

R output 1 for Question 1

```
express=read.csv("C:\\Users\\thuntida.ngamkham\\OneDrive - University of Calgary\\dataset603\\EXPRESS.csv",header=TRUE)
#express=read.csv("~/OneDrive - University of Calgary/MyCoursesThierry/DATA603/data/dataset603/EXPRESS.csv",header=TRUE)
summary(express)

##           Weight           Distance           Cost
##  Min.      :0.300    Min.      : 45.00    Min.      : 1.000
##  1st Qu.:2.075    1st Qu.: 93.75    1st Qu.: 1.975
##  Median :4.250    Median :160.00    Median : 4.700
##  Mean   :4.058    Mean   :156.05    Mean    : 6.335
##  3rd Qu.:6.275    3rd Qu.:216.75    3rd Qu.: 9.650
##  Max.    :8.100    Max.    :280.00    Max.    :15.500

model<-lm(Cost~Distance+Weight,data=express)
summary(model)

##
## Call:
## lm(formula = Cost ~ Distance + Weight, data = express)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.239 -1.101 -0.129  1.283  2.313
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -4.672757   0.891147  -5.244 6.60e-05 ***
## Distance     0.036936   0.004602   8.026 3.49e-07 ***
## Weight       1.292414   0.137842   9.376 3.95e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.493 on 17 degrees of freedom
## Multiple R-squared:  0.9162, Adjusted R-squared:  0.9063
## F-statistic: 92.89 on 2 and 17 DF,  p-value: 7.066e-10

reducedmodel<-lm(Cost~1,data=express)
coefficients(model)

## (Intercept)      Distance      Weight
## -4.67275662   0.03693551   1.29241393

anova(reducedmodel,model)

## Analysis of Variance Table
##
## Model 1: Cost ~ 1
```

```
## Model 2: Cost ~ Distance + Weight
##   Res.Df    RSS Df Sum of Sq    F    Pr(>F)
## 1      19 452.09
## 2      17  37.90  2    414.18 92.888 7.066e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

confint(model)

##              2.5 %      97.5 %
## (Intercept) -6.55291261 -2.79260064
## Distance      0.02722672  0.04664431
## Weight        1.00159293  1.58323493

confint(model,level=0.99)

##              0.5 %      99.5 %
## (Intercept) -7.25550628 -2.09000697
## Distance      0.02359865  0.05027238
## Weight        0.89291631  1.69191154

newdata1 = data.frame(Weight=150, Distance=6.5)
predict(model,newdata1,interval="predict")

##      fit      lwr      upr
## 1 189.4294 146.5771 232.2817

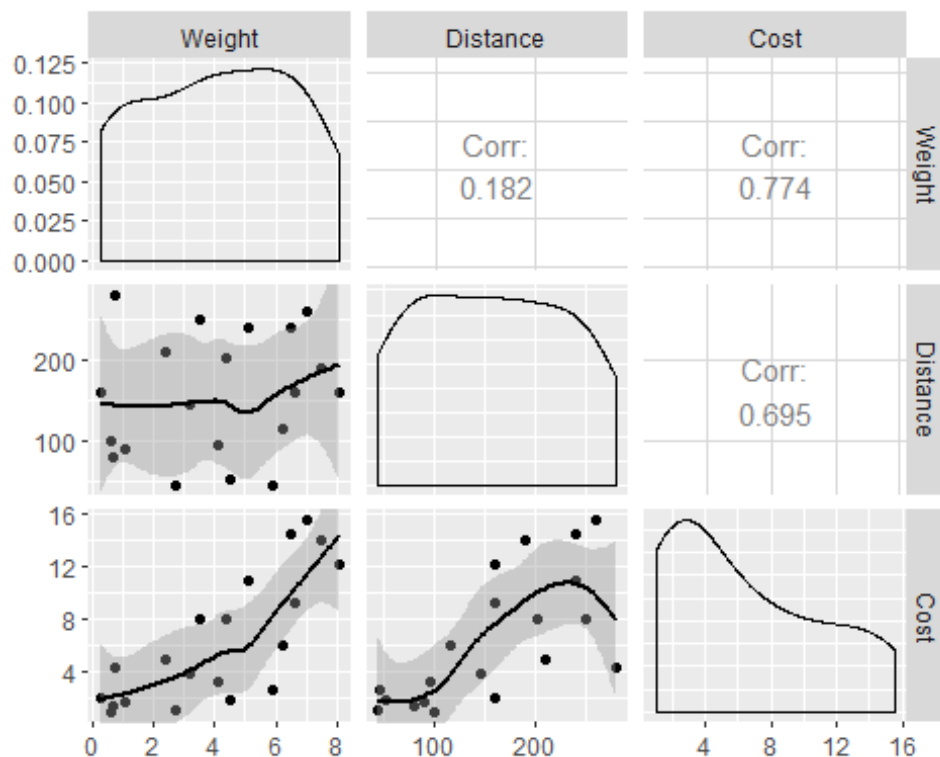
newdata2 = data.frame(Weight=6.5, Distance=150)
predict(model,newdata2,interval="predict")

##      fit      lwr      upr
## 1  9.268261  5.960167 12.57636
```

