449
## [2,] -0.2020408  0.222449
```

```
solve(B1)
```

```
##      [,1]       [,2]
## [1,]  0.2 0.05714286
## [2,] -0.1 0.04285714
```

```
solve(A1)
```

```
##            [,1]       [,2]
## [1,]  1.7142857 -1.8571429
## [2,] -0.7142857  0.8571429
```

```
solve(B1) %*% solve(A1)
```

```
##            [,1]      [,2]
## [1,]  0.3020408 -0.322449
## [2,] -0.2020408  0.222449
```

5.3

(a) $A = \begin{bmatrix} -1 & 3 & 0 \\ 0 & 2 & 1 \\ 1 & 0 & 4 \end{bmatrix}$

```
(A3 <- matrix(c(-1, 0, 1, 3, 2, 0, 0, 1, 4), 3))
```

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

```
minor(A3, 1, 1)
```

```
## [1] 8
```

```
minor(A3, 2, 1)
```

```
## [1] 12
```

```
minor(A3, 3, 1)
```

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

```
minor(A3, 1, 2)
```

```
## [1] -1
```

```
minor(A3, 2, 2)
```

```
## [1] -4
```

```
minor(A3, 3, 2)
```

```
## [1] -1
```

```
minor(A3, 1, 3)
```

```
## [1] -2
```

```
minor(A3, 2, 3)
```

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

```
minor(A3, 3, 3)
```

```
## [1] -2
```

```
cofactor(A3, 1, 1)
```

```
## [1] 8
```

```
cofactor(A3, 2, 1)
```

```
## [1] -12
```

```
cofactor(A3, 3, 1)
```

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

```
cofactor(A3, 1, 2)
```

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

```
cofactor(A3, 2, 2)
```

```
## [1] -4
```

```
cofactor(A3, 3, 2)
```

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

```
cofactor(A3, 1, 3)
```

```
## [1] -2
```

```
cofactor(A3, 2, 3)
```

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

```
cofactor(A3, 3, 3)
```

```
## [1] -2
```

```
A3[1, 1]*cofactor(A3, 1, 1) + A3[2, 1]*cofactor(A3, 2, 1) + A3[3, 1]*cofactor(A
3, 3, 1)
```

```
## [1] -5
```

```
A3[1, 2]*cofactor(A3, 1, 2) + A3[2, 2]*cofactor(A3, 2, 2) + A3[3, 2]*cofactor(A
3, 3, 2)
```

```
## [1] -5
```

```
A3[1, 3]*cofactor(A3, 1, 3) + A3[2, 3]*cofactor(A3, 2, 3) + A3[3, 3]*cofactor(A
3, 3, 3)
```

```
## [1] -5
```

```
det(A3)
```

```
## [1] -5
```

```
adjoint(A3)
```

```
##      [,1] [,2] [,3]
## [1,]    8  -12    3
## [2,]    1   -4    1
## [3,]   -2    3   -2
```

```
1/det(A3) * adjoint(A3)
```

```
##      [,1] [,2] [,3]
## [1,] -1.6  2.4 -0.6
## [2,] -0.2  0.8 -0.2
## [3,]  0.4 -0.6  0.4
```

```
solve(A3)
```

```
##      [,1] [,2] [,3]
## [1,] -1.6  2.4 -0.6
## [2,] -0.2  0.8 -0.2
## [3,]  0.4 -0.6  0.4
```

```
A3 %*% solve(A3)
```

```
##               [,1] [,2]          [,3]
## [1,]  1.000000e+00    0  0.000000e+00
## [2,] -5.551115e-17    1 -5.551115e-17
## [3,]  0.000000e+00    0  1.000000e+00
```

```
round(A3 %*% solve(A3), digits = 2)
```

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

```
solve(A3) %*% A3
```

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

(b) $B = \begin{bmatrix} 10 & 6 & -1 \\ 6 & 5 & 4 \\ -1 & 4 & 17 \end{bmatrix}$

