Advanced Computational Methods for Data Science CS 6301.012

Assignment 7

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Ames Iowa Housing Data

```
library(glmnet)
library(pls)
attach()


# remove columns with too many NA values
sum(is.na(HousingData))
sum(is.na(HousingData$Fireplace.Qu))
sum(is.na(HousingData$Alley))
sum(is.na(HousingData$Pool.QC))
sum(is.na(HousingData$Fence))
sum(is.na(HousingData$Misc.Feature))
drops <- c("Fireplace.Qu","Alley","Pool.QC","Fence","Misc.Feature")
cleanData <- HousingData[ , !(names(HousingData) %in% drops)]
fix(cleanData)
sum(is.na(cleanData))
cleanData=na.omit(cleanData)


  x = model.matrix(SalePrice~.,cleanData )[,-77]
  y = cleanData$SalePrice
  grid=10^seq(10,-2,length=100)

# no of rows after cleaning data
  dim(x)
[1] 2223  258
  train=sample(1:nrow(x), nrow(x)/2)
  test=(-train)
  y.test=y[test]
  ridge.mod=glmnet(x[train,],y[train],alpha=0,lambda=grid, thresh=1e-12)
  ridge.pred=predict(ridge.mod,s=4,newx=x[test,])
  mean((ridge.pred-y.test)^2)
[1] 1102703119
  mean((mean(y[train])-y.test)^2)
[1] 6657361561
  ridge.pred=predict(ridge.mod,s=1e10,newx=x[test,])
  mean((ridge.pred-y.test)^2)
[1] 6655925486
  ridge.pred=predict(ridge.mod,s=0,newx=x[test,],exact=T)
  mean((ridge.pred-y.test)^2)
[1] 1103185465
  lm(y~x, subset=train)
```

```
Call:
lm(formula = y ~ x, subset = train)

Coefficients:
           (Intercept)            x(Intercept)                  xOrder
xPID
             1.043e+07                      NA             -7.754e+00
1.269e-05
          xMS.SubClass       xMS.ZoningC (all)            xMS.ZoningFV
xMS.ZoningI (all)
            -5.686e+01             -9.009e+03              8.256e+03
NA
          xMS.ZoningRH            xMS.ZoningRL            xMS.ZoningRM
xLot.Frontage
             2.705e+03              5.523e+03                      NA
8.088e+01
             xLot.Area             xStreetPave           xLot.ShapeIR2
xLot.ShapeIR3
             8.040e-01              4.962e+04              4.587e+03
1.573e+04
         xLot.ShapeReg        xLand.ContourHLS        xLand.ContourLow
xLand.ContourLvl
             2.960e+03              2.729e+04              4.406e+03
1.614e+04
      xUtilitiesNoSeWa        xUtilitiesNoSewr      xLot.ConfigCulDSac
xLot.ConfigFR2
                    NA                     NA              1.198e+04
-7.401e+03
        xLot.ConfigFR3       xLot.ConfigInside          xLand.SlopeMod
xLand.SlopeSev
            -1.737e+04              1.001e+02              1.272e+04
-6.826e+04
  xNeighborhoodBlueste     xNeighborhoodBrDale    xNeighborhoodBrkSide    xNe
ighborhoodClearCr
            -1.308e+04              5.825e+03             -2.348e+03
-1.152e+04
  xNeighborhoodCollgCr    xNeighborhoodCrawfor    xNeighborhoodEdwards    xNe
ighborhoodGilbert
            -8.397e+03              9.107e+03             -2.589e+04
-1.088e+04
   xNeighborhoodGreens    xNeighborhoodGrnHill     xNeighborhoodIDOTRR    xNe
ighborhoodLandmrk
            -7.284e+03                     NA             -5.202e+03
NA
  xNeighborhoodMeadowV    xNeighborhoodMitchel      xNeighborhoodNAmes    xNe
ighborhoodNoRidge
            -1.058e+04             -1.138e+04             -9.695e+03
3.427e+04
  xNeighborhoodNPkVill    xNeighborhoodNridgHt     xNeighborhoodNWAmes    xNe
ighborhoodOldTown
             1.881e+04              2.937e+04             -1.197e+04
-1.338e+04
   xNeighborhoodSawyer    xNeighborhoodSawyerW    xNeighborhoodSomerst    xNe
ighborhoodStoneBr
            -1.238e+04             -1.161e+04              7.462e+03
3.898e+04
```

```
    xNeighborhoodSWISU     xNeighborhoodTimber    xNeighborhoodVeenker
xCondition.1Feedr
            -1.097e+04              -4.237e+03              4.679e+03
6.841e+03
      xCondition.1Norm        xCondition.1PosA        xCondition.1PosN
xCondition.1RRAe
             1.338e+04               1.104e+04              2.137e+04
4.269e+03
      xCondition.1RRAn        xCondition.1RRNe        xCondition.1RRNn
xCondition.2Feedr
             1.409e+04              -1.915e+03             -6.095e+03
-5.367e+04
      xCondition.2Norm        xCondition.2PosA        xCondition.2PosN
xCondition.2RRAe
            -3.913e+04               2.916e+04             -2.374e+05
NA
      xCondition.2RRAn        xCondition.2RRNn        xBldg.Type2fmCon
xBldg.TypeDuplex
                    NA              -3.504e+04             -5.258e+03
-3.428e+03
       xBldg.TypeTwnhs        xBldg.TypeTwnhsE      xHouse.Style1.5Unf      x
House.Style1Story
            -2.090e+04              -1.477e+04              2.208e+03
5.861e+03
    xHouse.Style2.5Fin      xHouse.Style2Story      xHouse.StyleSFoyer
xHouse.StyleSLvl
            -3.571e+04              -4.051e+03              1.223e+04
3.349e+03
         xOverall.Qual           xOverall.Cond           xYear.Built
xYear.Remod.Add
             7.832e+03               5.690e+03              2.402e+02
4.331e+01
      xRoof.StyleGable      xRoof.StyleGambrel          xRoof.StyleHip      x
Roof.StyleMansard
             6.041e+04               7.320e+04              6.306e+04
8.190e+04
       xRoof.StyleShed       xRoof.MatlCompShg       xRoof.MatlMembran
xRoof.MatlMetal
            -2.713e+04              -2.437e+04              1.271e+05
NA
        xRoof.MatlRoll       xRoof.MatlTar&Grv       xRoof.MatlWdShake
xRoof.MatlWdShngl
            -2.468e+04               1.915e+04             -6.290e+04
NA
  xExterior.1stAsphShn    xExterior.1stBrkComm    xExterior.1stBrkFace     xE
xterior.1stCBlock
                    NA               1.527e+04              1.551e+04
-6.327e+03
  xExterior.1stCemntBd    xExterior.1stHdBoard    xExterior.1stImStucc    xEx
terior.1stMetalSd
             3.508e+04              -1.890e+04             -9.422e+04
-1.152e+04
  xExterior.1stPlywood    xExterior.1stPreCast      xExterior.1stStone     xE
xterior.1stStucco
            -1.104e+04                      NA              5.814e+03
-1.704e+04
```

```
  xExterior.1stVinylSd    xExterior.1stWd Sdng    xExterior.1stWdShing    xEx
terior.2ndAsphShn
            -1.759e+04             -3.421e+02             -9.093e+03
NA
  xExterior.2ndBrk Cmn    xExterior.2ndBrkFace     xExterior.2ndCBlock    xEx
terior.2ndCmentBd
             5.084e+03              1.217e+03                      NA
-2.493e+04
  xExterior.2ndHdBoard    xExterior.2ndImStucc    xExterior.2ndMetalSd      x
Exterior.2ndOther
             1.922e+04              6.455e+04              1.745e+04
6.670e+03
  xExterior.2ndPlywood    xExterior.2ndPreCast      xExterior.2ndStone     xE
xterior.2ndStucco
             1.289e+04                        NA             -6.683e+03
1.443e+04
  xExterior.2ndVinylSd    xExterior.2ndWd Sdng    xExterior.2ndWd Shng     xM
as.Vnr.TypeBrkCmn
             2.025e+04              6.589e+03              5.755e+03
-1.234e+04
  xMas.Vnr.TypeBrkFace     xMas.Vnr.TypeCBlock       xMas.Vnr.TypeNone      x
Mas.Vnr.TypeStone
            -9.289e+03                        NA             -7.261e+03
NA
         xMas.Vnr.Area           xExter.QualFa           xExter.QualGd
xExter.QualTA
             1.374e+01             -1.380e+03             -1.586e+04
-2.035e+04
         xExter.CondFa           xExter.CondGd           xExter.CondPo
xExter.CondTA
            -3.107e+03              4.818e+03             -1.135e+04
5.163e+03
     xFoundationCBlock        xFoundationPConc         xFoundationSlab
xFoundationStone
            -3.372e+03             -6.572e+02                      NA
7.349e+03
       xFoundationWood            xBsmt.QualEx            xBsmt.QualFa
xBsmt.QualGd
            -1.142e+04              1.680e+04              3.114e+02
-1.804e+03
          xBsmt.QualPo            xBsmt.QualTA            xBsmt.CondEx
xBsmt.CondFa
             6.642e+03                        NA             -5.711e+03
1.711e+03
          xBsmt.CondGd            xBsmt.CondPo            xBsmt.CondTA
xBsmt.ExposureAv
            -2.404e+03              3.386e+04                      NA
1.087e+04
      xBsmt.ExposureGd        xBsmt.ExposureMn        xBsmt.ExposureNo      x
BsmtFin.Type.1ALQ
             2.099e+04              5.048e+03              5.841e+03
-2.503e+03
    xBsmtFin.Type.1BLQ      xBsmtFin.Type.1GLQ      xBsmtFin.Type.1LwQ      x
BsmtFin.Type.1Rec
            -3.326e+03              4.811e+03             -3.938e+03
-8.152e+03
```

```
    xBsmtFin.Type.1Unf           xBsmtFin.SF.1      xBsmtFin.Type.2ALQ      x
BsmtFin.Type.2BLQ
                    NA            2.993e+01            8.587e+03
9.782e+02
    xBsmtFin.Type.2GLQ      xBsmtFin.Type.2LwQ      xBsmtFin.Type.2Rec      x
BsmtFin.Type.2Unf
             3.628e+03           -1.061e+04           -6.607e+03
NA
         xBsmtFin.SF.2           xBsmt.Unf.SF         xTotal.Bsmt.SF
xHeatingGasA
             1.944e+01            9.703e+00                     NA
-2.197e+04
          xHeatingGasW           xHeatingGrav           xHeatingOthW
xHeatingWall
            -2.471e+04                     NA                     NA
NA
         xHeating.QCFa           xHeating.QCGd           xHeating.QCPo
xHeating.QCTA
            -2.556e+03           -1.209e+03           -1.284e+04
1.394e+03
         xCentral.AirY       xElectricalFuseA       xElectricalFuseF
xElectricalFuseP
             1.570e+03           -9.705e+03           -7.866e+03
-2.788e+03
        xElectricalMix       xElectricalSBrkr          xX1st.Flr.SF
xX2nd.Flr.SF
                    NA           -6.943e+03            4.884e+01
5.953e+01
      xLow.Qual.Fin.SF          xGr.Liv.Area        xBsmt.Full.Bath
xBsmt.Half.Bath
             2.109e+01                     NA            3.498e+03
-6.066e+03
            xFull.Bath            xHalf.Bath         xBedroom.AbvGr
xKitchen.AbvGr
             5.145e+03            6.715e+03           -6.647e+02
-1.884e+04
       xKitchen.QualFa         xKitchen.QualGd         xKitchen.QualPo
xKitchen.QualTA
            -2.118e+04           -1.824e+04                     NA
-2.006e+04
        xTotRms.AbvGrd        xFunctionalMaj2        xFunctionalMin1
xFunctionalMin2
            -2.139e+03           -8.428e+03            8.118e+03
2.938e+02
        xFunctionalMod         xFunctionalSal         xFunctionalSev
xFunctionalTyp
             6.879e+02                     NA                     NA
7.519e+03
           xFireplaces      xGarage.TypeAttchd     xGarage.TypeBasment     xG
arage.TypeBuiltIn
             2.115e+03            2.613e+03            5.778e+03
-1.568e+03
   xGarage.TypeCarPort      xGarage.TypeDetchd          xGarage.Yr.Blt
xGarage.FinishFin
            -5.923e+03            2.298e+03            3.008e+01
6.837e+02
```

```
     xGarage.FinishRFn       xGarage.FinishUnf             xGarage.Cars
xGarage.Area
          -2.386e+03                      NA              5.833e+03
3.158e+00
        xGarage.QualEx          xGarage.QualFa          xGarage.QualGd
xGarage.QualPo
           2.092e+04              -8.860e+03              -1.016e+04
-3.090e+04
        xGarage.QualTA          xGarage.CondEx          xGarage.CondFa
xGarage.CondGd
                   NA              -1.416e+04              9.817e+03
1.703e+04
        xGarage.CondPo          xGarage.CondTA           xPaved.DriveP
xPaved.DriveY
           5.364e+03                      NA              4.925e+02
5.863e+03
         xWood.Deck.SF          xOpen.Porch.SF         xEnclosed.Porch
xX3Ssn.Porch
           7.420e+00              -1.306e+01              7.860e+00
4.097e+01
         xScreen.Porch              xPool.Area              xMisc.Val
xMo.Sold
           3.144e+01               6.701e+01             -1.413e+01
-1.609e+02
          xYr.Sold           xSale.TypeCon         xSale.TypeConLD
xSale.TypeConLI
          -5.523e+03               7.609e+04              9.941e+03
4.281e+03
       xSale.TypeConLw           xSale.TypeCWD           xSale.TypeNew
xSale.TypeOth
          -6.334e+03               8.659e+03              1.310e+04
7.171e+04
         xSale.TypeVWD           xSale.TypeWD   xSale.ConditionAdjLand   xSal
e.ConditionAlloca
          -2.126e+03               5.720e+02              2.750e+04
-1.720e+03
 xSale.ConditionFamily   xSale.ConditionNormal  xSale.ConditionPartial
           6.868e+03               7.221e+03             -4.840e+02

  predict(ridge.mod,s=0,exact=T,type="coefficients")[1:259,]
         (Intercept)           (Intercept)                  Order
PID           MS.SubClass
        1.038853e+07          0.000000e+00         -7.746492e+00          1.
268391e-05         -5.686502e+01
     MS.ZoningC (all)           MS.ZoningFV      MS.ZoningI (all)           M
S.ZoningRH            MS.ZoningRL
        -1.244567e+04          4.822409e+03          0.000000e+00         -7.
281601e+02           2.088786e+03
          MS.ZoningRM          Lot.Frontage              Lot.Area
StreetPave          Lot.ShapeIR2
        -3.434976e+03          8.087708e+01          8.040838e-01          4.
962247e+04           4.585003e+03
         Lot.ShapeIR3          Lot.ShapeReg       Land.ContourHLS       Land.
ContourLow       Land.ContourLvl
         1.573679e+04          2.959141e+03          2.729478e+04          4.
407131e+03           1.613808e+04
```