R output 2 for Question 2

```
library(GGally)

express=read.csv("C:\\Users\\thuntida.ngamkham\\OneDrive - University of Calgary\\dataset603\\EXPRESS.csv",header=TRUE)
#express=read.csv("~/OneDrive - University of Calgary/MyCoursesThierry/DATA603/data/dataset603/EXPRESS.csv",header=TRUE)
#ggpairs(express)
ggpairs(express,lower = list(continuous = "smooth_loess", combo = "facethist", discrete = "facetbar", na = "na"))
```



```
additivemodel<-lm(Cost~Distance+Weight,data=express)
summary(additivemodel)

##
## Call:
## lm(formula = Cost ~ Distance + Weight, data = express)
##
## Residuals:
##    Min     1Q   Median     3Q    Max
## -2.239 -1.101 -0.129  1.283  2.313
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -4.672757   0.891147  -5.244 6.60e-05 ***
## Distance      0.036936   0.004602   8.026 3.49e-07 ***
```

```
## Weight          1.292414    0.137842    9.376 3.95e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.493 on 17 degrees of freedom
## Multiple R-squared:  0.9162, Adjusted R-squared:  0.9063
## F-statistic: 92.89 on 2 and 17 DF,  p-value: 7.066e-10

interacmodel<-lm(Cost~Distance+Weight+Distance*Weight,data=express)
summary(interacmodel)

##
## Call:
## lm(formula = Cost ~ Distance + Weight + Distance * Weight, data = express)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.7573 -0.4254 -0.1820  0.5079  1.4214
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -0.1405007  0.6481000  -0.217   0.8311
## Distance       0.0077208  0.0039057   1.977   0.0656 .
## Weight         0.0190880  0.1582116   0.121   0.9055
## Distance:Weight 0.0077957  0.0008977   8.684 1.88e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6439 on 16 degrees of freedom
## Multiple R-squared:  0.9853, Adjusted R-squared:  0.9826
## F-statistic: 358.2 on 3 and 16 DF,  p-value: 7.125e-15

quadmodel<-lm(Cost~Distance+Weight+I(Weight^2)+Distance*Weight,data=express);
summary(quadmodel)

##
## Call:
## lm(formula = Cost ~ Distance + Weight + I(Weight^2) + Distance *
##      Weight, data = express)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.7487 -0.2558  0.0532  0.2266  0.9142
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.4746969  0.4584500   1.035 0.316870
## Distance       0.0090777  0.0026535   3.421 0.003791 **
## Weight        -0.5781705  0.1706879  -3.387 0.004062 **
## I(Weight^2)    0.0867388  0.0193380   4.485 0.000436 ***
## Distance:Weight 0.0072587  0.0006176  11.753 5.74e-09 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4346 on 15 degrees of freedom
## Multiple R-squared:  0.9937, Adjusted R-squared:  0.9921
## F-statistic: 594.6 on 4 and 15 DF,  p-value: 2.541e-16

quadmodel2<-lm(Cost~Distance+I(Distance^2)+Weight+I(Weight^2)+Distance*Weight,data=
express);
summary(quadmodel2)

##
## Call:
## lm(formula = Cost ~ Distance + I(Distance^2) + Weight + I(Weight^2) +
##     Distance * Weight, data = express)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.86027 -0.19898 -0.00885  0.16531  0.94396
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    8.270e-01  7.023e-01   1.178  0.258588
## Distance       4.021e-03  7.998e-03   0.503  0.622999
## I(Distance^2)  1.507e-05  2.243e-05   0.672  0.512657
## Weight        -6.091e-01  1.799e-01  -3.386  0.004436 **
## I(Weight^2)     8.975e-02  2.021e-02   4.442  0.000558 ***
## Distance:Weight  7.327e-03  6.374e-04  11.495  1.62e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4428 on 14 degrees of freedom
## Multiple R-squared:  0.9939, Adjusted R-squared:  0.9918
## F-statistic: 458.4 on 5 and 14 DF,  p-value: 5.371e-15
```