```
(B3 <- matrix(c(10, 6, -1, 6, 5, 4, -1, 4, 17), 3))
```

```
##      [,1] [,2] [,3]
## [1,]   10    6   -1
## [2,]    6    5    4
## [3,]   -1    4   17
```

```
minor(B3, 1, 1)
```

```
## [1] 69
```

```
minor(B3, 2, 1)
```

```
## [1] 106
```

```
minor(B3, 3, 1)
```

```
## [1] 29
```

```
minor(B3, 1, 2)
```

```
## [1] 106
```

```
minor(B3, 2, 2)
```

```
## [1] 169
```

```
minor(B3, 3, 2)
```

```
## [1] 46
```

```
minor(B3, 1, 3)
```

```
## [1] 29
```

```
minor(B3, 2, 3)
```

```
## [1] 46
```

```
minor(B3, 3, 3)
```

```
## [1] 14
```

```
cofactor(B3, 1, 1)
```

```
## [1] 69
```

```
cofactor(B3, 2, 1)
```

```
## [1] -106
```

```
cofactor(B3, 3, 1)
```

```
## [1] 29
```

```
cofactor(B3, 1, 2)
```

```
## [1] -106
```

```
cofactor(B3, 2, 2)
```

```
## [1] 169
```

```
cofactor(B3, 3, 2)
```

```
## [1] -46
```

```
cofactor(B3, 1, 3)
```

```
## [1] 29
```

```
cofactor(B3, 2, 3)
```

```
## [1] -46
```

```
cofactor(B3, 3, 3)
```

```
## [1] 14
```

```
B3[1, 1]*cofactor(B3, 1, 1) + B3[2, 1]*cofactor(B3, 2, 1) + B3[3, 1]*cofactor(B
3, 3, 1)
```

```
## [1] 25
```

```
B3[1, 2]*cofactor(B3, 1, 2) + B3[2, 2]*cofactor(B3, 2, 2) + B3[3, 2]*cofactor(B
3, 3, 2)
```

```
## [1] 25
```

```
B3[1, 3]*cofactor(B3, 1, 3) + B3[2, 3]*cofactor(B3, 2, 3) + B3[3, 3]*cofactor(B
3, 3, 3)
```

```
## [1] 25
```

```
det(B3)
```

```
## [1] 25
```

```
adjoint(B3)
```

```
##      [,1] [,2] [,3]
## [1,]   69 -106   29
## [2,] -106  169  -46
## [3,]   29  -46   14
```

```
1/det(B3) * adjoint(B3)
```

```
##       [,1]  [,2]  [,3]
## [1,]  2.76 -4.24  1.16
## [2,] -4.24  6.76 -1.84
## [3,]  1.16 -1.84  0.56
```

```
solve(B3)
```

```
##       [,1]  [,2]  [,3]
## [1,]  2.76 -4.24  1.16
## [2,] -4.24  6.76 -1.84
## [3,]  1.16 -1.84  0.56
```

```
B3 %*% solve(B3)
```

```
##               [,1]         [,2]         [,3]
## [1,]  1.000000e+00 1.998401e-15 7.771561e-16
## [2,] -3.552714e-15 1.000000e+00 4.440892e-16
## [3,]  3.552714e-15 0.000000e+00 1.000000e+00
```

```
round(B3 %*% solve(B3), digits = 2)
```

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

```
solve(B3) %*% B3
```

```
##              [,1]          [,2]          [,3]
## [1,] 1.000000e+00 -3.552714e-15  3.552714e-15
## [2,] 2.220446e-15  1.000000e+00 -3.552714e-15
## [3,] 2.553513e-15  4.440892e-16  1.000000e+00
```

```
round(solve(B3) %*% B3, digits = 2)
```

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

(c) $C = (1/10)\begin{bmatrix} -0 & -10 & 0 \\ -6 & 0 & -8 \\ 8 & 0 & -6 \end{bmatrix}$