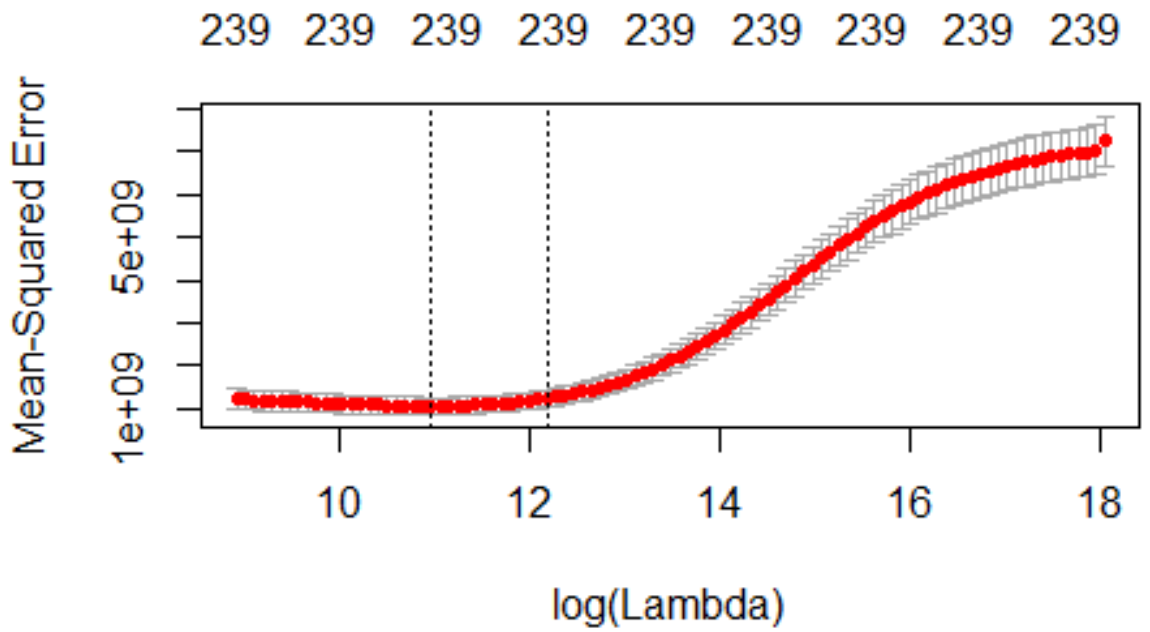
```
      UtilitiesNoSeWa       UtilitiesNoSewr     Lot.ConfigCulDSac         Lot
.ConfigFR2         Lot.ConfigFR3
         0.000000e+00          0.000000e+00         1.197666e+04        -7.
400189e+03         -1.737111e+04
     Lot.ConfigInside         Land.SlopeMod         Land.SlopeSev   Neighborh
oodBlueste    NeighborhoodBrDale
         1.015760e+02          1.272347e+04        -6.825341e+04        -1.
308620e+04          5.824818e+03
  NeighborhoodBrkSide   NeighborhoodClearCr   NeighborhoodCollgCr   Neighborh
oodCrawfor   NeighborhoodEdwards
        -2.347903e+03         -1.153467e+04        -8.399176e+03         9.
106093e+03         -2.588981e+04
  NeighborhoodGilbert    NeighborhoodGreens   NeighborhoodGrnHill    Neighbor
hoodIDOTRR   NeighborhoodLandmrk
        -1.088076e+04         -7.279532e+03         0.000000e+00        -5.
203198e+03          0.000000e+00
  NeighborhoodMeadowV   NeighborhoodMitchel     NeighborhoodNAmes   Neighborh
oodNoRidge   NeighborhoodNPkVill
        -1.058232e+04         -1.137896e+04        -9.696128e+03         3.
427285e+04          1.880844e+04
  NeighborhoodNridgHt    NeighborhoodNWAmes   NeighborhoodOldTown    Neighbor
hoodSawyer   NeighborhoodSawyerW
         2.936741e+04         -1.196985e+04        -1.337842e+04        -1.
238081e+04         -1.161337e+04
  NeighborhoodSomerst   NeighborhoodStoneBr    NeighborhoodSWISU    Neighbor
hoodTimber   NeighborhoodVeenker
         7.460755e+03          3.898277e+04        -1.097428e+04        -4.
240444e+03          4.678528e+03
     Condition.1Feedr       Condition.1Norm      Condition.1PosA       Condi
tion.1PosN       Condition.1RRAe
         6.841455e+03          1.337867e+04         1.103779e+04         2.
137325e+04          4.268749e+03
      Condition.1RRAn       Condition.1RRNe      Condition.1RRNn      Condit
ion.2Feedr       Condition.2Norm
         1.408418e+04         -1.916107e+03        -6.095645e+03        -5.
367834e+04         -3.913508e+04
      Condition.2PosA       Condition.2PosN      Condition.2RRAe       Condi
tion.2RRAn       Condition.2RRNn
         2.915766e+04         -2.373776e+05         0.000000e+00         0.
000000e+00         -3.505045e+04
      Bldg.Type2fmCon       Bldg.TypeDuplex       Bldg.TypeTwnhs       Bldg.
TypeTwnhsE     House.Style1.5Unf
        -5.255306e+03         -3.424804e+03        -2.090059e+04        -1.
476921e+04          2.207977e+03
    House.Style1Story     House.Style2.5Fin     House.Style2Story     House.S
tyleSFoyer       House.StyleSLvl
         5.861104e+03         -3.570426e+04        -4.049077e+03         1.
222558e+04          3.348612e+03
         Overall.Qual          Overall.Cond           Year.Built        Year
.Remod.Add       Roof.StyleGable
         7.833152e+03          5.690001e+03         2.401393e+02         4.
331210e+01          6.036405e+04
    Roof.StyleGambrel         Roof.StyleHip     Roof.StyleMansard        Roof
.StyleShed      Roof.MatlCompShg
         7.315919e+04          6.301512e+04         8.184679e+04        -8.
332678e+03         -1.627193e+04
```

```
     Roof.MatlMembran        Roof.MatlMetal         Roof.MatlRoll      Roof.M
atlTar&Grv      Roof.MatlWdShake
         1.351600e+05          0.000000e+00         -1.657947e+04          2.
722801e+04         -5.479186e+04
     Roof.MatlWdShngl   Exterior.1stAsphShn   Exterior.1stBrkComm   Exterior.
1stBrkFace    Exterior.1stCBlock
         8.098494e+03          0.000000e+00          1.541502e+04          1.
563717e+04         -1.080097e+03
  Exterior.1stCemntBd   Exterior.1stHdBoard   Exterior.1stImStucc   Exterior.
1stMetalSd   Exterior.1stPlywood
         3.523014e+04         -1.876509e+04         -9.408074e+04         -1.
138571e+04         -1.090029e+04
  Exterior.1stPreCast     Exterior.1stStone    Exterior.1stStucco   Exterior.
1stVinylSd   Exterior.1stWd Sdng
         0.000000e+00          5.936178e+03         -1.691234e+04         -1.
744751e+04         -2.115527e+02
  Exterior.1stWdShing   Exterior.2ndAsphShn   Exterior.2ndBrk Cmn   Exterior.
2ndBrkFace    Exterior.2ndCBlock
        -8.959106e+03          0.000000e+00          4.943562e+03          1.
093066e+03         -5.247693e+03
  Exterior.2ndCmentBd   Exterior.2ndHdBoard   Exterior.2ndImStucc   Exterior.
2ndMetalSd     Exterior.2ndOther
        -2.508802e+04          1.908020e+04          6.442035e+04          1.
731307e+04          6.530369e+03
  Exterior.2ndPlywood   Exterior.2ndPreCast     Exterior.2ndStone    Exterior
.2ndStucco   Exterior.2ndVinylSd
         1.275061e+04          0.000000e+00         -6.807246e+03          1.
429748e+04          2.011230e+04
  Exterior.2ndWd Sdng   Exterior.2ndWd Shng    Mas.Vnr.TypeBrkCmn   Mas.Vnr.T
ypeBrkFace    Mas.Vnr.TypeCBlock
         6.458835e+03          5.621063e+03         -5.414076e+03         -2.
365682e+03         -1.191434e+04
     Mas.Vnr.TypeNone     Mas.Vnr.TypeStone          Mas.Vnr.Area          Ex
ter.QualFa          Exter.QualGd
        -3.385647e+02          6.922949e+03          1.374068e+01         -1.
372475e+03         -1.586118e+04
         Exter.QualTA          Exter.CondFa          Exter.CondGd          Ex
ter.CondPo          Exter.CondTA
        -2.034171e+04         -3.104976e+03          4.818476e+03         -1.
134443e+04          5.163042e+03
     FoundationCBlock       FoundationPConc        FoundationSlab       Found
ationStone        FoundationWood
        -3.372699e+03         -6.570755e+02          0.000000e+00          7.
406560e+03         -1.142454e+04
          Bsmt.QualEx           Bsmt.QualFa           Bsmt.QualGd           B
smt.QualPo           Bsmt.QualTA
         1.483203e+04         -1.655996e+03         -3.769433e+03          4.
620847e+03         -1.966262e+03
          Bsmt.CondEx           Bsmt.CondFa           Bsmt.CondGd           B
smt.CondPo           Bsmt.CondTA
        -5.475459e+03          1.945986e+03         -2.169990e+03          1.
701417e+04          2.349508e+02
      Bsmt.ExposureAv       Bsmt.ExposureGd       Bsmt.ExposureMn       Bsmt.
ExposureNo     BsmtFin.Type.1ALQ
         1.086494e+04          2.099074e+04          5.045518e+03          5.
838428e+03         -1.784162e+03
```

```
    BsmtFin.Type.1BLQ     BsmtFin.Type.1GLQ     BsmtFin.Type.1LwQ     BsmtFin
.Type.1Rec     BsmtFin.Type.1Unf
        -2.607297e+03          5.529408e+03         -3.218130e+03         -7.
432302e+03          7.183766e+02
         BsmtFin.SF.1     BsmtFin.Type.2ALQ     BsmtFin.Type.2BLQ     BsmtFin
.Type.2GLQ     BsmtFin.Type.2LwQ
         1.544327e+01          1.007448e+04          2.465608e+03          5.
115503e+03         -9.116796e+03
    BsmtFin.Type.2Rec     BsmtFin.Type.2Unf          BsmtFin.SF.2           B
smt.Unf.SF         Total.Bsmt.SF
        -5.119614e+03          1.488417e+03          4.956353e+00         -4.
781194e+00          1.448278e+01
          HeatingGasA           HeatingGasW           HeatingGrav           H
eatingOthW           HeatingWall
        -5.088063e+02         -3.261511e+03          2.145940e+04          0.
000000e+00          0.000000e+00
         Heating.QCFa          Heating.QCGd          Heating.QCPo          He
ating.QCTA          Central.AirY
        -2.555458e+03         -1.208195e+03         -1.283663e+04          1.
393506e+03          1.570242e+03
      ElectricalFuseA       ElectricalFuseF       ElectricalFuseP         Ele
ctricalMix       ElectricalSBrkr
        -9.703907e+03         -7.864342e+03         -2.790419e+03          1.
706555e+04         -6.942392e+03
         X1st.Flr.SF           X2nd.Flr.SF      Low.Qual.Fin.SF           G
r.Liv.Area        Bsmt.Full.Bath
         1.774513e+01          2.843327e+01         -1.000042e+01          3.
109236e+01          3.498800e+03
       Bsmt.Half.Bath             Full.Bath             Half.Bath         Bed
room.AbvGr          Kitchen.AbvGr
        -6.066438e+03          5.145787e+03          6.715715e+03         -6.
637938e+02         -1.884053e+04
       Kitchen.QualFa        Kitchen.QualGd        Kitchen.QualPo        Kitc
hen.QualTA          TotRms.AbvGrd
        -2.118167e+04         -1.824155e+04          0.000000e+00         -2.
006131e+04         -2.139549e+03
       FunctionalMaj2        FunctionalMin1        FunctionalMin2         Fun
ctionalMod          FunctionalSal
        -8.414282e+03          8.119377e+03          2.927651e+02          6.
861789e+02          0.000000e+00
        FunctionalSev         FunctionalTyp           Fireplaces     Garage.
TypeAttchd    Garage.TypeBasment
         0.000000e+00          7.519611e+03          2.115590e+03          2.
611718e+03          5.777855e+03
   Garage.TypeBuiltIn    Garage.TypeCarPort     Garage.TypeDetchd         Gar
age.Yr.Blt      Garage.FinishFin
        -1.568411e+03         -5.922247e+03          2.297900e+03          3.
009741e+01          1.248074e+03
     Garage.FinishRFn      Garage.FinishUnf          Garage.Cars           G
arage.Area          Garage.QualEx
        -1.821563e+03          5.641574e+02          5.833206e+03          3.
156833e+00          2.574164e+04
        Garage.QualFa         Garage.QualGd         Garage.QualPo         Gar
age.QualTA          Garage.CondEx
        -4.042349e+03         -5.344799e+03         -2.608750e+04          4.
816395e+03         -1.877157e+04
```

```
        Garage.CondFa          Garage.CondGd          Garage.CondPo          Gar
age.CondTA           Paved.DriveP
         5.203090e+03           1.241567e+04           7.549165e+02          -4.
613242e+03           4.940943e+02
         Paved.DriveY           Wood.Deck.SF          Open.Porch.SF          Encl
osed.Porch            X3Ssn.Porch
         5.863650e+03           7.420268e+00          -1.305665e+01           7.
857944e+00           4.096943e+01
         Screen.Porch              Pool.Area               Misc.Val
Mo.Sold                Yr.Sold
         3.143259e+01           6.701319e+01          -1.413139e+01          -1.
609717e+02          -5.518433e+03
         Sale.TypeCon         Sale.TypeConLD         Sale.TypeConLI         Sale
.TypeConLw           Sale.TypeCWD
         7.610070e+04           9.943661e+03           4.280125e+03          -6.
333838e+03           8.661725e+03
         Sale.TypeNew           Sale.TypeOth           Sale.TypeVWD           Sa
le.TypeWD  Sale.ConditionAdjLand
         1.310530e+04           7.171389e+04          -2.126211e+03           5.
720004e+02           2.750046e+04
 Sale.ConditionAlloca  Sale.ConditionFamily  Sale.ConditionNormal Sale.Condit
ionPartial
        -1.717744e+03           6.868475e+03           7.220630e+03          -4.
895394e+02
```

```
  set.seed(1)
  cv.out=cv.glmnet(x[train,],y[train],alpha=0)
  plot(cv.out)
```