R output 3 for Question 3

```
library(olsrr)
condo=read.csv("C:\\Users\\thuntida.ngamkham\\OneDrive - University of Calgary\\data\\ataset603\\CONDO.CSV", header = TRUE)
#condo=read.csv("~/OneDrive - University of Calgary/MyCoursesThierry/DATA603/data/d\\ataset603/CONDO.CSV", header = TRUE)
model<-lm(PRICE100 ~FLOOR+ DIST+ factor(VIEW)+factor(END)+factor(FURNISH) ,data=condo )
summary(model)
## Call:
## lm(formula = PRICE100 ~ FLOOR + DIST + factor(VIEW) + factor(END) +
##     factor(FURNISH), data = condo)
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -70.878 -17.141  -1.102   14.253   66.830
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    183.5701     5.2207   35.162 < 2e-16 ***
## FLOOR           -3.8076     0.7482   -5.089 8.18e-07 ***
## DIST            1.7414     0.3750    4.644 6.14e-06 ***
## factor(VIEW)1    40.3251     3.4565   11.667 < 2e-16 ***
## factor(END)1     4.2792     3.6023    1.188 0.236267
## factor(FURNISH)1 -32.7162     9.5814   -3.415 0.000771 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 24.39 on 203 degrees of freedom
## Multiple R-squared:  0.4943, Adjusted R-squared:  0.4819
## F-statistic: 39.69 on 5 and 203 DF,  p-value: < 2.2e-16
```

```
goodmodel=ols_step_both_p(model, pent = 0.1, prem = 0.3, details=TRUE)
```

```
## Stepwise Selection Method
## -----
## Candidate Terms:
## 1. FLOOR
## 2. DIST
## 3. factor(VIEW)
## 4. factor(END)
## 5. factor(FURNISH)
##
## We are selecting variables based on p value...
## Stepwise Selection: Step 1
##
## - factor(VIEW) added
##
##              Model Summary
## -----
## R              0.579      RMSE              27.701
## R-Squared       0.335      Coef. Var         13.762
## Adj. R-Squared  0.332      MSE              767.357
## Pred R-Squared  0.322      MAE              22.134
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
##              ANOVA
## -----
##              Sum of
##              Squares      DF      Mean Square      F      Sig.
## -----
## Regression    80049.921      1      80049.921    104.319    0.0000
## Residual     158842.854     207       767.357
## Total        238892.775     208
## -----
```

```

##                                     Parameter Estimates
## -----
##          model      Beta      Std. Error      Std. Beta      t      Sig      lower      upper
## -----
##   (Intercept)    181.050          2.756              65.684    0.000    175.615    186.484
## factor(VIEW)1     39.163          3.834          0.579    10.214    0.000     31.604     46.723
## -----
## Stepwise Selection: Step 2
##
## - FLOOR added
##
##                                     Model Summary
## -----
## R                0.635      RMSE                26.304
## R-Squared         0.403      Coef. Var          13.068
## Adj. R-Squared    0.398      MSE                691.900
## Pred R-Squared    0.387      MAE                20.616
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
##                                     ANOVA
## -----
##          Sum of      DF      Mean Square      F      Sig.
##          Squares
## -----
## Regression    96361.421         2      48180.710    69.635    0.0000
## Residual     142531.355        206         691.900
## Total        238892.775        208
## -----
##
##                                     Parameter Estimates
## -----
##          model      Beta      Std. Error      Std. Beta      t      Sig      lower      upper
## -----
##   (Intercept)    198.249          4.404          45.012    0.000    189.566    206.932
## factor(VIEW)1     39.708          3.643          0.587    10.900    0.000     32.526     46.889
## FLOOR           -3.895          0.802         -0.261    -4.855    0.000     -5.477     -2.313
## -----
##                                     Model Summary
## -----
## R                0.635      RMSE                26.304
## R-Squared         0.403      Coef. Var          13.068
## Adj. R-Squared    0.398      MSE                691.900
## Pred R-Squared    0.387      MAE                20.616
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
##                                     ANOVA
## -----
##          Sum of      DF      Mean Square      F      Sig.
##          Squares
## -----