```
(C3 <- (1/10)*matrix(c(0, -10, 0, -6, 0, -8, 8, 0, -6), 3))
```

```
##      [,1] [,2] [,3]
## [1,]    0 -0.6  0.8
## [2,]   -1  0.0  0.0
## [3,]    0 -0.8 -0.6
```

```
minor(C3, 1, 1)
```

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

```
minor(C3, 2, 1)
```

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

```
minor(C3, 3, 1)
```

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

```
minor(C3, 1, 2)
```

```
## [1] 0.6
```

```
minor(C3, 2, 2)
```

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

```
minor(C3, 3, 2)
```

```
## [1] 0.8
```

```
minor(C3, 1, 3)
```

```
## [1] 0.8
```

```
minor(C3, 2, 3)
```

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

```
minor(C3, 3, 3)
```

```
## [1] -0.6
```

```
cofactor(C3, 1, 1)
```

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

```
cofactor(C3, 2, 1)
```

```
## [1] -1
```

```
cofactor(C3, 3, 1)
```

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

```
cofactor(C3, 1, 2)
```

```
## [1] -0.6
```

```
cofactor(C3, 2, 2)
```

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

```
cofactor(C3, 3, 2)
```

```
## [1] -0.8
```

```
cofactor(C3, 1, 3)
```

```
## [1] 0.8
```

```
cofactor(C3, 2, 3)
```

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

```
cofactor(C3, 3, 3)
```

```
## [1] -0.6
```

```
C3[1, 1]*cofactor(C3, 1, 1) + C3[2, 1]*cofactor(C3, 2, 1) + C3[3, 1]*cofactor(C
3, 3, 1)
```

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

```
C3[1, 2]*cofactor(C3, 1, 2) + C3[2, 2]*cofactor(C3, 2, 2) + C3[3, 2]*cofactor(C
3, 3, 2)
```

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

```
C3[1, 3]*cofactor(C3, 1, 3) + C3[2, 3]*cofactor(C3, 2, 3) + C3[3, 3]*cofactor(C
3, 3, 3)
```

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

```
det(C3)
```

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

```
adjoint(C3)
```

```
##      [,1] [,2] [,3]
## [1,]  0.0   -1  0.0
## [2,] -0.6    0 -0.8
## [3,]  0.8    0 -0.6
```

```
1/det(C3) * adjoint(C3)
```

```
##      [,1] [,2] [,3]
## [1,]  0.0   -1  0.0
## [2,] -0.6    0 -0.8
## [3,]  0.8    0 -0.6
```

```
solve(C3)
```

```
##      [,1] [,2] [,3]
## [1,]  0.0   -1  0.0
## [2,] -0.6    0 -0.8
## [3,]  0.8    0 -0.6
```

```
t(C3)
```

```
##      [,1] [,2] [,3]
## [1,]  0.0   -1  0.0
## [2,] -0.6    0 -0.8
## [3,]  0.8    0 -0.6
```

```
C3 %*% solve(C3)
```

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

```
round(C3 %*% solve(C3), digits = 2)
```

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

```
solve(C3) %*% C3
```

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

5.4

(a) $\begin{bmatrix} 7 & 3 \\ 8 & 9 \end{bmatrix}$

```
matrix(c(7, 8, 3, 9), 2)
```

```
##      [,1] [,2]
## [1,]    7    3
## [2,]    8    9
```

```
det(matrix(c(7, 8, 3, 9), 2))
```

```
## [1] 39
```

```
adjoint(matrix(c(7, 8, 3, 9), 2))
```

```
##      [,1] [,2]
## [1,]    9   -3
## [2,]   -8    7
```

```
solve(matrix(c(7, 8, 3, 9), 2))
```

```
##            [,1]        [,2]
## [1,]  0.2307692 -0.07692308
## [2,] -0.2051282  0.17948718
```

(b) $\begin{bmatrix} 6 & 31 \\ 8 & 29 \end{bmatrix}$