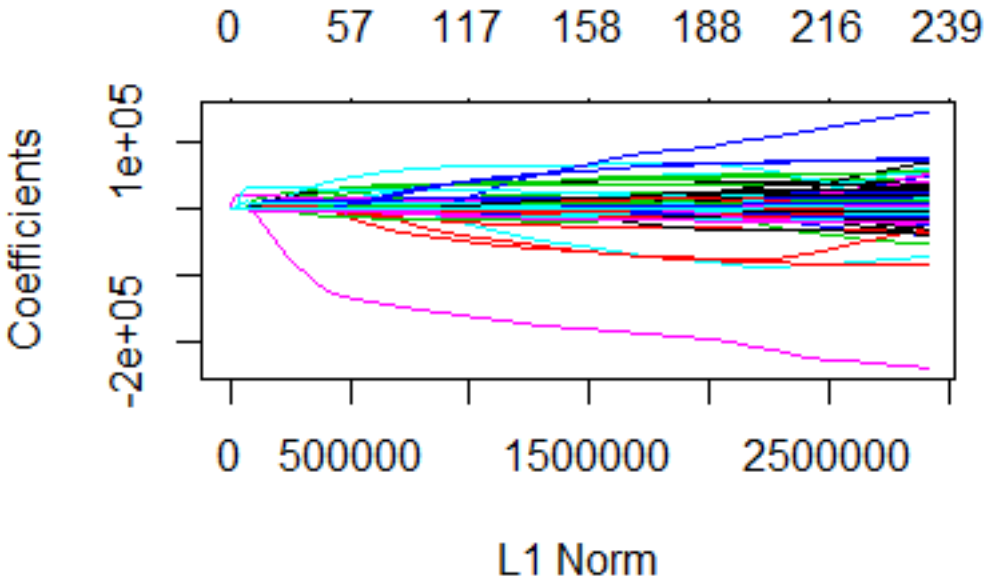
```
  bestlam=cv.out$lambda.min
  bestlam
[1] 58228.82
  ridge.pred=predict(ridge.mod,s=bestlam,newx=x[test,])
  mean((ridge.pred-y.test)^2)
[1] 1063608009
  out=glmnet(x,y,alpha=0)
  predict(out,type="coefficients",s=bestlam)[1:259,]
          (Intercept)           (Intercept)                 Order
PID           MS.SubClass
        -9.626573e+03          0.000000e+00         -4.094619e-01         -7.
315203e-06         -5.190688e+01
     MS.ZoningC (all)           MS.ZoningFV      MS.ZoningI (all)           M
S.ZoningRH           MS.ZoningRL
        -1.288642e+04          3.397352e+03          0.000000e+00         -1.
305885e+03          1.968130e+03
          MS.ZoningRM          Lot.Frontage              Lot.Area
StreetPave          Lot.ShapeIR2
        -3.043574e+03          6.137924e+01          4.501693e-01          1.
659481e+04          7.314976e+03
         Lot.ShapeIR3          Lot.ShapeReg       Land.ContourHLS       Land.
ContourLow       Land.ContourLvl
        -1.949551e+04         -1.832439e+03          9.735327e+03         -2.
238546e+03          1.698433e+03
      UtilitiesNoSeWa       UtilitiesNoSewr     Lot.ConfigCulDSac         Lot
.ConfigFR2         Lot.ConfigFR3
         0.000000e+00          0.000000e+00          1.063538e+04         -5.
856766e+03         -1.086089e+04
     Lot.ConfigInside         Land.SlopeMod         Land.SlopeSev   Neighborh
oodBlueste    NeighborhoodBrDale
        -4.475959e+01          4.014295e+03         -9.555456e+03         -4.
488125e+02         -1.874329e+03
  NeighborhoodBrkSide   NeighborhoodClearCr   NeighborhoodCollgCr   Neighborh
oodCrawfor   NeighborhoodEdwards
         2.086617e+03          2.634195e+02         -3.245974e+03          1.
054901e+04         -1.038400e+04
  NeighborhoodGilbert    NeighborhoodGreens   NeighborhoodGrnHill    Neighbor
hoodIDOTRR   NeighborhoodLandmrk
        -8.837125e+03          9.054265e+02          0.000000e+00         -1.
652926e+03          0.000000e+00
  NeighborhoodMeadowV   NeighborhoodMitchel     NeighborhoodNAmes   Neighborh
oodNoRidge   NeighborhoodNPkVill
        -1.150416e+04         -4.533596e+03         -5.387048e+03          2.
567015e+04          2.944811e+03
  NeighborhoodNridgHt    NeighborhoodNWAmes   NeighborhoodOldTown    Neighbor
hoodSawyer   NeighborhoodSawyerW
         1.927104e+04         -6.818033e+03         -3.794023e+03         -1.
654473e+03         -3.126428e+03
  NeighborhoodSomerst   NeighborhoodStoneBr     NeighborhoodSWISU    Neighbor
hoodTimber   NeighborhoodVeenker
         4.773216e+03          2.710912e+04         -2.491630e+03          5.
669416e+02          8.330813e+03
     Condition.1Feedr       Condition.1Norm       Condition.1PosA       Condi
tion.1PosN       Condition.1RRAe
```

```
        -4.522578e+03          4.136257e+03          1.301729e+04          6.
267793e+03         -7.240251e+03
      Condition.1RRAn       Condition.1RRNe       Condition.1RRNn      Condit
ion.2Feedr       Condition.2Norm
        -1.426530e+03         -1.682336e+04         -2.942946e+03         -1.
536363e+03         -4.559863e+02
      Condition.2PosA       Condition.2PosN       Condition.2RRAe       Condi
tion.2RRAn       Condition.2RRNn
         5.021516e+04         -3.062989e+04          0.000000e+00          0.
000000e+00          1.984548e+03
      Bldg.Type2fmCon       Bldg.TypeDuplex        Bldg.TypeTwnhs       Bldg.
TypeTwnhsE     House.Style1.5Unf
        -3.382658e+03         -8.441924e+03         -8.452317e+03         -6.
476819e+03         -2.532103e+02
    House.Style1Story     House.Style2.5Fin     House.Style2Story     House.S
tyleSFoyer       House.StyleSLvl
        -9.263605e+02          1.538912e+03          1.558472e+03         -1.
519085e+03         -4.186089e+03
         Overall.Qual          Overall.Cond            Year.Built        Year
.Remod.Add       Roof.StyleGable
         5.481358e+03          2.350158e+03          5.752370e+01          1.
270763e+02         -3.363319e+03
    Roof.StyleGambrel         Roof.StyleHip     Roof.StyleMansard        Roof
.StyleShed      Roof.MatlCompShg
        -9.411825e+02          3.876081e+03          4.283486e+03         -6.
660491e+03          9.823762e+03
     Roof.MatlMembran        Roof.MatlMetal         Roof.MatlRoll      Roof.M
atlTar&Grv      Roof.MatlWdShake
         2.367371e+04          0.000000e+00          3.986365e+03         -3.
701484e+03         -1.063002e+04
     Roof.MatlWdShngl   Exterior.1stAsphShn   Exterior.1stBrkComm   Exterior.
1stBrkFace    Exterior.1stCBlock
         5.579156e+04          0.000000e+00          3.483195e+03          1.
042819e+04         -6.333176e+03
  Exterior.1stCemntBd   Exterior.1stHdBoard   Exterior.1stImStucc   Exterior.
1stMetalSd   Exterior.1stPlywood
         5.035295e+03         -2.280169e+03         -8.123527e+03          6.
157062e+02         -1.653178e+03
  Exterior.1stPreCast     Exterior.1stStone    Exterior.1stStucco   Exterior.
1stVinylSd   Exterior.1stWd Sdng
         0.000000e+00          7.330518e+03         -5.469006e+03          3.
130185e+02         -5.284903e+02
  Exterior.1stWdShing   Exterior.2ndAsphShn   Exterior.2ndBrk Cmn   Exterior.
2ndBrkFace    Exterior.2ndCBlock
        -1.241255e+03          2.506211e+03         -1.402715e+02         -1.
819495e+01         -6.361339e+03
  Exterior.2ndCmentBd   Exterior.2ndHdBoard   Exterior.2ndImStucc   Exterior.
2ndMetalSd     Exterior.2ndOther
         4.524479e+03         -1.453898e+03          1.485317e+04          8.
884635e+02         -1.996164e+03
  Exterior.2ndPlywood   Exterior.2ndPreCast     Exterior.2ndStone    Exterior
.2ndStucco   Exterior.2ndVinylSd
        -2.562862e+03          0.000000e+00          2.688434e+03         -5.
731191e+03          5.893831e+02
  Exterior.2ndWd Sdng   Exterior.2ndWd Shng    Mas.Vnr.TypeBrkCmn   Mas.Vnr.T
ypeBrkFace    Mas.Vnr.TypeCBlock
```