```

```

## -----
## Regression      96361.421      2      48180.710      69.635      0.0000
## Residual       142531.355     206      691.900
## Total          238892.775     208
## -----
##
##                               Parameter Estimates
## -----
##      model      Beta      Std. Error      Std. Beta      t      Sig      lower      upper
## -----
##      (Intercept)  198.249      4.404              45.012      0.000      189.566      206.932
## factor(VIEW)1    39.708      3.643       0.587      10.900      0.000      32.526      46.889
##      FLOOR      -3.895      0.802      -0.261      -4.855      0.000      -5.477      -2.313
## -----
## Stepwise Selection: Step 3
##
## - DIST added
##
##                               Model Summary
## -----
##      R      0.680      RMSE      25.034
##      R-Squared      0.462      Coef. Var      12.437
##      Adj. R-Squared      0.454      MSE      626.685
##      Pred R-Squared      0.441      MAE      19.725
## -----
##      RMSE: Root Mean Square Error
##      MSE: Mean Square Error
##      MAE: Mean Absolute Error
##
##                               ANOVA
## -----
##      Sum of      DF      Mean Square      F      Sig.
##      Squares
## -----
## Regression      110422.268      3      36807.423      58.733      0.0000
## Residual        128470.507     205      626.685
## Total           238892.775     208
## -----
##
##                               Parameter Estimates
## -----
##      model      Beta      Std. Error      Std. Beta      t      Sig      lower      upper
## -----
##      (Intercept)  184.008      5.158              35.672      0.000      173.838      194.179
## factor(VIEW)1    38.119      3.483       0.563      10.944      0.000      31.252      44.987
##      FLOOR      -3.664      0.765      -0.246      -4.789      0.000      -5.172      -2.156
##      DIST       1.797      0.379       0.244      4.737      0.000      1.049      2.545
## -----
##
##                               Model Summary
## -----
##      R      0.680      RMSE      25.034
##      R-Squared      0.462      Coef. Var      12.437
##      Adj. R-Squared      0.454      MSE      626.685
##      Pred R-Squared      0.441      MAE      19.725
## -----
##      RMSE: Root Mean Square Error
##      MSE: Mean Square Error
##      MAE: Mean Absolute Error

