លំហាត់ទី ២២

```
> x1=c(532,478,530,508,514,556,541,513,532,537,499,510,490,516,482)
> x2=c(6,4,7,7,5,6,4,6,5,5,3,8,4,8,7)
> x3=c(44,51,45,46,44,46,49,52,46,46,48,47,48,45,43)
>
> y=c(1840,1746,1812,1806,1792,1825,1811,1803,1830,1827,1764,1825,1763,1846,1815)
> x=matrix(c(rep (1,15),x1,x2,x3), ncol=4,nrow=15)
> x
      [,1] [,2] [,3] [,4]
 [1,]    1  532    6   44
 [2,]    1  478    4   51
 [3,]    1  530    7   45
 [4,]    1  508    7   46
 [5,]    1  514    5   44
 [6,]    1  556    6   46
 [7,]    1  541    4   49
 [8,]    1  513    6   52
 [9,]    1  532    5   46
[10,]    1  537    5   46
[11,]    1  499    3   48
[12,]    1  510    8   47
[13,]    1  490    4   48
[14,]    1  516    8   45
[15,]    1  482    7   43

> xx=t (x)%*%x
> xx
     [,1]    [,2]  [,3]   [,4]
[1,]   15    7738    85    700
[2,] 7738 3998828 43902 360943
[3,]   85   43902   515   3942
[4,]  700  360943  3942  32758

> solve(xx)
             [,1]          [,2]          [,3]          [,4]
[1,]  88.52271857 -8.781773e-02 -6.549371e-01 -0.8451965188
[2,]  -0.08781773  1.480315e-04 -5.068072e-05  0.0002515805
[3,]  -0.65493706 -5.068072e-05  3.751051e-02  0.0100397572
[4,]  -0.84519652  2.515805e-04  1.003976e-02  0.0141111974

> xy=t (x)%*%y
> xy
         [,1]
[1,]    27105
[2,] 13988635
[3,]   154024
[4,]  1264323

> bete=solve(xx)%*%xy
```

```
> bete
           [,1]
[1,] 1480.7446116
[2,]    0.7314989
[3,]    9.9914874
[4,]   -2.3082627
```

ឧទាហរណ៍ ២៣

```
> x1=c(140,65,130,115,390,670,205,40,480,810,120,590,440,280,650,150)
> x2=c(12,21,42,80,120,64,43,14,88,98,44,110,38,24,60,24)
> x3=c(1800 ,320,820,76,3600,8400,508,870,5500,9875,6500,9130,1200,890,1200,1300)
>
>
y=c(2800,1300,1230,1600,4500,5700,3150,640,3400,6700,3700,6440,1280,4160,3870,980)
> x=matrix(c(rep(1,16),x1,x2,x3),ncol=4,nrow=16)
> x
      [,1] [,2] [,3] [,4]
 [1,]    1  140   12 1800
 [2,]    1   65   21  320
 [3,]    1  130   42  820
 [4,]    1  115   80   76
 [5,]    1  390  120 3600
 [6,]    1  670   64 8400
 [7,]    1  205   43  508
 [8,]    1   40   14  870
 [9,]    1  480   88 5500
[10,]    1  810   98 9875
[11,]    1  120   44 6500
[12,]    1  590  110 9130
[13,]    1  440   38 1200
[14,]    1  280   24  890
[15,]    1  650   60 1200
[16,]    1  150   24 1300

> xx=t(x)%*%x
> xx
      [,1]     [,2]    [,3]      [,4]
[1,]    16     5275     882     51989
[2,]  5275  2664575  374600  26116730
[3,]   882   374600   66870   3984674
[4,] 51989 26116730 3984674 347290165

> solve(xx)
              [,1]          [,2]          [,3]          [,4]
[1,]  2.453364e-01 -1.995035e-04 -2.604604e-03  8.160561e-06
[2,] -1.995035e-04  2.461102e-06 -6.027668e-06 -8.605383e-08
[3,] -2.604604e-03 -6.027668e-06  1.037929e-04 -3.476838e-07
[4,]  8.160561e-06 -8.605383e-08 -3.476838e-07  1.211837e-08
```

```
> xy=t(x)%*%y
> xy
          [,1]
[1,]     51450
[2,]  22758850
[3,]   3520970
[4,] 251689300
> bete=solve(xx)%*%xy
> bete
            [,1]