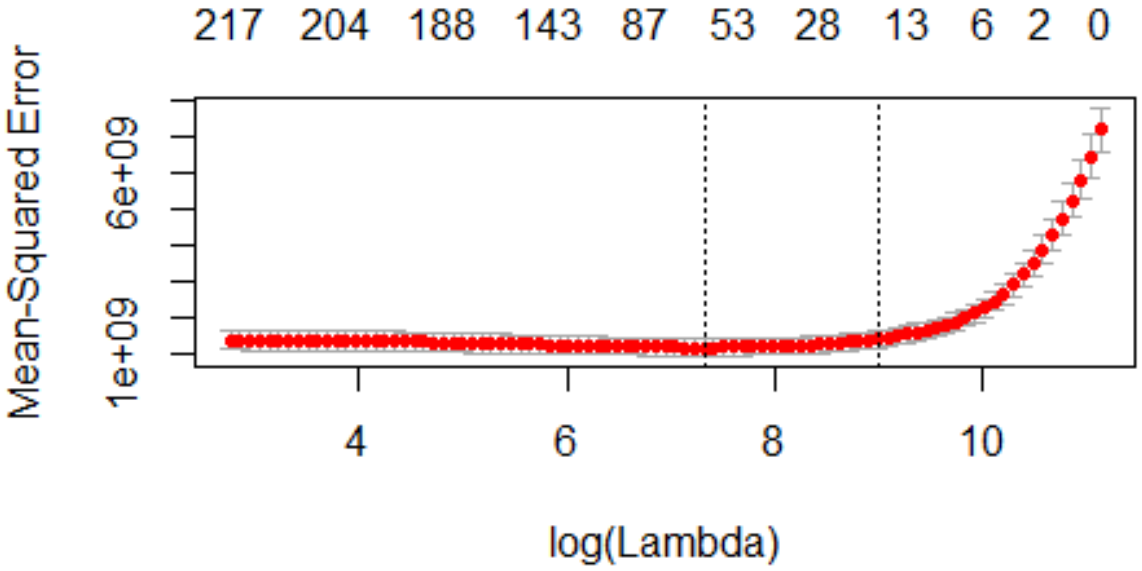
```
         4.367333e+02          -1.902289e+03          -7.754521e+03          -8.
583922e+02          -3.105481e+04
     Mas.Vnr.TypeNone     Mas.Vnr.TypeStone          Mas.Vnr.Area          Ex
ter.QualFa          Exter.QualGd
        -4.776141e+02           3.906761e+03           2.290083e+01          -3.
654875e+03          -1.406694e+03
         Exter.QualTA          Exter.CondFa          Exter.CondGd          Ex
ter.CondPo          Exter.CondTA
        -6.240878e+03          -5.618821e+03           3.198803e+02          -7.
483052e+03           2.801063e+02
     FoundationCBlock       FoundationPConc        FoundationSlab       Found
ationStone        FoundationWood
        -2.407346e+03           2.658608e+03           0.000000e+00           5.
939742e+03          -1.099039e+04
          Bsmt.QualEx           Bsmt.QualFa           Bsmt.QualGd           B
smt.QualPo           Bsmt.QualTA
         2.096842e+04          -3.770735e+03          -3.618788e+03           7.
712692e+03          -3.829536e+03
          Bsmt.CondEx           Bsmt.CondFa           Bsmt.CondGd           B
smt.CondPo           Bsmt.CondTA
         6.981194e+03          -5.584986e+02           6.144782e+02          -7.
906306e+03          -1.040528e+02
      Bsmt.ExposureAv       Bsmt.ExposureGd       Bsmt.ExposureMn       Bsmt.
ExposureNo     BsmtFin.Type.1ALQ
         1.507014e+03           1.126492e+04          -2.429786e+03          -4.
508296e+03          -7.525842e+02
    BsmtFin.Type.1BLQ     BsmtFin.Type.1GLQ     BsmtFin.Type.1LwQ     BsmtFin
.Type.1Rec     BsmtFin.Type.1Unf
        -1.465593e+03           5.724047e+03          -2.407306e+03          -2.
278843e+03          -3.053841e+03
         BsmtFin.SF.1     BsmtFin.Type.2ALQ     BsmtFin.Type.2BLQ     BsmtFin
.Type.2GLQ     BsmtFin.Type.2LwQ
         7.356633e+00           1.971161e+03          -1.696181e+03           7.
161301e+03          -1.254588e+03
    BsmtFin.Type.2Rec     BsmtFin.Type.2Unf          BsmtFin.SF.2           B
smt.Unf.SF          Total.Bsmt.SF
        -2.273655e+03           3.316977e+02           4.648526e+00           4.
089269e-02           9.759053e+00
          HeatingGasA           HeatingGasW           HeatingGrav           H
eatingOthW           HeatingWall
        -2.866436e+03           3.333938e+03           2.710248e+03          -7.
366582e+03           0.000000e+00
         Heating.QCFa          Heating.QCGd          Heating.QCPo          He
ating.QCTA          Central.AirY
        -5.856350e+03          -1.619133e+03          -6.783345e+03          -3.
709681e+03           3.916410e+03
      ElectricalFuseA       ElectricalFuseF       ElectricalFuseP         Ele
ctricalMix       ElectricalSBrkr
        -4.448846e+02          -1.637989e+03           1.324773e+03           4.
308590e+03           5.282039e+02
          X1st.Flr.SF           X2nd.Flr.SF       Low.Qual.Fin.SF           G
r.Liv.Area        Bsmt.Full.Bath
         1.283021e+01           8.570546e+00          -4.319954e+00           1.
403389e+01           3.889582e+03
       Bsmt.Half.Bath             Full.Bath             Half.Bath         Bed
room.AbvGr         Kitchen.AbvGr
```

```
        -3.623781e+03          6.191651e+03          4.648112e+03          1.
141200e+03         -1.032352e+04
       Kitchen.QualFa        Kitchen.QualGd        Kitchen.QualPo        Kitc
hen.QualTA         TotRms.AbvGrd
        -4.786042e+03         -4.521355e+03          2.669171e+03         -6.
459863e+03          2.533184e+03
       FunctionalMaj2        FunctionalMin1        FunctionalMin2         Fun
ctionalMod         FunctionalSal
        -1.197647e+04         -3.364840e+03         -1.472383e+03         -5.
113031e+01         -1.697620e+04
        FunctionalSev         FunctionalTyp            Fireplaces     Garage.
TypeAttchd    Garage.TypeBasment
         0.000000e+00          4.153680e+03          5.878241e+03          1.
274376e+03         -3.684127e+03
   Garage.TypeBuiltIn    Garage.TypeCarPort     Garage.TypeDetchd         Gar
age.Yr.Blt      Garage.FinishFin
         4.875890e+03         -4.199895e+03         -1.904194e+03          4.
142533e+01          3.631817e+03
     Garage.FinishRFn      Garage.FinishUnf           Garage.Cars           G
arage.Area         Garage.QualEx
        -1.779224e+03         -1.340403e+03          6.012520e+03          1.
998906e+01          3.216823e+04
        Garage.QualFa         Garage.QualGd         Garage.QualPo         Gar
age.QualTA         Garage.CondEx
        -1.389122e+03          1.297420e+04         -1.451541e+03         -1.
508161e+03         -1.639875e+04
        Garage.CondFa         Garage.CondGd         Garage.CondPo         Gar
age.CondTA          Paved.DriveP
        -2.234502e+03          7.427294e+02         -2.014920e+03          2.
439952e+03         -3.299803e+02
         Paved.DriveY          Wood.Deck.SF         Open.Porch.SF        Encl
osed.Porch           X3Ssn.Porch
         1.796068e+03          1.722071e+01          1.060556e+01          2.
475535e+00          1.413336e+01
         Screen.Porch             Pool.Area              Misc.Val
Mo.Sold               Yr.Sold
         3.829651e+01          1.307010e+01         -6.080142e+00         -4.
701895e+01         -2.130904e+02
         Sale.TypeCon        Sale.TypeConLD        Sale.TypeConLI        Sale
.TypeConLw         Sale.TypeCWD
         1.586507e+04          1.483216e+03         -1.513782e+03         -2.
107326e+03          3.288103e+03
         Sale.TypeNew          Sale.TypeOth          Sale.TypeVWD          Sa
le.TypeWD  Sale.ConditionAdjLand
         5.067929e+03          1.103848e+04         -4.600761e+03         -1.
020688e+03          8.588874e+03
 Sale.ConditionAlloca  Sale.ConditionFamily  Sale.ConditionNormal Sale.Condit
ionPartial
         1.476156e+03         -1.363944e+03          4.098467e+02          5.
094033e+03
  lasso.mod=glmnet(x[train,],y[train],alpha=1,lambda=grid)
```

```
plot(lasso.mod)
```




```
set.seed(1)
cv.out=cv.glmnet(x[train,],y[train],alpha=1)
plot(cv.out)
```




```
bestlam=cv.out$lambda.min
```

```
  lasso.pred=predict(lasso.mod,s=bestlam,newx=x[test,])
  mean((lasso.pred-y.test)^2)
[1] 1051037698
  out=glmnet(x,y,alpha=1,lambda=grid)
  lasso.coef=predict(out,type="coefficients",s=bestlam)[1:259,]
  lasso.coef
          (Intercept)           (Intercept)                 Order
PID           MS.SubClass
        -6.425584e+05          0.000000e+00          0.000000e+00          0.
000000e+00         -1.471870e+02
     MS.ZoningC (all)           MS.ZoningFV      MS.ZoningI (all)           M
S.ZoningRH           MS.ZoningRL
        -3.490420e+02          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
          MS.ZoningRM          Lot.Frontage              Lot.Area
StreetPave          Lot.ShapeIR2
        -3.838722e+03          0.000000e+00          4.153255e-01          1.
690445e+03          5.125573e+03
          Lot.ShapeIR3          Lot.ShapeReg       Land.ContourHLS       Land.
ContourLow       Land.ContourLvl
        -1.287089e+04          0.000000e+00          4.707810e+03          0.
000000e+00          0.000000e+00
      UtilitiesNoSeWa       UtilitiesNoSewr     Lot.ConfigCulDSac         Lot
.ConfigFR2          Lot.ConfigFR3
         0.000000e+00          0.000000e+00          7.295989e+03         -6.
916527e+01         -1.319916e+02
     Lot.ConfigInside         Land.SlopeMod         Land.SlopeSev   Neighborh
oodBlueste    NeighborhoodBrDale
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
  NeighborhoodBrkSide   NeighborhoodClearCr   NeighborhoodCollgCr   Neighborh
oodCrawfor   NeighborhoodEdwards
         0.000000e+00          0.000000e+00          0.000000e+00          1.
115085e+04         -6.703876e+03
  NeighborhoodGilbert    NeighborhoodGreens   NeighborhoodGrnHill    Neighbor
hoodIDOTRR   NeighborhoodLandmrk
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
  NeighborhoodMeadowV   NeighborhoodMitchel     NeighborhoodNAmes   Neighborh
oodNoRidge   NeighborhoodNPkVill
         0.000000e+00          0.000000e+00          0.000000e+00          3.
283999e+04          0.000000e+00
  NeighborhoodNridgHt    NeighborhoodNWAmes   NeighborhoodOldTown    Neighbor
hoodSawyer   NeighborhoodSawyerW
         2.900726e+04         -1.176464e+03          0.000000e+00          0.
000000e+00          0.000000e+00
  NeighborhoodSomerst   NeighborhoodStoneBr     NeighborhoodSWISU    Neighbor
hoodTimber   NeighborhoodVeenker
         8.032422e+03          3.787520e+04          0.000000e+00          0.
000000e+00          0.000000e+00
     Condition.1Feedr       Condition.1Norm       Condition.1PosA       Condi
tion.1PosN       Condition.1RRAe
        -3.811860e+02          4.310128e+03          2.484733e+02          0.
000000e+00          0.000000e+00
      Condition.1RRAn       Condition.1RRNe       Condition.1RRNn      Condit
ion.2Feedr       Condition.2Norm
```

```
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
      Condition.2PosA       Condition.2PosN       Condition.2RRAe       Condi
tion.2RRAn       Condition.2RRNn
         4.554746e+04         -2.610345e+04          0.000000e+00          0.
000000e+00          0.000000e+00
      Bldg.Type2fmCon       Bldg.TypeDuplex        Bldg.TypeTwnhs       Bldg.
TypeTwnhsE     House.Style1.5Unf
         0.000000e+00         -1.613816e+02         -5.618622e+02          0.
000000e+00          0.000000e+00
    House.Style1Story     House.Style2.5Fin     House.Style2Story     House.S
tyleSFoyer       House.StyleSLvl
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
         Overall.Qual          Overall.Cond            Year.Built        Year
.Remod.Add       Roof.StyleGable
         1.292705e+04          2.874401e+03          1.690550e+02          1.
404624e+02          0.000000e+00
    Roof.StyleGambrel          Roof.StyleHip     Roof.StyleMansard        Roof
.StyleShed      Roof.MatlCompShg
         0.000000e+00          1.434883e+03          0.000000e+00          0.
000000e+00          8.306739e+03
     Roof.MatlMembran        Roof.MatlMetal         Roof.MatlRoll      Roof.M
atlTar&Grv      Roof.MatlWdShake
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
     Roof.MatlWdShngl   Exterior.1stAsphShn   Exterior.1stBrkComm   Exterior.
1stBrkFace    Exterior.1stCBlock
         4.919045e+04          0.000000e+00          0.000000e+00          9.
941572e+03          0.000000e+00
  Exterior.1stCemntBd   Exterior.1stHdBoard   Exterior.1stImStucc   Exterior.
1stMetalSd   Exterior.1stPlywood
         1.355362e+03          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
  Exterior.1stPreCast     Exterior.1stStone    Exterior.1stStucco   Exterior.
1stVinylSd   Exterior.1stWd Sdng
         0.000000e+00          0.000000e+00         -1.276464e+03          0.
000000e+00          0.000000e+00
  Exterior.1stWdShing   Exterior.2ndAsphShn   Exterior.2ndBrk Cmn   Exterior.
2ndBrkFace    Exterior.2ndCBlock
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
  Exterior.2ndCmentBd   Exterior.2ndHdBoard   Exterior.2ndImStucc   Exterior.
2ndMetalSd     Exterior.2ndOther
         0.000000e+00          0.000000e+00          4.568325e+02          0.
000000e+00          0.000000e+00
  Exterior.2ndPlywood   Exterior.2ndPreCast     Exterior.2ndStone    Exterior
.2ndStucco   Exterior.2ndVinylSd
        -6.288799e+01          0.000000e+00          0.000000e+00         -2.
289972e+03          0.000000e+00
  Exterior.2ndWd Sdng   Exterior.2ndWd Shng    Mas.Vnr.TypeBrkCmn   Mas.Vnr.T
ypeBrkFace    Mas.Vnr.TypeCBlock
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00         -8.074848e+02
     Mas.Vnr.TypeNone     Mas.Vnr.TypeStone          Mas.Vnr.Area          Ex
ter.QualFa          Exter.QualGd
```

```
         0.000000e+00          0.000000e+00          1.738144e+01          0.
000000e+00          0.000000e+00
         Exter.QualTA          Exter.CondFa          Exter.CondGd          Ex
ter.CondPo          Exter.CondTA
        -1.953584e+03          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
     FoundationCBlock       FoundationPConc        FoundationSlab       Found
ationStone        FoundationWood
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
          Bsmt.QualEx           Bsmt.QualFa           Bsmt.QualGd           B
smt.QualPo           Bsmt.QualTA
         3.529420e+04          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
          Bsmt.CondEx           Bsmt.CondFa           Bsmt.CondGd           B
smt.CondPo           Bsmt.CondTA
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
      Bsmt.ExposureAv       Bsmt.ExposureGd       Bsmt.ExposureMn       Bsmt.
ExposureNo     BsmtFin.Type.1ALQ
         4.393219e+02          1.200056e+04          0.000000e+00         -3.
085645e+03          0.000000e+00
    BsmtFin.Type.1BLQ     BsmtFin.Type.1GLQ     BsmtFin.Type.1LwQ     BsmtFin
.Type.1Rec     BsmtFin.Type.1Unf
         0.000000e+00          4.458277e+03          0.000000e+00          0.
000000e+00          0.000000e+00
         BsmtFin.SF.1     BsmtFin.Type.2ALQ     BsmtFin.Type.2BLQ     BsmtFin
.Type.2GLQ     BsmtFin.Type.2LwQ
         1.062233e+01          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
    BsmtFin.Type.2Rec     BsmtFin.Type.2Unf         BsmtFin.SF.2           B
smt.Unf.SF          Total.Bsmt.SF
         0.000000e+00          0.000000e+00          1.134169e+00          0.
000000e+00          2.945117e+00
          HeatingGasA           HeatingGasW           HeatingGrav           H
eatingOthW           HeatingWall
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
         Heating.QCFa          Heating.QCGd          Heating.QCPo          He
ating.QCTA          Central.AirY
        -1.085446e+02          0.000000e+00          0.000000e+00         -7.
604316e+02          0.000000e+00
      ElectricalFuseA       ElectricalFuseF       ElectricalFuseP         Ele
ctricalMix       ElectricalSBrkr
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
          X1st.Flr.SF           X2nd.Flr.SF       Low.Qual.Fin.SF           G
r.Liv.Area        Bsmt.Full.Bath
         0.000000e+00          0.000000e+00          0.000000e+00          4.
747308e+01          3.404570e+03
       Bsmt.Half.Bath             Full.Bath             Half.Bath         Bed
room.AbvGr          Kitchen.AbvGr
         0.000000e+00          1.492465e+03          7.509512e+00          0.
000000e+00         -8.030678e+03
       Kitchen.QualFa        Kitchen.QualGd        Kitchen.QualPo        Kitc
hen.QualTA         TotRms.AbvGrd
```

```
         0.000000e+00         -1.063106e+03          0.000000e+00         -3.
833206e+03          0.000000e+00
       Functional.Maj2        Functional.Min1        Functional.Min2         Fun
ctional.Mod         Functional.Sal
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
        Functional.Sev         Functional.Typ            Fireplaces     Garage.
Type.Attchd    Garage.Type.Basment
         0.000000e+00          2.607700e+03          4.062577e+03          0.
000000e+00          0.000000e+00
   Garage.Type.BuiltIn    Garage.Type.CarPort     Garage.Type.Detchd         Gar
age.Yr.Blt      Garage.Finish.Fin
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          2.492025e+03
     Garage.Finish.RFn      Garage.Finish.Unf           Garage.Cars           G
arage.Area         Garage.Qual.Ex
         0.000000e+00          0.000000e+00          7.384026e+03          1.
447594e+01          0.000000e+00
        Garage.Qual.Fa         Garage.Qual.Gd         Garage.Qual.Po         Gar
age.Qual.TA         Garage.Cond.Ex
         0.000000e+00          2.421360e+03          0.000000e+00          0.
000000e+00          0.000000e+00
        Garage.Cond.Fa         Garage.Cond.Gd         Garage.Cond.Po         Gar
age.Cond.TA          Paved.Drive.P
         0.000000e+00          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
         Paved.Drive.Y          Wood.Deck.SF         Open.Porch.SF        Encl
osed.Porch           X3Ssn.Porch
         0.000000e+00          6.124815e+00          0.000000e+00          0.
000000e+00          0.000000e+00
         Screen.Porch              Pool.Area               Misc.Val
Mo.Sold              Yr.Sold
         3.852267e+01          0.000000e+00         -7.728169e+00          0.
000000e+00          0.000000e+00
         Sale.Type.Con        Sale.Type.ConLD        Sale.Type.ConLI        Sale
.Type.ConLw          Sale.Type.CWD
         1.536438e+03          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
         Sale.Type.New          Sale.Type.Oth          Sale.Type.VWD          Sa
le.Type.WD  Sale.Condition.AdjLand
         3.914226e+03          0.000000e+00          0.000000e+00          0.
000000e+00          0.000000e+00
 Sale.Condition.Alloca  Sale.Condition.Family  Sale.Condition.Normal Sale.Condit
ion.Partial
         0.000000e+00          0.000000e+00          0.000000e+00          3.
501780e+03
  lasso.coef[lasso.coef!=0]
          (Intercept)           MS.SubClass      MS.Zoning.C (all)           M
S.Zoning.RM              Lot.Area
        -6.425584e+05         -1.471870e+02         -3.490420e+02         -3.
838722e+03          4.153255e-01
          Street.Pave          Lot.Shape.IR2          Lot.Shape.IR3       Land.
Contour.HLS     Lot.Config.CulDSac
         1.690445e+03          5.125573e+03         -1.287089e+04          4.
707810e+03          7.295989e+03
        Lot.Config.FR2         Lot.Config.FR3   Neighborhood.Crawfor   Neighborh
ood.Edwards   Neighborhood.NoRidge
```

```
        -6.916527e+01         -1.319916e+02          1.115085e+04         -6.
703876e+03          3.283999e+04
  NeighborhoodNridgHt    NeighborhoodNWAmes   NeighborhoodSomerst   Neighborh
oodStoneBr      Condition.1Feedr
         2.900726e+04         -1.176464e+03          8.032422e+03          3.
787520e+04         -3.811860e+02
      Condition.1Norm       Condition.1PosA       Condition.2PosA       Condi
tion.2PosN       Bldg.TypeDuplex
         4.310128e+03          2.484733e+02          4.554746e+04         -2.
610345e+04         -1.613816e+02
       Bldg.TypeTwnhs          Overall.Qual          Overall.Cond
Year.Built        Year.Remod.Add
        -5.618622e+02          1.292705e+04          2.874401e+03          1.
690550e+02          1.404624e+02
        Roof.StyleHip      Roof.MatlCompShg      Roof.MatlWdShngl   Exterior.
1stBrkFace   Exterior.1stCemntBd
         1.434883e+03          8.306739e+03          4.919045e+04          9.
941572e+03          1.355362e+03
   Exterior.1stStucco   Exterior.2ndImStucc   Exterior.2ndPlywood    Exterior
.2ndStucco    Mas.Vnr.TypeCBlock
        -1.276464e+03          4.568325e+02         -6.288799e+01         -2.
289972e+03         -8.074848e+02
         Mas.Vnr.Area          Exter.QualTA           Bsmt.QualEx       Bsmt.
ExposureAv       Bsmt.ExposureGd
         1.738144e+01         -1.953584e+03          3.529420e+04          4.
393219e+02          1.200056e+04
      Bsmt.ExposureNo     BsmtFin.Type.1GLQ         BsmtFin.SF.1          Bs
mtFin.SF.2         Total.Bsmt.SF
        -3.085645e+03          4.458277e+03          1.062233e+01          1.
134169e+00          2.945117e+00
         Heating.QCFa          Heating.QCTA          Gr.Liv.Area        Bsmt
.Full.Bath             Full.Bath
        -1.085446e+02         -7.604316e+02          4.747308e+01          3.
404570e+03          1.492465e+03
            Half.Bath         Kitchen.AbvGr        Kitchen.QualGd        Kitc
hen.QualTA         FunctionalTyp
         7.509512e+00         -8.030678e+03         -1.063106e+03         -3.
833206e+03          2.607700e+03
          Fireplaces      Garage.FinishFin          Garage.Cars           G
arage.Area         Garage.QualGd
         4.062577e+03          2.492025e+03          7.384026e+03          1.
447594e+01          2.421360e+03
         Wood.Deck.SF          Screen.Porch              Misc.Val          Sa
le.TypeCon          Sale.TypeNew
         6.124815e+00          3.852267e+01         -7.728169e+00          1.
536438e+03          3.914226e+03
Sale.ConditionPartial
         3.501780e+03
```

```
  set.seed(2)
  pcr.fit=pcr(SalePrice~., data=cleanData,validation="CV")
  summary(pcr.fit)
```

```
Data:   X dimension: 2223 258
        Y dimension: 2223 1
Fit method: svdpc
Number of components considered: 258

VALIDATION: RMSEP
```

```
Cross-validated using 10 random segments.
       (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 c
omps  8 comps  9 comps  10 comps
CV           83386    80748    78947    78999    52099    50559    50378    4
9234    49374    47072     47160
adjCV        83386    80745    78754    78806    51420    50380    49803    4
9081    49216    46866     47014
       11 comps  12 comps  13 comps  14 comps  15 comps  16 comps  17 comps
18 comps  19 comps  20 comps
CV        46792     46584     46102     46231     46293     46274     46304
46703     43071     43088
adjCV     46624     46415     45926     46056     46114     46095     46122
46524     42856     42873
       21 comps  22 comps  23 comps  24 comps  25 comps  26 comps  27 comps
28 comps  29 comps  30 comps
CV        43035     42793     42639     42656     39543     38847     36595
36000     36125     36151
adjCV     42818     42568     42414     42429     39312     38705     36388
35777     35891     35914
       31 comps  32 comps  33 comps  34 comps  35 comps  36 comps  37 comps
38 comps  39 comps  40 comps
CV        36166     36056     36086     36102     35957     35882     35920
35924     35957     35989
adjCV     35933     35815     35846     35869     35705     35631     35677
35681     35720     35755
       41 comps  42 comps  43 comps  44 comps  45 comps  46 comps  47 comps
48 comps  49 comps  50 comps
CV        35843     35840     35933     35886     35817     35673     35605
35600     35656     35638
adjCV     35596     35593     35670     35628     35578     35424     35336
35340     35396     35388
       51 comps  52 comps  53 comps  54 comps  55 comps  56 comps  57 comps
58 comps  59 comps  60 comps
CV        35339     35375     35296     35236     35181     35183     35163
35160     35118     35102
adjCV     35076     35116     35036     34958     34916     34920     34898
34914     34851     34841
       61 comps  62 comps  63 comps  64 comps  65 comps  66 comps  67 comps
68 comps  69 comps  70 comps
CV        35125     35124     35076     35028     34953     34760     34725
34446     34516     34445
adjCV     34868     34871     34819     34787     34687     34502     34479
34179     34255     34172
       71 comps  72 comps  73 comps  74 comps  75 comps  76 comps  77 comps
78 comps  79 comps  80 comps
CV        34499     34152     34093     34092     33885     33906     33865
33767     33742     33685
adjCV     34243     33893     33825     33827     33616     33643     33631
33500     33469     33413
       81 comps  82 comps  83 comps  84 comps  85 comps  86 comps  87 comps
88 comps  89 comps  90 comps
CV        33698     33735     33776     33797     33769     33796     33832
33835     33851     33828
adjCV     33428     33463     33504     33533     33494     33522     33560
33577     33603     33541
       91 comps  92 comps  93 comps  94 comps  95 comps  96 comps  97 comps
98 comps  99 comps  100 comps
```