```
matrix(c(6, 8, 31, 29), 2)
```

```
##      [,1] [,2]
## [1,]    6   31
## [2,]    8   29
```

```
det(matrix(c(6, 8, 31, 29), 2))
```

```
## [1] -74
```

```
adjoint(matrix(c(6, 8, 31, 29), 2))
```

```
##      [,1] [,2]
## [1,]   29  -31
## [2,]   -8    6
```

```
solve(matrix(c(6, 8, 31, 29), 2))
```

```
##            [,1]        [,2]
## [1,] -0.3918919  0.41891892
## [2,]  0.1081081 -0.08108108
```

(c) $\begin{bmatrix} -7 & -4 \\ 3 & 1 \end{bmatrix}$

```
matrix(c(-7, 3, -4, 1), 2)
```

```
##      [,1] [,2]
## [1,]   -7   -4
## [2,]    3    1
```

```
det(matrix(c(-7, 3, -4, 1), 2))
```

```
## [1] 5
```

```
adjoint(matrix(c(-7, 3, -4, 1), 2))
```

```
##      [,1] [,2]
## [1,]    1    4
## [2,]   -3   -7
```

```
solve(matrix(c(-7, 3, -4, 1), 2))
```

```
##      [,1] [,2]
## [1,]  0.2  0.8
## [2,] -0.6 -1.4
```

(d) $\begin{bmatrix} 1 & 5 & -5 \\ 3 & 2 & -5 \\ 6 & -2 & -5 \end{bmatrix}$

```
matrix(c(1, 3, 6, 5, 2, -2, -5, -5, -5), 3)
```

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

```
det(matrix(c(1, 3, 6, 5, 2, -2, -5, -5, -5), 3))
```

```
## [1] -5
```

```
adjoint(matrix(c(1, 3, 6, 5, 2, -2, -5, -5, -5), 3))
```

```
##      [,1] [,2] [,3]
## [1,]  -20   35  -15
## [2,]  -15   25  -10
## [3,]  -18   32  -13
```

```
solve(matrix(c(1, 3, 6, 5, 2, -2, -5, -5, -5), 3))
```

```
##      [,1] [,2] [,3]
## [1,]  4.0 -7.0  3.0
## [2,]  3.0 -5.0  2.0
## [3,]  3.6 -6.4  2.6
```

(e) $\begin{bmatrix} -3 & -3 & -2 \\ 2 & 5 & 3 \\ -6 & -7 & -4 \end{bmatrix}$

```
matrix(c(-3, -3, -2, 2, 5, 3, -6, -7, -4), 3)
```

```
##      [,1] [,2] [,3]
## [1,]   -3    2   -6
## [2,]   -3    5   -7
## [3,]   -2    3   -4
```

```
det(matrix(c(-3, -3, -2, 2, 5, 3, -6, -7, -4), 3))
```

```
## [1] -5
```

```
adjoint(matrix(c(-3, -3, -2, 2, 5, 3, -6, -7, -4), 3))
```

```
##      [,1] [,2] [,3]
## [1,]    1  -10   16
## [2,]    2    0   -3
## [3,]    1    5   -9
```

```
solve(matrix(c(-3, -3, -2, 2, 5, 3, -6, -7, -4), 3))
```

```
##      [,1] [,2] [,3]
## [1,] -0.2    2 -3.2
## [2,] -0.4    0  0.6
## [3,] -0.2   -1  1.8
```

(f) $\begin{bmatrix} 2 & -5 & 1 \\ 1 & 1 & 4 \\ 3 & 0 & -2 \end{bmatrix}$

```
matrix(c(2, -5, 1, 1, 1, 4, 3, 0, -2), 3)
```

```
##      [,1] [,2] [,3]
## [1,]    2    1    3
## [2,]   -5    1    0
## [3,]    1    4   -2
```

