R Code and Output for the Movie Ratings Example

```
y=c(4,1,3,5,3,3,1)

X=matrix(c(
1,1,0,0,0,1,0,0,
1,1,0,0,0,0,1,0,
1,0,1,0,0,0,1,0,
1,0,1,0,0,0,0,1,
1,0,0,1,0,0,0,1,
1,0,0,0,1,1,0,0,
1,0,0,0,1,0,1,0
),byrow=T,nrow=7)

XX=t(X)%*%X

library(MASS)

XXgi=ginv(XX)
```

```
Px=X%*%XXgi%*%t(X)

Px  #Has entries like -1.110223e-16

round(Px,2)
```

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]
[1,]	0.75	0.25	0	0	0	0.25	-0.25
[2,]	0.25	0.75	0	0	0	-0.25	0.25
[3,]	0.00	0.00	1	0	0	0.00	0.00
[4,]	0.00	0.00	0	1	0	0.00	0.00
[5,]	0.00	0.00	0	0	1	0.00	0.00
[6,]	0.25	-0.25	0	0	0	0.75	0.25
[7,]	-0.25	0.25	0	0	0	0.25	0.75

```
fractions(Px)
```

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]
[1,]	3/4	1/4	0	0	0	1/4	-1/4
[2,]	1/4	3/4	0	0	0	-1/4	1/4
[3,]	0	0	1	0	0	0	0
[4,]	0	0	0	1	0	0	0
[5,]	0	0	0	0	1	0	0
[6,]	1/4	-1/4	0	0	0	3/4	1/4
[7,]	-1/4	1/4	0	0	0	1/4	3/4

```
yhat=Px%*%y

yhat
```

```
     [,1]
[1,] 3.75
[2,] 1.25
[3,] 3.00
[4,] 5.00
[5,] 3.00
[6,] 3.25
[7,] 0.75
```

```
bhat=XXgi%*%t(X)%*%y
```

```
bhat
```

```
              [,1]
[1,]  1.89473684
[2,]  0.22368421
[3,]  1.97368421
[4,] -0.02631579
[5,] -0.27631579
[6,]  1.63157895
[7,] -0.86842105
[8,]  1.13157895
```

```
C=matrix(c(
1,1,0,0,0,1,0,0,
1,1,0,0,0,0,1,0,
1,1,0,0,0,0,0,1,
1,0,1,0,0,1,0,0,
1,0,1,0,0,0,1,0,
1,0,1,0,0,0,0,1,
1,0,0,1,0,1,0,0,
1,0,0,1,0,0,1,0,
1,0,0,1,0,0,0,1,
1,0,0,0,1,1,0,0,
1,0,0,0,1,0,1,0,
1,0,0,0,1,0,0,1
),byrow=T,nrow=12)

Cbhat=C%*%bhat
```

```
Cbhat
      [,1]
 [1,] 3.75
 [2,] 1.25
 [3,] 3.25
 [4,] 5.50
 [5,] 3.00
 [6,] 5.00
 [7,] 3.50
 [8,] 1.00
 [9,] 3.00
[10,] 3.25
[11,] 0.75
[12,] 2.75
```

```
M=matrix(Cbhat,nrow=4,byrow=T)

M
     [,1] [,2] [,3]
[1,] 3.75 1.25 3.25
[2,] 5.50 3.00 5.00
[3,] 3.50 1.00 3.00
[4,] 3.25 0.75 2.75

apply(M,2,mean)

[1] 4.0 1.5 3.5
```

```
C=matrix(c(
0,0,0,0,0,1,-1,0,
0,0,0,0,0,1,0,-1,
0,0,0,0,0,0,1,-1
),byrow=T,nrow=3)
```

```
Cbhat=C%*%bhat
Cbhat
     [,1]
[1,]  2.5
[2,]  0.5
[3,] -2.0
```

```
round(C%*%XXgi%*%t(X),2)
```

```
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]  0.5 -0.5    0    0    0  0.5 -0.5
[2,]  0.5 -0.5    1   -1    0  0.5 -0.5
[3,]  0.0  0.0    1   -1    0  0.0  0.0
```

```
customer=factor(c(1,1,2,2,3,4,4))

movie=factor(c(1,2,2,3,3,1,2))

d=data.frame(customer,movie,y)

d
  customer movie y
1        1     1 4
2        1     2 1
3        2     2 3
4        2     3 5
5        3     3 3
6        4     1 3
7        4     2 1
```

```
o=lm(y~customer+movie,data=d)

model.matrix(o)
```

	(Intercept)	customer2	customer3	customer4	movie2	movie3
1	1	0	0	0	0	0
2	1	0	0	0	1	0
3	1	1	0	0	1	0
4	1	1	0	0	0	1
5	1	0	1	0	0	1
6	1	0	0	1	0	0
7	1	0	0	1	1	0

```
coef(o)
(Intercept)   customer2   customer3
       3.75        1.75       -0.25

  customer4       movie2       movie3
      -0.50        -2.50        -0.50


fitted(o)

   1    2    3    4    5    6    7
3.75 1.25 3.00 5.00 3.00 3.25 0.75

resid(o)
```

```
#The next commands are equivalent to
#coef(o), fitted(o), and resid(o),
#respectively.

o$coe
o$fit
o$res

-o$coe[5]
movie2
   2.5
-o$coe[6]
movie3
   0.5
o$coe[5]-o$coe[6]
movie2
    -2
```

```
C=matrix(c(
0,0,0,0,-1,0,
0,0,0,0,0,-1,
0,0,0,0,1,-1
),byrow=T,nrow=3)

C%*%o$coe
     [,1]
[1,]  2.5
[2,]  0.5
[3,] -2.0
```

```
C=matrix(c(
1,0,0,0,0,0,
1,0,0,0,1,0,
1,0,0,0,0,1,
1,1,0,0,0,0,
1,1,0,0,1,0,
1,1,0,0,0,1,
1,0,1,0,0,0,
1,0,1,0,1,0,
1,0,1,0,0,1,
1,0,0,1,0,0,
1,0,0,1,1,0,
1,0,0,1,0,1
),byrow=T,nrow=12)
```

```
matrix(C%*%o$coe,nrow=4,byrow=T)
```

```
     [,1] [,2] [,3]
[1,] 3.75 1.25 3.25
[2,] 5.50 3.00 5.00
[3,] 3.50 1.00 3.00
[4,] 3.25 0.75 2.75
```