CV 33789 33724 33658 33630 33633 33674 33662
33672 33659 33560
adjCV 33527 33434 33374 33357 33354 33405 33372
33388 33382 33238
101 comps 102 comps 103 comps 104 comps 105 comps 106 comps 107
comps 108 comps 109 comps
CV 33513 33507 33446 33474 33380 33372
33269 33295 33326
adjCV 33227 33286 33134 33160 33072 33076
32972 33021 33071
110 comps 111 comps 112 comps 113 comps 114 comps 115 comps 116
comps 117 comps 118 comps
CV 33231 33221 33154 33057 33029 32927
32890 32888 32714
adjCV 32926 32935 32852 32764 32706 32610
32585 32606 32388
119 comps 120 comps 121 comps 122 comps 123 comps 124 comps 125
comps 126 comps 127 comps
CV 32712 32723 32640 32785 32702 32541
32561 32538 32522
adjCV 32382 32400 32342 32506 32414 32237
32243 32230 32183
128 comps 129 comps 130 comps 131 comps 132 comps 133 comps 134
comps 135 comps 136 comps
CV 32517 32500 32431 32382 32425 32439
32406 32382 32308
adjCV 32220 32188 32113 32068 32109 32138
32097 32059 32014
137 comps 138 comps 139 comps 140 comps 141 comps 142 comps 143
comps 144 comps 145 comps
CV 32276 32255 32267 32207 32153 32148
32183 32049 32041
adjCV 31961 31924 31928 31894 31849 31830
31877 31723 31718
146 comps 147 comps 148 comps 149 comps 150 comps 151 comps 152
comps 153 comps 154 comps
CV 31984 31941 31929 31877 31856 31860
31832 31830 31871
adjCV 31634 31607 31597 31524 31514 31526
31506 31507 31546
155 comps 156 comps 157 comps 158 comps 159 comps 160 comps 161
comps 162 comps 163 comps
CV 31887 31827 31830 31826 31902 31935
31918 31907 31910
adjCV 31573 31482 31489 31486 31563 31598
31587 31592 31653
164 comps 165 comps 166 comps 167 comps 168 comps 169 comps 170
comps 171 comps 172 comps
CV 31808 31853 31912 31957 32026 32019
32037 32019 32029
adjCV 31444 31495 31552 31606 31638 31640
31665 31659 31667
173 comps 174 comps 175 comps 176 comps 177 comps 178 comps 179
comps 180 comps 181 comps
CV 32035 32030 32052 32060 32147 32201
32220 32224 32224