[1,] 965.2808939
[2,]   2.8653231
[3,]   6.7537560
[4,]   0.2872553
```

លំហាត់ទី ២៤

```
> x1=c(190, 121, 161, 161, 179, 99, 114, 202, 184, 90, 181, 143, 132, 127, 153,
145, 174, 177, 188, 153, 150, 173, 163, 150, 139)
> x2=c(14, 15, 14, 14, 14, 14, 15, 14, 13, 14, 14, 15, 14, 14, 14, 14, 15, 15, 15,
15, 16, 13, 14, 15, 14)
> x3=c(53, 49, 44, 39, 53, 46, 42, 49, 37, 43, 48, 54, 44, 37, 50, 50, 52, 47, 49,
53, 58, 42, 46, 50, 45)
> x4=c(230, 370, 397, 181, 378, 304, 285, 551, 370, 135, 332, 217, 490, 220, 270,
279, 329, 274, 433, 333, 148, 390, 142, 343, 373)

> y=c(40.3, 39.6, 40.8, 40.3, 40.0, 38.1, 40.4, 40.7, 40.8, 37.1, 39.9, 40.4,
38.0, 39.0, 39.5, 40.6, 40.3, 40.1, 41.7, 40.1, 40.6, 40.4, 40.9, 40.1, 38.5)
> x=matrix(c(rep(1,25),x1,x2,x3,x4),ncol=5,nrow=25)
> x
      [,1] [,2] [,3] [,4] [,5]
 [1,]    1  190   14   53  230
 [2,]    1  121   15   49  370
 [3,]    1  161   14   44  397
 [4,]    1  161   14   39  181
 [5,]    1  179   14   53  378
 [6,]    1   99   14   46  304
 [7,]    1  114   15   42  285
 [8,]    1  202   14   49  551
 [9,]    1  184   13   37  370
[10,]    1   90   14   43  135
[11,]    1  181   14   48  332
[12,]    1  143   15   54  217
[13,]    1  132   14   44  490
[14,]    1  127   14   37  220
[15,]    1  153   14   50  270
[16,]    1  145   14   50  279
[17,]    1  174   15   52  329
[18,]    1  177   15   47  274
[19,]    1  188   15   49  433
```

```
[20,]    1  153   15   53  333
[21,]    1  150   16   58  148
[22,]    1  173   13   42  390
[23,]    1  163   14   46  142
[24,]    1  150   15   50  343
[25,]    1  139   14   45  373

> xx=t(x)%*%x
> xx
     [,1]    [,2]   [,3]   [,4]    [,5]
[1,]   25    3849    358   1180    7774
[2,] 3849  612555  55049 182491 1223026
[3,]  358   55049   5138  16953  110956
[4,] 1180  182491  16953  56392  366416
[5,] 7774 1223026 110956 366416 2684616

> solve(xx)
             [,1]          [,2]          [,3]          [,4]          [,5]
[1,] 25.511713049 -1.564751e-02 -1.8954295019  9.993004e-02 -2.047756e-03
[2,] -0.015647507  6.766347e-05  0.0010314042 -1.657402e-04 -5.520750e-06
[3,] -1.895429502  1.031404e-03  0.1665362812 -1.439384e-02  1.004122e-04
[4,]  0.099930035 -1.657402e-04 -0.0143938389  2.778662e-03  1.782448e-06
[5,] -0.002047756 -5.520750e-06  0.0001004122  1.782448e-06  4.424031e-06

> xy=t(x)%*%y
> xy
         [,1]
[1,]    998.2
[2,] 154206.6
[3,]  14297.5
[4,]  47148.0
[5,] 310708.4

> bete=solve(xx)%*%xy
> bete
             [,1]
[1,] 28.186258525
[2,]  0.031652240
[3,]  0.642266980
[4,] -0.041823083
[5,] -0.001140504
```

លំហាត់ទី ២៥

```
> x1=c(190, 121, 161, 161, 179, 99, 114, 202, 184, 90, 181, 143, 132, 127, 153,
145, 174, 177, 188, 153, 150, 173, 163, 150, 139)
> x2=c(14, 15, 14, 14, 14, 14, 15, 14, 13, 14, 14, 15, 14, 14, 14, 14, 15, 15, 15,
15, 16, 13, 14, 15, 14)
> x3=c(53, 49, 44, 39, 53, 46, 42, 49, 37, 43, 48, 54, 44, 37, 50, 50, 52, 47, 49,
```

```
53, 58, 42, 46, 50, 45)