```



```

##
## ANOVA
## -----
## Sum of
## Squares DF Mean Square F Sig.
## -----
## Regression 110422.268 3 36807.423 58.733 0.0000
## Residual 128470.507 205 626.685
## Total 238892.775 208
## -----
## Parameter Estimates
## -----
## model Beta Std. Error Std. Beta t Sig. lower upper
## -----
## (Intercept) 184.008 5.158 35.672 0.000 173.838 194.179
## factor(VIEW)1 38.119 3.483 0.563 10.944 0.000 31.252 44.987
## FLOOR -3.664 0.765 -0.246 -4.789 0.000 -5.172 -2.156
## DIST 1.797 0.379 0.244 4.737 0.000 1.049 2.545
## -----
## Stepwise Selection: Step 4
##
## - factor(FURNISH) added
##
## Model Summary
## -----
## R 0.701 RMSE 24.419
## R-Squared 0.491 Coef. Var 12.131
## Adj. R-Squared 0.481 MSE 596.281
## Pred R-Squared 0.469 MAE 19.058
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
## ANOVA
## -----
## Sum of
## Squares DF Mean Square F Sig.
## -----
## Regression 117251.530 4 29312.883 49.16 0.0000
## Residual 121641.245 204 596.281
## Total 238892.775 208
## -----
## Parameter Estimates
## -----
## model Beta Std. Error Std. Beta t Sig. lower upper
## -----
## (Intercept) 185.193 5.044 36.717 0.000 175.248 195.138
## factor(VIEW)1 40.335 3.460 0.596 11.658 0.000 33.513 47.157
## FLOOR -3.736 0.747 -0.251 -5.004 0.000 -5.208 -2.264
## DIST 1.679 0.372 0.228 4.518 0.000 0.946 2.412
## factor(FURNISH)1 -32.450 9.588 -0.173 -3.384 0.001 -51.355 -13.544
## -----
##
## Model Summary
## -----

```

```
## R                0.701      RMSE                24.419
## R-Squared        0.491      Coef. Var            12.131
## Adj. R-Squared   0.481      MSE                596.281
## Pred R-Squared   0.469      MAE                19.058
```

```
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
```

ANOVA

```
## -----
##              Sum of
##              Squares      DF      Mean Square      F      Sig.
## -----
## Regression    117251.530      4      29312.883      49.16    0.0000
## Residual      121641.245     204       596.281
## Total         238892.775     208
```

Parameter Estimates

```
## -----
##              model      Beta      Std. Error      Std. Beta      t      Sig      lower      upper
## -----
##      (Intercept)    185.193      5.044              36.717    0.000    175.248    195.138
##      factor(VIEW)1    40.335      3.460       0.596    11.658    0.000     33.513     47.157
##      FLOOR          -3.736      0.747      -0.251    -5.004    0.000     -5.208     -2.264
##      DIST           1.679      0.372       0.228     4.518    0.000      0.946      2.412
## factor(FURNISH)1   -32.450      9.588      -0.173    -3.384    0.001    -51.355    -13.544
```

```
## No more variables to be added/removed.
```

Final Model Output

Model Summary

```
## -----
## R                0.701      RMSE                24.419
## R-Squared        0.491      Coef. Var            12.131
## Adj. R-Squared   0.481      MSE                596.281
## Pred R-Squared   0.469      MAE                19.058
```

```
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
```

ANOVA

```
## -----
##              Sum of
##              Squares      DF      Mean Square      F      Sig.
## -----
## Regression    117251.530      4      29312.883      49.16    0.0000
## Residual      121641.245     204       596.281
## Total         238892.775     208
```

Parameter Estimates

```
## -----
##              model      Beta      Std. Error      Std. Beta      t      Sig      lower      upper
## -----
##      (Intercept)    185.193      5.044              36.717    0.000    175.248    195.138
##      factor(VIEW)1    40.335      3.460       0.596    11.658    0.000     33.513     47.157
```

```
##          FLOOR      -3.736      0.747      -0.251      -5.004      0.000      -5.208      -2.264
##          DIST       1.679      0.372      0.228      4.518      0.000      0.946      2.412
## factor(FURNISH)1    -32.450      9.588      -0.173      -3.384      0.001     -51.355     -13.544
```

```
summary(goodmodel$model)
```

```
##
## Call:
## lm(formula = paste(response, "~", paste(preds, collapse = " + ")),
##     data = l)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -68.527 -17.773  -0.287  14.184  66.490
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    185.1932     5.0438  36.717 < 2e-16 ***
## factor(VIEW)1     40.3347     3.4599  11.658 < 2e-16 ***
## FLOOR           -3.7359     0.7465  -5.004 1.21e-06 ***
## DIST             1.6793     0.3717   4.518 1.06e-05 ***
## factor(FURNISH)1 -32.4497     9.5885  -3.384 0.000856 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 24.42 on 204 degrees of freedom
## Multiple R-squared:  0.4908, Adjusted R-squared:  0.4808
## F-statistic: 49.16 on 4 and 204 DF,  p-value: < 2.2e-16
```