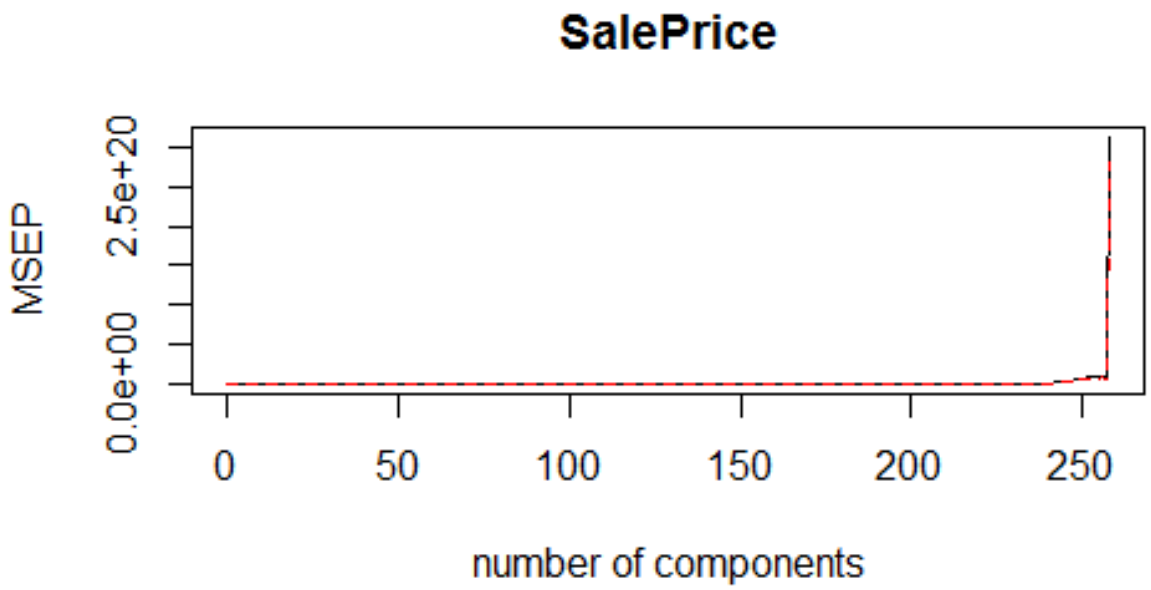
```
adjCV      31676      31659      31683      31688      31780      31842
31873      31881      31870
       182 comps  183 comps  184 comps  185 comps  186 comps  187 comps  188
comps  189 comps  190 comps
CV         32274      32282      32306      32292      32279      32273
32291      32337      32271
adjCV      31952      31894      31939      31931      31930      31862
31909      31989      31939
       191 comps  192 comps  193 comps  194 comps  195 comps  196 comps  197
comps  198 comps  199 comps
CV         32308      32251      32316      32291      32299      32306
32408      32412      32411
adjCV      31921      31835      31902      31881      31867      31851
31971      31984      31985
       200 comps  201 comps  202 comps  203 comps  204 comps  205 comps  206
comps  207 comps  208 comps
CV         32441      32458      32450      32475      32448      32470
32484      32495      32582
adjCV      32017      32030      32017      32035      32015      32041
32058      32074      32149
       209 comps  210 comps  211 comps  212 comps  213 comps  214 comps  215
comps  216 comps  217 comps
CV         32577      32561      32646      32669      32688      32662
32623      32665      32756
adjCV      32145      32128      32214      32219      32240      32230
32178      32222      32290
       218 comps  219 comps  220 comps  221 comps  222 comps  223 comps  224
comps  225 comps  226 comps
CV         32750      32771      32729      32737      32741      32737
32737      32738      33175
adjCV      32280      32301      32265      32273      32281      32274
32280      32282      32711
       227 comps  228 comps  229 comps  230 comps  231 comps  232 comps  233
comps  234 comps  235 comps
CV         33219      33910     225483     243645     646232     921057   364
88355   12065335   39370333
adjCV      32890      33514     214156     231454     613142     873695   346
18487   11446425   37351914
       236 comps  237 comps  238 comps  239 comps  240 comps  241 comps  242
comps  243 comps  244 comps
CV     327870019  524512316  511918502  603372205  644217103  601833503  7331
73876  845755331  844293843
adjCV  310991414  497510129  485570985  572377641  611142311  570912431  6955
07184  802288693  800906145
       245 comps  246 comps  247 comps  248 comps  249 comps  250 comps  251
comps  252 comps  253 comps
CV     969133744  1.122e+09  1.690e+09  2.253e+09  2.354e+09  2.464e+09  2.52
5e+09  2.607e+09  2.607e+09
adjCV  919297678  1.065e+09  1.603e+09  2.137e+09  2.233e+09  2.337e+09  2.39
6e+09  2.473e+09  2.473e+09
       254 comps  255 comps  256 comps  257 comps  258 comps
CV     2.640e+09  2.644e+09  2.795e+09  2.693e+09  1.767e+10
adjCV  2.504e+09  2.508e+09  2.651e+09  2.555e+09  1.676e+10

TRAINING: % variance explained
          1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 comps  8 c
omps  9 comps  10 comps  11 comps
```

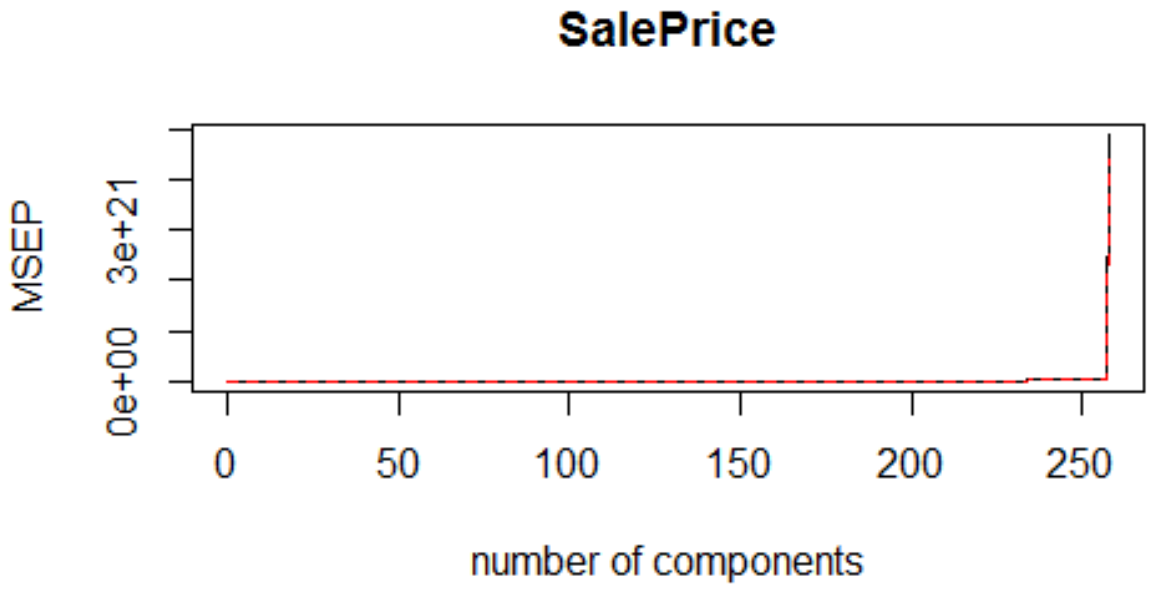
```
X          100.000   100.00   100.00   100.00   100.00   100.00    100.0   10
0.00   100.00    100.00    100.00
SalePrice    6.255    16.97    16.97    59.35    62.26    63.28     68.6    6
8.61    71.62     71.67     72.16
           12 comps  13 comps  14 comps  15 comps  16 comps  17 comps  18 com
ps  19 comps  20 comps  21 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     72.45     73.04     73.05     73.06     73.11     73.15     73.
19     77.64     77.64     77.75
           22 comps  23 comps  24 comps  25 comps  26 comps  27 comps  28 com
ps  29 comps  30 comps  31 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     78.16     78.36     78.37     81.66     82.46     84.33     85.
05     85.16     85.17     85.19
           32 comps  33 comps  34 comps  35 comps  36 comps  37 comps  38 com
ps  39 comps  40 comps  41 comps
X             100.0     100.0     100.0    100.00    100.00    100.00    100.
00    100.00    100.00     100.0
SalePrice      85.3      85.3      85.3     85.42     85.48     85.49     85.
51     85.52     85.53      85.7
           42 comps  43 comps  44 comps  45 comps  46 comps  47 comps  48 com
ps  49 comps  50 comps  51 comps
X            100.00    100.00     100.0    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     85.72     85.77      85.8     85.84     85.94     86.06     86.
06     86.06     86.11     86.33
           52 comps  53 comps  54 comps  55 comps  56 comps  57 comps  58 com
ps  59 comps  60 comps  61 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     86.36     86.42     86.51     86.51     86.52     86.55     86.
56     86.63     86.63     86.64
           62 comps  63 comps  64 comps  65 comps  66 comps  67 comps  68 com
ps  69 comps  70 comps  71 comps
X            100.00    100.00    100.00     100.0    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     86.65     86.69     86.72      86.8     86.95     86.97     87.
16     87.16     87.24     87.25
           72 comps  73 comps  74 comps  75 comps  76 comps  77 comps  78 com
ps  79 comps  80 comps  81 comps
X             100.0    100.00    100.00    100.00     100.0    100.00    100.
00    100.00     100.0     100.0
SalePrice      87.4     87.51     87.56     87.69      87.7     87.73     87.
83     87.87      87.9      87.9
           82 comps  83 comps  84 comps  85 comps  86 comps  87 comps  88 com
ps  89 comps  90 comps  91 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00     100.0
SalePrice     87.91     87.91     87.91     87.93     87.93     87.93     87.
93     87.94     88.04      88.1
           92 comps  93 comps  94 comps  95 comps  96 comps  97 comps  98 com
ps  99 comps  100 comps  101 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00      100.0      100.0
```

```
SalePrice     88.17     88.18     88.19     88.22     88.23     88.27     88.
28     88.29       88.4       88.4
           102 comps  103 comps  104 comps  105 comps  106 comps  107 comps
108 comps  109 comps  110 comps
X              100.0     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       88.4      88.55      88.57      88.62      88.64      88.71
88.71      88.73      88.87
           111 comps  112 comps  113 comps  114 comps  115 comps  116 comps
117 comps  118 comps  119 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00      100.0     100.00
SalePrice       88.88      88.94      88.99      89.08      89.12      89.14
89.14       89.3      89.32
           120 comps  121 comps  122 comps  123 comps  124 comps  125 comps
126 comps  127 comps  128 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       89.33      89.33      89.33      89.43      89.53      89.58
89.58      89.63      89.63
           129 comps  130 comps  131 comps  132 comps  133 comps  134 comps
135 comps  136 comps  137 comps
X             100.00      100.0     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       89.66       89.7      89.72      89.73      89.73      89.75
89.79      89.79      89.86
           138 comps  139 comps  140 comps  141 comps  142 comps  143 comps
144 comps  145 comps  146 comps
X             100.00     100.00        100     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       89.91      89.97         90      90.01      90.04      90.06
90.12      90.12      90.19
           147 comps  148 comps  149 comps  150 comps  151 comps  152 comps
153 comps  154 comps  155 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00      100.0
SalePrice       90.21      90.23      90.27      90.27      90.27      90.28
90.28      90.29       90.3
           156 comps  157 comps  158 comps  159 comps  160 comps  161 comps
162 comps  163 comps  164 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       90.36      90.36      90.37      90.37      90.37      90.37
90.38      90.38      90.51
           165 comps  166 comps  167 comps  168 comps  169 comps  170 comps
171 comps  172 comps  173 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       90.51      90.52      90.53      90.56      90.56      90.57
90.57      90.58      90.58
           174 comps  175 comps  176 comps  177 comps  178 comps  179 comps
180 comps  181 comps  182 comps
X              100.0      100.0     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice       90.6       90.6      90.61      90.61      90.61      90.61
90.61      90.64      90.64
```

```
           183 comps  184 comps  185 comps  186 comps  187 comps  188 comps
189 comps  190 comps  191 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      90.72      90.72      90.73      90.73      90.82      90.83
90.85      90.87      90.94
           192 comps  193 comps  194 comps  195 comps  196 comps  197 comps
198 comps  199 comps  200 comps
X             100.00        100     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      90.99         91      91.01      91.04      91.07      91.07
91.08      91.08      91.08
           201 comps  202 comps  203 comps  204 comps  205 comps  206 comps
207 comps  208 comps  209 comps
X             100.00      100.0      100.0      100.0      100.0      100.0
100.0      100.00     100.00
SalePrice      91.09       91.1       91.1       91.1       91.1       91.1
91.1       91.11      91.12
           210 comps  211 comps  212 comps  213 comps  214 comps  215 comps
216 comps  217 comps  218 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00      100.0     100.00
SalePrice      91.13      91.13      91.15      91.15      91.15      91.17
91.18       91.2      91.21
           219 comps  220 comps  221 comps  222 comps  223 comps  224 comps
225 comps  226 comps  227 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      91.21      91.22      91.22      91.22      91.22      91.22
91.23      91.23      91.23
           228 comps  229 comps  230 comps  231 comps  232 comps  233 comps
234 comps  235 comps  236 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      91.24      91.24      91.24      91.25      92.75      92.76
92.76      92.76      92.77
           237 comps  238 comps  239 comps  240 comps  241 comps  242 comps
243 comps  244 comps  245 comps
X              100.0      100.0      100.0      100.0      100.0      100.0
100.0      100.00     100.00
SalePrice       92.8       92.8       92.8       92.8       92.8       92.8
92.8       92.81      92.81
           246 comps  247 comps  248 comps  249 comps  250 comps  251 comps
252 comps  253 comps  254 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      92.81      92.82      92.82      92.83      92.83      92.84
92.85      92.85      92.85
           255 comps  256 comps  257 comps  258 comps
X             100.00     100.00     100.00     100.00
SalePrice      92.85      92.85      92.85      92.86
  validationplot(pcr.fit,val.type="MSEP")
```




```
  set.seed(1)
  pcr.fit=pcr(SalePrice~., data=cleanData,subset=train, validation="CV")
  validationplot(pcr.fit,val.type="MSEP")
```




```
  pcr.pred=predict(pcr.fit,x[test,],ncomp=100)
  mean((pcr.pred-y.test)^2)
[1] 1.542901e+22
  pcr.fit=pcr(y~x,ncomp=100)
  summary(pcr.fit)
Data:   X dimension: 2223 258
        Y dimension: 2223 1
```

```
Fit method: svdpc
Number of components considered: 100
TRAINING: % variance explained
   1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 comps  8 comps  9
comps  10 comps  11 comps
X  100.000   100.00   100.00   100.00   100.00   100.00    100.0   100.00   1
00.00    100.00    100.00
y    6.255    16.97    16.97    59.35    62.26    63.28     68.6    68.61
71.62     71.67     72.16
   12 comps  13 comps  14 comps  15 comps  16 comps  17 comps  18 comps  19 c
omps  20 comps  21 comps  22 comps
X    100.00    100.00    100.00    100.00    100.00    100.00    100.00    10
0.00    100.00    100.00    100.00
y     72.45     73.04     73.05     73.06     73.11     73.15     73.19     7
7.64     77.64     77.75     78.16
   23 comps  24 comps  25 comps  26 comps  27 comps  28 comps  29 comps  30 c
omps  31 comps  32 comps  33 comps
X    100.00    100.00    100.00    100.00    100.00    100.00    100.00    10
0.00    100.00     100.0     100.0
y     78.36     78.37     81.66     82.46     84.33     85.06     85.16     8
5.17     85.19      85.3      85.3
   34 comps  35 comps  36 comps  37 comps  38 comps  39 comps  40 comps  41 c
omps  42 comps  43 comps  44 comps
X     100.0    100.00    100.00    100.00    100.00    100.00    100.00     1
00.0    100.00    100.00     100.0
y      85.3     85.42     85.48     85.49     85.51     85.52     85.53
85.7     85.72     85.77      85.8
   45 comps  46 comps  47 comps  48 comps  49 comps  50 comps  51 comps  52 c
omps  53 comps  54 comps  55 comps
X    100.00    100.00    100.00    100.00    100.00    100.00    100.00    10
0.00    100.00    100.00    100.00
y     85.84     85.94     86.06     86.06     86.06     86.11     86.33     8
6.36     86.42     86.51     86.52
   56 comps  57 comps  58 comps  59 comps  60 comps  61 comps  62 comps  63 c
omps  64 comps  65 comps  66 comps
X    100.00    100.00    100.00    100.00    100.00    100.00    100.00    10
0.00    100.00     100.0    100.00
y     86.52     86.55     86.56     86.63     86.63     86.64     86.65     8
6.69     86.72      86.8     86.95
   67 comps  68 comps  69 comps  70 comps  71 comps  72 comps  73 comps  74 c
omps  75 comps  76 comps  77 comps
X    100.00    100.00    100.00    100.00    100.00     100.0    100.00    10
0.00    100.00    100.00    100.00
y     86.97     87.16     87.16     87.24     87.25      87.4     87.51     8
7.56     87.69     87.71     87.72
   78 comps  79 comps  80 comps  81 comps  82 comps  83 comps  84 comps  85 c
omps  86 comps  87 comps  88 comps
X    100.00    100.00     100.0    100.00    100.00    100.00    100.00    10
0.00    100.00    100.00    100.00
y     87.83     87.87      87.9     87.91     87.91     87.91     87.91     8
7.93     87.93     87.94     87.94
   89 comps  90 comps  91 comps  92 comps  93 comps  94 comps  95 comps  96 c
omps  97 comps  98 comps  99 comps
X    100.00    100.00     100.0    100.00    100.00    100.00    100.00    10
0.00    100.00    100.00    100.00
y     87.94     88.04      88.1     88.17     88.18     88.19     88.22     8
8.23     88.27     88.28     88.29
```

```
   100 comps
X      100.0
y       88.4
  set.seed(1)
  pls.fit=plsr(SalePrice~., data=cleanData,subset=train, validation="CV")
  summary(pls.fit)
Data:   X dimension: 1111 258
        Y dimension: 1111 1
Fit method: kernelpls
Number of components considered: 258

VALIDATION: RMSEP
Cross-validated using 10 random segments.
       (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 c
omps  8 comps  9 comps  10 comps
CV           85179    82559    85455    48303    49265    48702    47516    4
7331    48037    46374     45834
adjCV        85179    82553    84911    48286    48988    48362    47211    4
7010    47684    46124     45500
       11 comps  12 comps  13 comps  14 comps  15 comps  16 comps  17 comps
18 comps  19 comps  20 comps
CV        45602     44742     44109     44000     43783     43865     43584
43606     43585     43444
adjCV     45211     44388     43774     43673     43452     43507     43241
43255     43237     43124
       21 comps  22 comps  23 comps  24 comps  25 comps  26 comps  27 comps
28 comps  29 comps  30 comps
CV        43161     42648     38019     36886     36220     36312     35776
35247     35247     35248
adjCV     42852     42375     38098     36393     36068     35848     36070
35747     35747     35747
       31 comps  32 comps  33 comps  34 comps  35 comps  36 comps  37 comps
38 comps  39 comps  40 comps
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248     35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747     35747
       41 comps  42 comps  43 comps  44 comps  45 comps  46 comps  47 comps
48 comps  49 comps  50 comps
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248     35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747     35747
       51 comps  52 comps  53 comps  54 comps  55 comps  56 comps  57 comps
58 comps  59 comps  60 comps
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248     35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747     35747
       61 comps  62 comps  63 comps  64 comps  65 comps  66 comps  67 comps
68 comps  69 comps  70 comps
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248     35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747     35747
       71 comps  72 comps  73 comps  74 comps  75 comps  76 comps  77 comps
78 comps  79 comps  80 comps
```

```
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248     35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747     35747
       81 comps  82 comps  83 comps  84 comps  85 comps  86 comps  87 comps
88 comps  89 comps  90 comps
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248     35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747     35747
       91 comps  92 comps  93 comps  94 comps  95 comps  96 comps  97 comps
98 comps  99 comps  100 comps
CV        35248     35248     35248     35248     35248     35248     35248
35248     35248      35248
adjCV     35747     35747     35747     35747     35747     35747     35747
35747     35747      35747
       101 comps  102 comps  103 comps  104 comps  105 comps  106 comps  107
comps  108 comps  109 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       110 comps  111 comps  112 comps  113 comps  114 comps  115 comps  116
comps  117 comps  118 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       119 comps  120 comps  121 comps  122 comps  123 comps  124 comps  125
comps  126 comps  127 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       128 comps  129 comps  130 comps  131 comps  132 comps  133 comps  134
comps  135 comps  136 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       137 comps  138 comps  139 comps  140 comps  141 comps  142 comps  143
comps  144 comps  145 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       146 comps  147 comps  148 comps  149 comps  150 comps  151 comps  152
comps  153 comps  154 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       155 comps  156 comps  157 comps  158 comps  159 comps  160 comps  161
comps  162 comps  163 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
```

```
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       164 comps  165 comps  166 comps  167 comps  168 comps  169 comps  170
comps  171 comps  172 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       173 comps  174 comps  175 comps  176 comps  177 comps  178 comps  179
comps  180 comps  181 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       182 comps  183 comps  184 comps  185 comps  186 comps  187 comps  188
comps  189 comps  190 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       191 comps  192 comps  193 comps  194 comps  195 comps  196 comps  197
comps  198 comps  199 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       200 comps  201 comps  202 comps  203 comps  204 comps  205 comps  206
comps  207 comps  208 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       209 comps  210 comps  211 comps  212 comps  213 comps  214 comps  215
comps  216 comps  217 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       218 comps  219 comps  220 comps  221 comps  222 comps  223 comps  224
comps  225 comps  226 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       227 comps  228 comps  229 comps  230 comps  231 comps  232 comps  233
comps  234 comps  235 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
       236 comps  237 comps  238 comps  239 comps  240 comps  241 comps  242
comps  243 comps  244 comps
CV         35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV      35747      35747      35747      35747      35747      35747
35747      35747      35747
```