```
det(matrix(c(2, -5, 1, 1, 1, 4, 3, 0, -2), 3))
```

```
## [1] -77
```

```
adjoint(matrix(c(2, -5, 1, 1, 1, 4, 3, 0, -2), 3))
```

```
##      [,1] [,2] [,3]
## [1,]   -2   14   -3
## [2,]  -10   -7  -15
## [3,]  -21   -7    7
```

```
solve(matrix(c(2, -5, 1, 1, 1, 4, 3, 0, -2), 3))
```

```
##            [,1]        [,2]        [,3]
## [1,] 0.02597403 -0.18181818  0.03896104
## [2,] 0.12987013  0.09090909  0.19480519
## [3,] 0.27272727  0.09090909 -0.09090909
```

(g) $\begin{bmatrix} -1 & -2 & 1 \\ -2 & 2 & -2 \\ 1 & -2 & -1 \end{bmatrix}$

```
matrix(c(-1, -2, 1, -2, 2, -2, 1, -2, -1), 3)
```

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

```
det(matrix(c(-1, -2, 1, -2, 2, -2, 1, -2, -1), 3))
```

```
## [1] 16
```

```
adjoint(matrix(c(-1, -2, 1, -2, 2, -2, 1, -2, -1), 3))
```

```
##      [,1] [,2] [,3]
## [1,]   -6   -4    2
## [2,]   -4    0   -4
## [3,]    2   -4   -6
```

```
solve(matrix(c(-1, -2, 1, -2, 2, -2, 1, -2, -1), 3))
```

```
##        [,1]  [,2]   [,3]
## [1,] -0.375 -0.25  0.125
## [2,] -0.250  0.00 -0.250
## [3,]  0.125 -0.25 -0.375
```

(h) $\begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix}$

```
# install.packages("Matrix", repos = "https://cran.rstudio.com")
library(Matrix)
matrix(c(1, -2, 1, -2, 4, -2, 1, -2, 1), 3)
```

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

```
det(matrix(c(1, -2, 1, -2, 4, -2, 1, -2, 1), 3))
```

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

```
adjoint(matrix(c(1, -2, 1, -2, 4, -2, 1, -2, 1), 3))
```

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

```
# solve(matrix(c(1, -2, 1, -2, 4, -2, 1, -2, 1), 3))
rankMatrix(matrix(c(1, -2, 1, -2, 4, -2, 1, -2, 1), 3))
```

```
## [1] 1
## attr(,"method")
## [1] "tolNorm2"
## attr(,"useGrad")
## [1] FALSE
## attr(,"tol")
## [1] 6.661338e-16
```

(i) $\begin{bmatrix} 7 & 4 & -1 \\ 4 & 7 & -1 \\ -4 & -4 & 4 \end{bmatrix}$

```
matrix(c(7, 4, -4, 4, 7, -4, -1, -1, 4), 3)
```

```
##      [,1] [,2] [,3]
## [1,]    7    4   -1
## [2,]    4    7   -1
## [3,]   -4   -4    4
```

```
det(matrix(c(7, 4, -4, 4, 7, -4, -1, -1, 4), 3))
```

```
## [1] 108
```

```
adjoint(matrix(c(7, 4, -4, 4, 7, -4, -1, -1, 4), 3))
```

```
##      [,1] [,2] [,3]
## [1,]   24  -12    3
## [2,]  -12   24    3
## [3,]   12   12   33
```

```
solve(matrix(c(7, 4, -4, 4, 7, -4, -1, -1, 4), 3))
```

```
##            [,1]       [,2]       [,3]
## [1,]  0.2222222 -0.1111111 0.02777778
## [2,] -0.1111111  0.2222222 0.02777778
## [3,]  0.1111111  0.1111111 0.30555556
```

자료 저장

```
save.image("chapter_5_lab.rda")
```