R output 4 for Question 4

```
promotion=read.csv("C:\\Users\\thuntida.ngamkham\\Desktop\\dataset603\\promote.csv",
,header=TRUE)
dummymodel<-lm(promote~factor(rank),data=promotion)
summary(dummymodel)

##
## Call:
## lm(formula = promote ~ factor(rank), data = promotion)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -20.875   -6.714    0.000    7.257    29.385
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    42.000      2.259   18.593 < 2e-16 ***
## factor(rank)2    10.571      4.005    2.640 0.013613 *
## factor(rank)3    14.875      3.830    3.884 0.000602 ***
## factor(rank)4    25.102      1.275    6.471 < 2e-16 ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.795 on 36 degrees of freedom
## Multiple R-squared:  0.889 , Adjusted R-squared:  0.856
## F-statistic: 14.515 on 3 and 36 DF,  p-value: 0.001319
```

R output 5 for Question 6

```
ski=read.csv("C:\\Users\\thuntida.ngamkham\\OneDrive - University of Calgary\\datas
et603\\ski.CSV", header = TRUE)
#ski=read.csv("~/OneDrive - University of Calgary/MyCoursesThierry/DATA603/data/dat
aset603/ski.CSV", header = TRUE)

model<-lm(skiers ~factor(weekend)+snow+temperature ,data=ski )
summary(model)

##
## Call:
## lm(formula = skiers ~ factor(weekend) + snow + temperature, data = ski)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -152.431  -38.371    2.996   46.566  117.806
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    561.037      72.403    7.749 1.93e-08 ***
## factor(weekend)1    92.582      29.321    3.157 0.00379 **
## snow              4.303       1.823    2.360 0.02546 *
## temperature     -6.843       2.144   -3.191 0.00348 **
##
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 64.06 on 28 degrees of freedom
## Multiple R-squared:  0.8234, Adjusted R-squared:  0.8045
## F-statistic: 43.52 on 3 and 28 DF,  p-value: 1.136e-10

intmodel<-lm(skiers ~factor(weekend)+snow+temperature+factor(weekend)*temperature,d
ata=ski )
summary(intmodel)
## Call:
## lm(formula = skiers ~ factor(weekend) + snow + temperature +
##     factor(weekend) * temperature, data = ski)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -153.60  -39.89   11.32   36.98  111.18
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      552.949      65.946   8.385 5.38e-09 ***
## factor(weekend)1    208.279      51.697   4.029 0.00041 ***
## snow              3.913       1.665   2.350 0.02635 *
## temperature       -6.037       1.975  -3.056 0.00500 **
## factor(weekend)1:temperature -13.021      4.984  -2.613 0.01450 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 58.28 on 27 degrees of freedom
## Multiple R-squared:  0.859, Adjusted R-squared:  0.8382
## F-statistic: 41.14 on 4 and 27 DF,  p-value: 4.1e-11
```