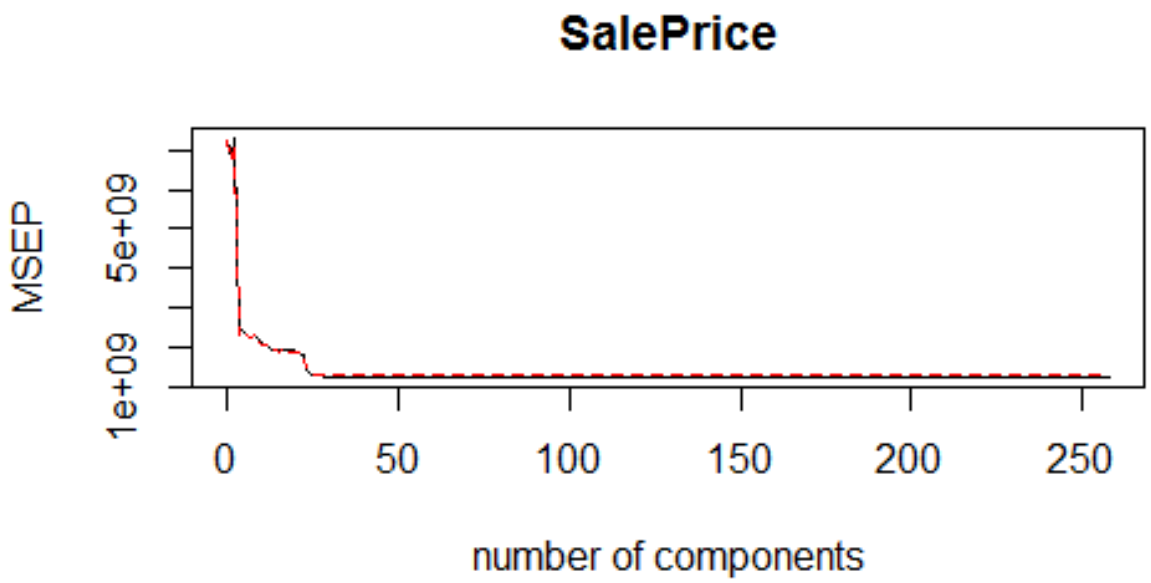
```
       245 comps  246 comps  247 comps  248 comps  249 comps  250 comps  251
comps  252 comps  253 comps
CV          35248      35248      35248      35248      35248      35248
35248      35248      35248
adjCV       35747      35747      35747      35747      35747      35747
35747      35747      35747
       254 comps  255 comps  256 comps  257 comps  258 comps
CV          35248      35248      35248      35248      35248
adjCV       35747      35747      35747      35747      35747

TRAINING: % variance explained
           1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 comps  8 c
omps  9 comps  10 comps  11 comps
X          100.000   100.00   100.00   100.00   100.00   100.00   100.00   10
0.00   100.00     100.0    100.00
SalePrice    6.153    17.05    70.11    72.69    73.93    74.98    75.45    7
5.63    75.92      77.5     78.41
           12 comps  13 comps  14 comps  15 comps  16 comps  17 comps  18 com
ps  19 comps  20 comps  21 comps
X             100.0    100.00    100.00    100.00    100.00     100.0    100.
00    100.00    100.00    100.00
SalePrice      79.1     79.48     79.54     79.71     79.93      80.1     80.
15     80.18     80.27     80.42
           22 comps  23 comps  24 comps  25 comps  26 comps  27 comps  28 com
ps  29 comps  30 comps  31 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     80.86     85.85     87.47     87.72     88.98     88.98     88.
98     88.98     88.98     88.98
           32 comps  33 comps  34 comps  35 comps  36 comps  37 comps  38 com
ps  39 comps  40 comps  41 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98     88.98     88.98
           42 comps  43 comps  44 comps  45 comps  46 comps  47 comps  48 com
ps  49 comps  50 comps  51 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98     88.98     88.98
           52 comps  53 comps  54 comps  55 comps  56 comps  57 comps  58 com
ps  59 comps  60 comps  61 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98     88.98     88.98
           62 comps  63 comps  64 comps  65 comps  66 comps  67 comps  68 com
ps  69 comps  70 comps  71 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98     88.98     88.98
           72 comps  73 comps  74 comps  75 comps  76 comps  77 comps  78 com
ps  79 comps  80 comps  81 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
```

```
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98     88.98     88.98
           82 comps  83 comps  84 comps  85 comps  86 comps  87 comps  88 com
ps  89 comps  90 comps  91 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00    100.00    100.00
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98     88.98     88.98
           92 comps  93 comps  94 comps  95 comps  96 comps  97 comps  98 com
ps  99 comps  100 comps  101 comps
X            100.00    100.00    100.00    100.00    100.00    100.00    100.
00    100.00     100.00     100.00
SalePrice     88.98     88.98     88.98     88.98     88.98     88.98     88.
98     88.98      88.98      88.98
           102 comps  103 comps  104 comps  105 comps  106 comps  107 comps
108 comps  109 comps  110 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           111 comps  112 comps  113 comps  114 comps  115 comps  116 comps
117 comps  118 comps  119 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           120 comps  121 comps  122 comps  123 comps  124 comps  125 comps
126 comps  127 comps  128 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           129 comps  130 comps  131 comps  132 comps  133 comps  134 comps
135 comps  136 comps  137 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           138 comps  139 comps  140 comps  141 comps  142 comps  143 comps
144 comps  145 comps  146 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           147 comps  148 comps  149 comps  150 comps  151 comps  152 comps
153 comps  154 comps  155 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           156 comps  157 comps  158 comps  159 comps  160 comps  161 comps
162 comps  163 comps  164 comps
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
```

	165 comps	166 comps	167 comps	168 comps	169 comps	170 comps	171 comps	172 comps	173 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	174 comps	175 comps	176 comps	177 comps	178 comps	179 comps	180 comps	181 comps	182 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	183 comps	184 comps	185 comps	186 comps	187 comps	188 comps	189 comps	190 comps	191 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	192 comps	193 comps	194 comps	195 comps	196 comps	197 comps	198 comps	199 comps	200 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	201 comps	202 comps	203 comps	204 comps	205 comps	206 comps	207 comps	208 comps	209 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	210 comps	211 comps	212 comps	213 comps	214 comps	215 comps	216 comps	217 comps	218 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	219 comps	220 comps	221 comps	222 comps	223 comps	224 comps	225 comps	226 comps	227 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	228 comps	229 comps	230 comps	231 comps	232 comps	233 comps	234 comps	235 comps	236 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	237 comps	238 comps	239 comps	240 comps	241 comps	242 comps	243 comps	244 comps	245 comps
X	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SalePrice	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98	88.98
	246 comps	247 comps	248 comps	249 comps	250 comps	251 comps	252 comps	253 comps	254 comps

```
X             100.00     100.00     100.00     100.00     100.00     100.00
100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98      88.98      88.98
88.98      88.98      88.98
           255 comps  256 comps  257 comps  258 comps
X             100.00     100.00     100.00     100.00
SalePrice      88.98      88.98      88.98      88.98
  validationplot(pls.fit,val.type="MSEP")
```




```
  pls.pred=predict(pls.fit,x[test,],ncomp=5)
  mean((pls.pred-y.test)^2)
[1] 4.277126e+18
  pls.fit=plsr(SalePrice~., data=cleanData,ncomp = 5)
  summary(pls.fit)
Data:   X dimension: 2223 258
        Y dimension: 2223 1
Fit method: kernelpls
Number of components considered: 5
TRAINING: % variance explained
           1 comps  2 comps  3 comps  4 comps  5 comps
X          100.000   100.00   100.00    100.0   100.00
SalePrice    6.255    18.02    67.78     69.7    71.52
```

Problem 2) The data is split into subsets and one for each battery type: a) Energizer and b) Ultracell

The 'subset' function in R is used to divide the data into subsets based battery type.