> x4=c(230, 370, 397, 181, 378, 304, 285, 551, 370, 135, 332, 217, 490, 220, 270,
279, 329, 274, 433, 333, 148, 390, 142, 343, 373)
>
> y=c(40.3, 39.6, 40.8, 40.3, 40.0, 38.1, 40.4, 40.7, 40.8, 37.1, 39.9, 40.4,
38.0, 39.0, 39.5, 40.6, 40.3, 40.1, 41.7, 40.1, 40.6, 40.4, 40.9, 40.1, 38.5)
> x=matrix(c(rep(1,25),x1,x2,x3,x4),ncol=5,nrow=25)
> x
      [,1] [,2] [,3] [,4] [,5]
 [1,]    1  190   14   53  230
 [2,]    1  121   15   49  370
 [3,]    1  161   14   44  397
 [4,]    1  161   14   39  181
 [5,]    1  179   14   53  378
 [6,]    1   99   14   46  304
 [7,]    1  114   15   42  285
 [8,]    1  202   14   49  551
 [9,]    1  184   13   37  370
[10,]    1   90   14   43  135
[11,]    1  181   14   48  332
[12,]    1  143   15   54  217
[13,]    1  132   14   44  490
[14,]    1  127   14   37  220
[15,]    1  153   14   50  270
[16,]    1  145   14   50  279
[17,]    1  174   15   52  329
[18,]    1  177   15   47  274
[19,]    1  188   15   49  433
[20,]    1  153   15   53  333
[21,]    1  150   16   58  148
[22,]    1  173   13   42  390
[23,]    1  163   14   46  142
[24,]    1  150   15   50  343
[25,]    1  139   14   45  373
>
> xx=t(x)%*%x
> xx
     [,1]    [,2]   [,3]   [,4]    [,5]
[1,]   25    3849    358   1180    7774
[2,] 3849  612555  55049 182491 1223026
[3,]  358   55049   5138  16953  110956
[4,] 1180  182491  16953  56392  366416
[5,] 7774 1223026 110956 366416 2684616
>
>
> solve(xx)
             [,1]          [,2]          [,3]          [,4]          [,5]
[1,] 25.511713049 -1.564751e-02 -1.8954295019  9.993004e-02 -2.047756e-03
[2,] -0.015647507  6.766347e-05  0.0010314042 -1.657402e-04 -5.520750e-06
[3,] -1.895429502  1.031404e-03  0.1665362812 -1.439384e-02  1.004122e-04
[4,]  0.099930035 -1.657402e-04 -0.0143938389  2.778662e-03  1.782448e-06
[5,] -0.002047756 -5.520750e-06  0.0001004122  1.782448e-06  4.424031e-06
>
>
```

```
>
> xy=t(x)%*%y
> xy
         [,1]
[1,]    998.2
[2,] 154206.6
[3,]  14297.5
[4,]  47148.0
[5,] 310708.4
>
>
> bete=solve(xx)%*%xy
> bete
             [,1]
[1,] 28.186258525
[2,]  0.031652240
[3,]  0.642266980
[4,] -0.041823083
[5,] -0.001140504
> # 25
> income <- c(48157, 48568, 46816, 34876, 35478, 34465, 35026, 38599, 33315)
> age <- c(57.7, 60.7, 47.9, 38.4, 42.8, 35.4, 39.5, 65.6, 27.0)
> pop400 <- c(1,1,1,0,0,0,1,0,0)
> data <- data.frame(income, age, pop400)
> # A.
> cor(age, income)
[1] 0.7214069
> # B.
> model1 <- lm(income ~ age, data = data)
> summary(model1)

Call:
lm(formula = income ~ age, data = data)

Residuals:
   Min     1Q Median     3Q    Max
 -7926  -2061  -1140   3815   6691

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  22804.7     6255.2   3.646  0.00822 **
age            361.6      131.2   2.756  0.02825 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4774 on 7 degrees of freedom
Multiple R-squared:  0.5204,    Adjusted R-squared:  0.4519
F-statistic: 7.596 on 1 and 7 DF,  p-value: 0.02825

> # C.