R output 6 for Question 7

```
wateroil=read.csv("C:\\Users\\thuntida.ngamkham\\Desktop\\dataset603\\wateroil.csv"
,header=TRUE)
model1<-lm(Voltage~Volume+Salinity+Temperature+Delay+Surfactant+SpanTriton+SolidPart
t,data=wateroil)
summary(model1)

##
## Call:
## lm(formula = Voltage ~ Volume + Salinity + Temperature + Delay +
##     Surfactant + SpanTriton + SolidPart, data = wateroil)
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.68444 -0.23788  0.03217  0.13755  0.74783
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.998082   0.247542   4.032 0.001975 **
## Volume      -0.022429   0.005039  -4.451 0.000977 ***
## Salinity      0.155711   0.074291   2.096 0.060018 .
## Temperature -0.017187   0.011860  -1.449 0.175188
## Delay        -0.009527   0.009619  -0.990 0.343279
## Surfactant   0.421421   0.100782   4.182 0.001533 **
## SpanTriton   0.417123   0.437702   0.953 0.361070
## SolidPart    -0.155244   0.148582  -1.045 0.318516
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4635 on 11 degrees of freedom
## Multiple R-squared:  0.771, Adjusted R-squared:  0.6253
## F-statistic: 5.292 on 7 and 11 DF, p-value: 0.007428

model2<-lm(Voltage~Volume+Salinity+Surfactant,data=wateroil)
summary(model2)

##
## Call:
## lm(formula = Voltage ~ Volume + Salinity + Surfactant, data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.7529 -0.3051  0.1074  0.1803  1.1318
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.93257   0.24819   3.757 0.001902 **
## Volume      -0.02427   0.00490  -4.953 0.000173 ***
## Salinity      0.14206   0.07573   1.876 0.010283 *
## Surfactant   0.38457   0.09801   3.924 0.001354 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4796 on 15 degrees of freedom
## Multiple R-squared:  0.6656, Adjusted R-squared:  0.6388
## F-statistic: 9.954 on 3 and 15 DF, p-value: 0.000735

model3<-lm(Voltage~Volume+Surfactant,data=wateroil)
summary(model3)

##
## Call:
```

```
## lm(formula = Voltage ~ Volume + Surfactant, data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.86384 -0.25726  0.01945  0.25781  1.35945
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   1.01041     0.26326   3.838 0.001451 **
## Volume       -0.02208     0.00512  -4.313 0.000536 ***
## Surfactant    0.42836     0.10240   4.183 0.000703 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.516 on 16 degrees of freedom
## Multiple R-squared:  0.5872, Adjusted R-squared:  0.6356
## F-statistic: 11.38 on 2 and 16 DF,  p-value: 0.000843

model4<-lm(Voltage~Volume+Salinity+Surfactant+Volume*Salinity+Volume*Surfactant+Salinity*Surfactant,data=wateroil)
summary(model4)

##
## Call:
## lm(formula = Voltage ~ Volume + Salinity + Surfactant + Volume *
##      Salinity + Volume * Surfactant + Salinity * Surfactant, data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.76973 -0.29242  0.09955  0.24755  0.81376
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.940454   0.271180   3.468  0.00465 **
## Volume       -0.010274   0.011149  -0.922  0.00149 **
## Salinity      0.030410   0.283332   0.107  0.00030 ***
## Surfactant    0.181183   0.222972   0.813  0.03228 *
## Volume:Salinity -0.003889   0.003654  -1.065  0.00805 **
## Volume:Surfactant -0.001351   0.004171  -0.324  0.00162 **
## Salinity:Surfactant 0.115549   0.073071   1.581  0.03979 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4778 on 12 degrees of freedom
## Multiple R-squared:  0.7345, Adjusted R-squared:  0.7018
## F-statistic: 5.534 on 6 and 12 DF,  p-value: 0.005857

model5<-lm(Voltage~Volume+Surfactant+Volume*Surfactant,data=wateroil)
summary(model5)
```

```
##
## Call:
## lm(formula = Voltage ~ Volume + Surfactant + Volume * Surfactant,
##     data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.91709 -0.17411  0.01823  0.20823  1.31354
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.944304   0.297053   3.179  0.00623 **
