Problem 3.(a)

```
> library(msos)
> data("grades")
> y1 = grades[,2:6]
> x_second1 = rep(1, 107)
> for (i in 1:107){
+   if (grades[i,1] == 1)
+     x_second1[i] = 0.37
+   else
+     x_second1[i] = -0.7
+ }
> x1 = matrix(c(rep(1,107),x_second1), ncol = 2)
> z1 = cbind(1,c(2,2,2,-3,-3),c(1,1,-2,0,0),c(1,-1,0,0,0),
c(0,0,0,1,-1))
> cx = solve(t(x1) %*% x1)
> bsm1 = bothsidesmodel(x1,y1,z1)
> cx
              [,1]          [,2]
[1,]  9.345794e-03 -7.862528e-19
[2,] -7.862528e-19  3.608415e-02
```

3.(b)

```
> bsm1$Beta
          [,1]     [,2]      [,3]      [,4]       [,5]
[1,] 81.615196 1.121545 -0.827866 -1.210981  4.6430841
[2,]  2.876149 1.194678 -1.981507  0.198212 -0.6876791
```

3.(c)

```
> bsm1$Sigmaz
            z1          z2          z3          z4         z5
z1 104.242052 13.8272877 -20.810396 -21.2024732 -3.8981053
z2  13.827288  6.1839223  -6.283455  -5.4067590  0.5149693
z3 -20.810396 -6.2834545  51.947483   3.5001651  1.6014915
z4 -21.202473 -5.4067590   3.500165  24.5936317 -0.5750511
z5  -3.898105  0.5149693   1.601491  -0.5750511 19.6422780
```

3.(d)

```
> bsm1$SE
          [,1]      [,2]      [,3]      [,4]      [,5]
[1,] 0.9870283 0.2404031 0.6967715 0.4794236 0.4284538
[2,] 1.9394550 0.4723786 1.3691168 0.9420405 0.8418877
```

3.(e)

```
> bsm1$T
           [,1]     [,2]      [,3]       [,4]       [,5]
[1,] 82.687801 4.665269 -1.188146 -2.5259107 10.8368363
[2,]  1.482968 2.529070 -1.447289  0.2104071 -0.8168299
```

3.(f)

$\beta_1, \beta_2, \beta_4, \beta_5, \delta_2$ are significantly different from zero.

3.(g)

Since $\delta_2$ is larger than 2, the grades of exams (midterms and final) and other scores (homework, labs, inclass) are significantly different between women and men. There is no strong evidence to conclude the difference of grades for other comparison.

Problem 4.(a)

$\beta_{11}$: overall mean of daily mean temperature
$\beta_{21}$: overall linear effect of latitude on daily mean temperature
$\beta_{31}$: overall quadratic effect of latitude on daily mean temperature
$\beta_{12}$: overall mean daily mean temperature's cosine part
$\beta_{22}$: linear effect of latitude on daily mean temperature's cosine part
$\beta_{32}$: linear effect of latitude on daily mean temperature's sine part
$\beta_{13}$: overall mean daily mean temperature's sine part
$\beta_{23}$: quadratic effect of latitude on daily mean temperature's cosine part
$\beta_{33}$: quadratic effect of latitude on daily mean temperature's sine part

4.(b)

```
> library(msos)
>
> #Problem 4
> mydata = read.csv("coastalcities.csv")
> x_second = rep(1, 12)
> x_third = rep(1, 12)
> for (i in 1:length(x_second)){
+   x_second[i]=cos(2*i/12*pi)
+   x_third[i]=sin(2*i/12*pi)
+ }
>
> y = mydata[,4:15]
> x = matrix(c(rep(1,31),mydata[,3],mydata[,3]^2), ncol = 3)
> qx = qr.Q(qr(x))
> z = matrix(c(rep(1,12),x_second,x_third), ncol = 3)
```

```
> bsm = bothsidesmodel(qx,y,z)
> bsm$Beta
           [,1]        [,2]        [,3]
[1,] -104.16359 13.24976147 10.45525683
[2,]   17.21285 21.11530639 17.01046780
[3,]  -31.99398  0.04341989  0.03296079
```

4.(c)

```
> bsm$SE
          [,1]     [,2]     [,3]
[1,] 2.053272 1.777754 1.644357
[2,] 2.053272 1.777754 1.644357
[3,] 2.053272 1.777754 1.644357
```

4.(d)

```
> bsm$T
           [,1]        [,2]        [,3]
[1,] -50.730549  7.45308901  6.35826386
[2,]   8.383135 11.87751631 10.34475235
[3,] -15.581954  0.02442401  0.02004479
```

from the t-statistics, $\beta_{11},\ \beta_{12},\ \beta_{13},\ \beta_{21},\ \beta_{22},\ \beta_{23},\ \beta_{31}$ exceed 2 in absolute value.

4.(e)

We conclude that linear effect of latitude is significant on daily mean temperature, cosine and sine parts. Also, the quadratic effect of latitude is signifiant on daily mean temperature.