> model1 <- lm(income ~ age, data = data)
> summary(model1)

Call:
```

```
lm(formula = income ~ age, data = data)

Residuals:
   Min     1Q Median     3Q    Max
 -7926  -2061  -1140   3815   6691

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  22804.7     6255.2   3.646  0.00822 **
age            361.6      131.2   2.756  0.02825 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4774 on 7 degrees of freedom
Multiple R-squared:  0.5204,    Adjusted R-squared:  0.4519
F-statistic: 7.596 on 1 and 7 DF,  p-value: 0.02825

> # D.
> model2 <- lm(income ~ age + pop400, data = data)
> # summary(model2)
> # E.
> summary(model2)

Call:
lm(formula = income ~ age + pop400, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-6622.2  -109.1   731.7  1686.0  3063.6

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  24865.3     4551.9   5.463  0.00157 **
age            250.5      102.4   2.445  0.05010 .
pop400        6887.7     2500.7   2.754  0.03310 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3427 on 6 degrees of freedom
Multiple R-squared:  0.7882,    Adjusted R-squared:  0.7176
F-statistic: 11.16 on 2 and 6 DF,  p-value: 0.0095

> # F.
> hist(residuals(model2))
> qqnorm(residuals(model2))
> qqline(residuals(model2))
> # g.
> plot(fitted(model2), residuals(model2))
> abline(h = 0)
>
```

លំហាត់ ២៦

```
> x1=c(73.98, 54.90, 94.14, 52.02, 65.70, 53.64, 79.74, 68.58, 165.60, 64.80,
138.42, 125.82, 77.58, 171.36, 82.08, 141.30, 36.90, 56.88, 71.82, 69.48, 54.36,
87.66, 38.16, 43.74, 48.42)
> x2=c(4, 2, 4, 1, 2, 4, 3, 4, 5, 1, 3, 1, 7, 2, 9, 3, 5, 4, 1, 3, 2, 5, 3, 7, 5)

> y=c(5.04, 4.08, 5.76, 3.48, 4.20, 4.80, 4.32, 5.04, 6.12, 3.24, 4.80, 3.24,
6.60, 4.92, 6.60, 5.40, 6.00, 5.40, 3.36, 4.68, 4.32, 5.52, 4.56, 5.40, 4.80)
> x=matrix(c(rep(1,25),x1,x2),ncol=3,nrow=25)
> x
      [,1]   [,2] [,3]
 [1,]    1  73.98    4
 [2,]    1  54.90    2
 [3,]    1  94.14    4
 [4,]    1  52.02    1
 [5,]    1  65.70    2
 [6,]    1  53.64    4
 [7,]    1  79.74    3
 [8,]    1  68.58    4
 [9,]    1 165.60    5
[10,]    1  64.80    1
[11,]    1 138.42    3
[12,]    1 125.82    1
[13,]    1  77.58    7
[14,]    1 171.36    2
[15,]    1  82.08    9
[16,]    1 141.30    3
[17,]    1  36.90    5
[18,]    1  56.88    4
[19,]    1  71.82    1
[20,]    1  69.48    3
[21,]    1  54.36    2
[22,]    1  87.66    5
[23,]    1  38.16    3
[24,]    1  43.74    7
[25,]    1  48.42    5

> xx=t(x)%*%x
> xx
        [,1]      [,2]    [,3]
[1,]   25.00   2017.08   90.00
[2,] 2017.08 197945.47 7078.14
[3,]   90.00   7078.14  424.00


> solve(xx)
             [,1]          [,2]          [,3]
[1,]  0.388113857 -2.503489e-03 -4.059010e-02
[2,] -0.002503489  2.868220e-05  5.258823e-05
[3,] -0.040590097  5.258823e-05  1.009642e-02
```

```
> xy=t(x)%*%y
> xy
         [,1]
[1,]  121.680
[2,] 9955.397
[3,]  479.400

> bete=solve(xx)%*%xy
> bete
          [,1]
[1,] 2.8435747
[2,] 0.0061289
[3,] 0.4247572
```