## Volume        -0.018915   0.007964  -2.375  0.03131 *
## Surfactant      0.491709   0.159277   3.087  0.00751 **
## Volume:Surfactant -0.001676   0.003173  -0.528  0.00511 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5281 on 15 degrees of freedom
## Multiple R-squared:  0.5947, Adjusted R-squared:  0.7137
## F-statistic: 7.338 on 3 and 15 DF, p-value: 0.002968

model6<-lm(Voltage~Volume+I(Volume^2)+Salinity+Surfactant+Volume*Salinity+Volume*Surfactant+Salinity*Surfactant,data=wateroil)
summary(model6)

##
## Call:
## lm(formula = Voltage ~ Volume + I(Volume^2) + Salinity + Surfactant +
##     Volume * Salinity + Volume * Surfactant + Salinity * Surfactant,
##     data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.48500 -0.14500  0.01333  0.18000  0.58500
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.0666667   0.2002322   5.327 0.000242 ***
## Volume        -0.1052292   0.0288264  -3.650 0.003818 **
## I(Volume^2)     0.0011693   0.0003407   3.432 0.005603 **
## Salinity        0.5300000   0.2519533   2.104 0.059234 .
## Surfactant      1.0883333   0.3099290   3.512 0.004870 **
## Volume:Salinity -0.0078333   0.0028901  -2.710 0.020276 *
## Volume:Surfactant -0.0120000   0.0043352  -2.768 0.018290 *
## Salinity:Surfactant 0.0366667   0.0578021   0.634 0.538822
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3168 on 11 degrees of freedom
```



```
## Multiple R-squared:  0.8718, Adjusted R-squared:  0.8202
## F-statistic: 10.69 on 7 and 11 DF,  p-value: 0.0003923

model7<-lm(Voltage~Volume+I(Volume^2)+Surfactant+Volume*Surfactant,data=wateroil)
summary(model7)

##
## Call:
## lm(formula = Voltage ~ Volume + I(Volume^2) + Surfactant + Volume *
##     Surfactant, data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.03  -0.07  -0.01   0.09   1.13
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.066667   0.2801134   3.808  0.00192 **
## Volume        -0.0751250   0.0298648  -2.515  0.02471 *
## I(Volume^2)     0.0007552   0.0003890   1.941  0.04262 .
## Surfactant      1.1800000   0.3835610   3.076  0.00821 **
## Volume:Surfactant -0.0120000   0.0060646  -1.979  0.08787 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4852 on 14 degrees of freedom
## Multiple R-squared:  0.6807, Adjusted R-squared:  0.8100
## F-statistic: 7.462 on 4 and 14 DF,  p-value: 0.001951

model8<-lm(Voltage~Volume+I(Volume^2)+Salinity+Surfactant+Volume*Salinity+Volume*Su
rfactant,data=wateroil)
summary(model8)

## Call:
## lm(formula = Voltage ~ Volume + I(Volume^2) + Salinity + Surfactant +
##     Volume * Salinity + Volume * Surfactant, data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.54000 -0.09000  0.01333  0.12500  0.64000
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.066667   0.1951827   5.465 0.000144 ***
## Volume        -0.1155417   0.0232047  -4.979 0.000320 ***
## I(Volume^2)     0.0012552   0.0003047   4.119 0.001423 **
## Salinity        0.6400000   0.1781766   3.592 0.003700
## Surfactant      1.1800000   0.2672650   4.415 0.000843 ***
## Volume:Salinity -0.0078333   0.0028172  -2.781 0.016634 *
## Volume:Surfactant -0.0120000   0.0042258  -2.840 0.014906 *
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3381 on 12 degrees of freedom
## Multiple R-squared:  0.8671, Adjusted R-squared:  0.8107
## F-statistic: 13.05 on 6 and 12 DF,  p-value: 0.0001211

model9<-lm(Voltage~Volume+I(Volume^2)+Surfactant,data=wateroil)
summary(model9)
## Call:
## lm(formula = Voltage ~ Volume + I(Volume^2) + Surfactant, data = wateroil)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.79000 -0.27000 -0.02667  0.27000  1.37000
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.067e+00  3.061e-01   3.484  0.00333 **
## Volume      -3.012e-02  2.115e-02  -1.424  0.01749 *
## I(Volume^2)  8.021e-05  2.043e-04   0.393  0.0019 **
## Surfactant   4.600e-01  1.326e-01   3.470  0.00343 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5302 on 15 degrees of freedom
## Multiple R-squared:  0.5914, Adjusted R-squared:  0.8097
## F-statistic: 7.237 on 3 and 15 DF,  p-value: 0.003149
```