1) The basis function (splines library) is used for splines and knot values for Time that are considered are 2.5, 6.0 and 7.5 as shown below.

fit=lm(Voltage~bs(Time, knots =c(2.5, 6.0, 7.5)))

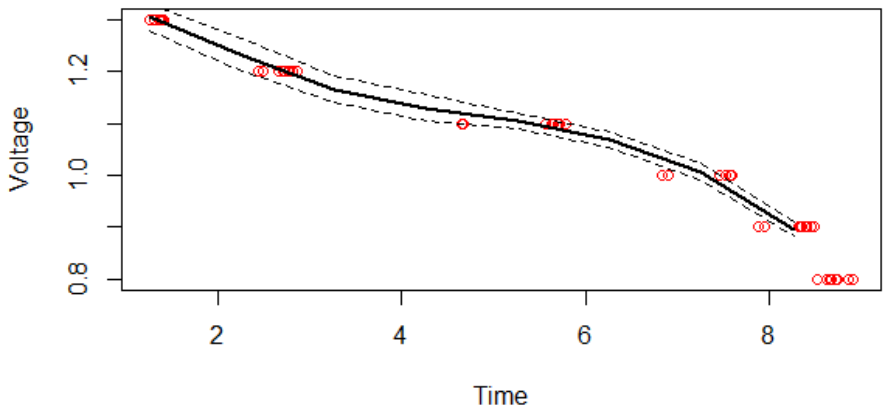
Below is the plot obtained for the same:

plot(Time, Voltage, col ="red")

lines(Time.grid, pred$fit, lwd =2)

lines(Time.grid, pred$fit +2 pred$se, lty ="dashed")*

lines(Time.grid, pred$fit -2 pred$se, lty = "dashed")*



2) Using Basis function for splines with degree of freedom as 6. The knot values generated are given by the 'attr' function :

```
> attr(bs(Time, df = 6), "knots")
   25%    50%    75%
2.7375 6.3050 8.3375
```

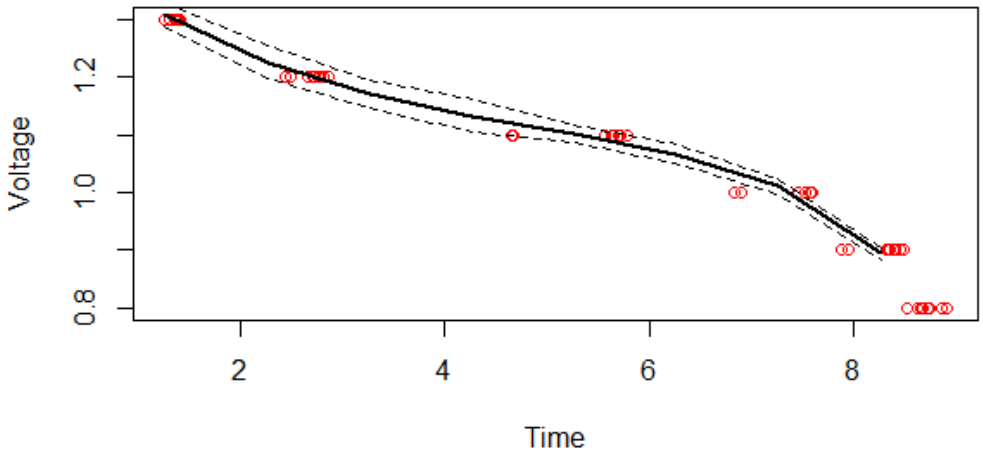
The plot for the same is:

plot(Time, Voltage, col ="red")

lines(Time.grid, pred$fit, lwd =2)

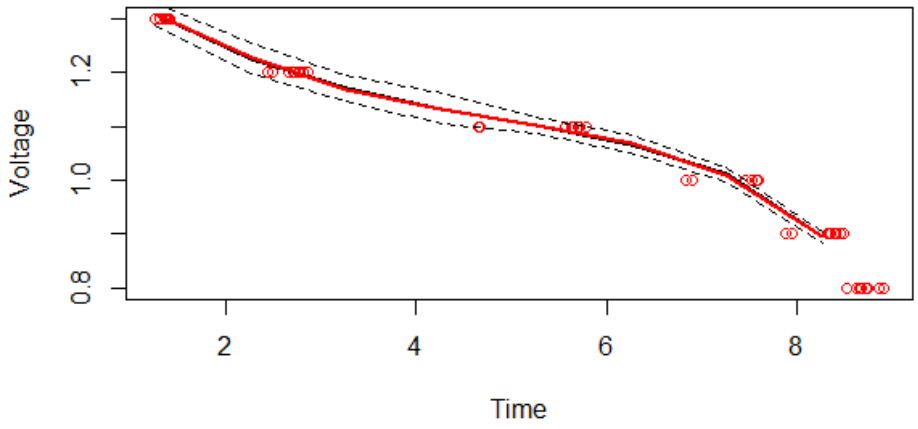
lines(Time.grid, pred$fit +2 pred$se, lty ="dashed")*

lines(Time.grid, pred$fit -2 pred$se, lty = "dashed")*



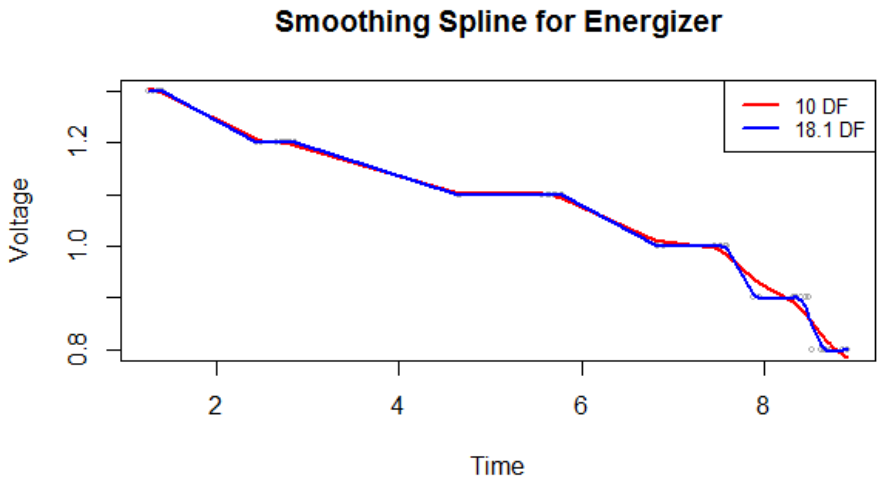
3) Natural Spline with degrees of freedom 4.

fit2 = lm(Voltage~ns(Time, df =4))



4) Smooth Spline

fit=smooth.spline (Time, Voltage, df =10)



The above same methodology is followed for the ultra-cell subset:

1) The basis function (splines library) is used for splines and knot values for Time that are considered are 2.5, 6.0 and 7.5 as shown below.

fit=lm(Voltage~bs(Time, knots =c(2.5, 6.0, 7.5)))

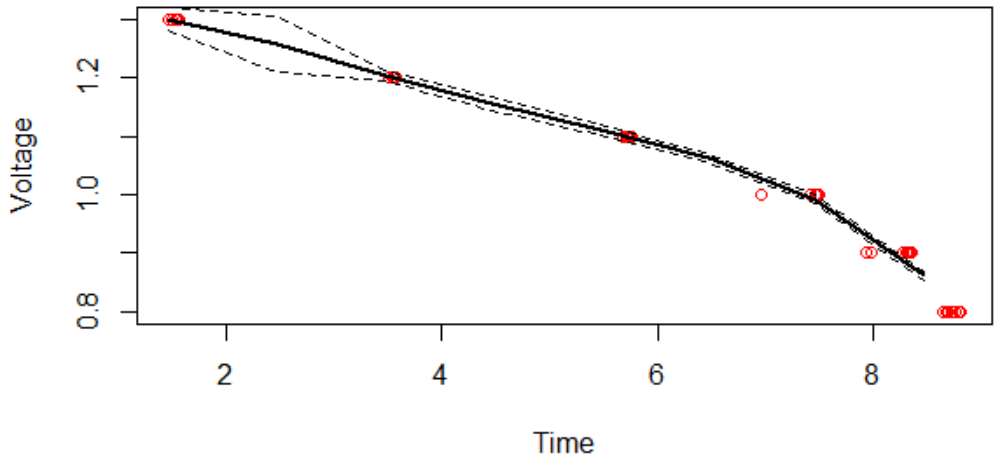
Below is the plot obtained for the same:

plot(Time, Voltage, col ="red")

lines(Time.grid, pred$fit, lwd =2)

lines(Time.grid, pred$fit +2 pred$se, lty ="dashed")*

lines(Time.grid, pred$fit -2 pred$se, lty = "dashed")*

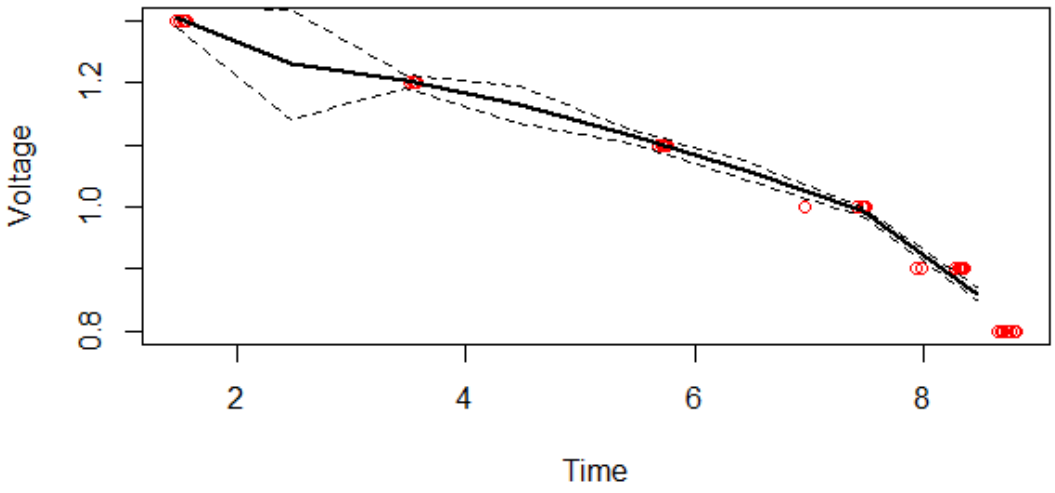


2) Using Basis function for splines with degree of freedom as 6. The knot values generated are given by the 'attr' function :

```
> attr(bs(Time, df = 6), "knots")
   25%    50%    75%
3.5425 6.3600 8.3175
```

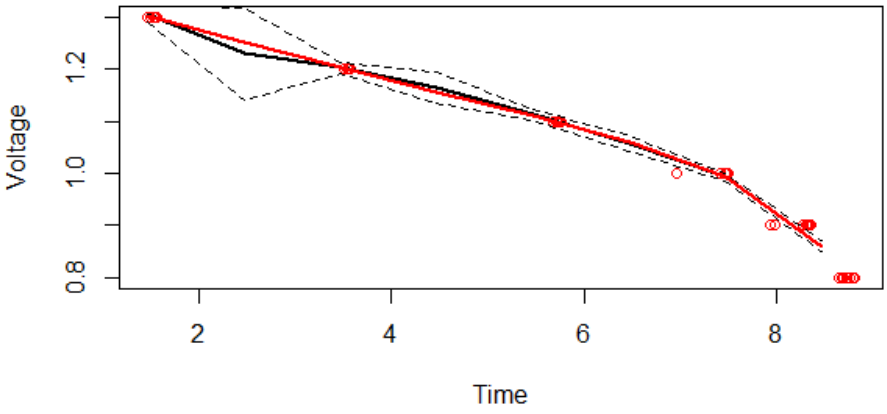
The plot for the same is as below:

```
plot(Time, Voltage, col ="red")
lines(Time.grid, pred$fit, lwd =2)
lines(Time.grid, pred$fit +2* pred$se, lty ="dashed")
lines(Time.grid, pred$fit -2* pred$se, lty = "dashed")
```



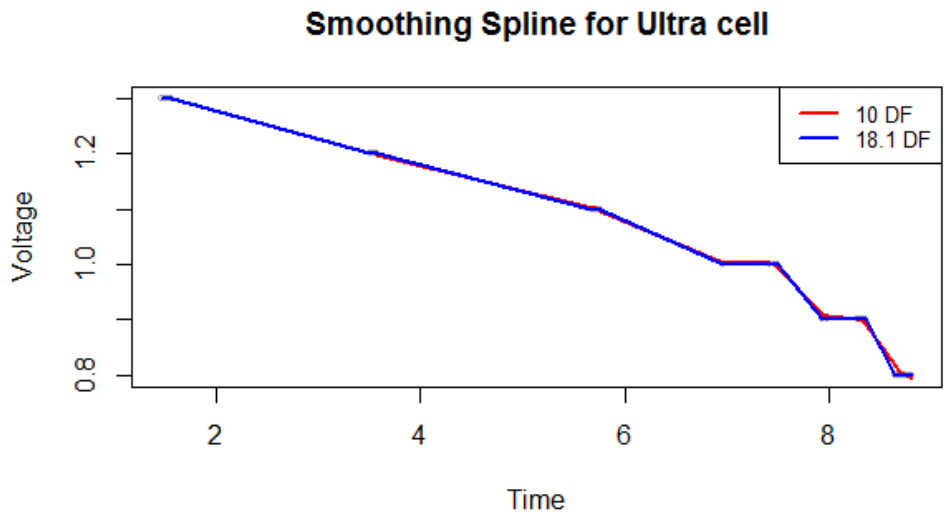
3) Natural Spline with degrees of freedom 4.

fit2 = lm(Voltage~ns(Time, df =4))



4)Smooth Spline

fit=smooth.spline (Time, Voltage, df =10)



R-Code for problem 2:

```
battery_life <- read.csv(file="batteries2.csv",head=TRUE,sep=",")
battery_energizer <- subset(battery_life,Brand=="Energizer")
battery_ultracell <- subset(battery_life,Brand=="Ultracell")

#Constructing models for the energizer subset
#using basis function
attach(battery_energizer)
timelims <- range(Time)
Time.grid <- seq(from = timelims[1], to = timelims[2])
fit=lm(Voltage~bs(Time, knots =c(2.5, 6.0, 7.5)))
pred=predict (fit ,newdata =list(Time = Time.grid),se=T)
plot(Time, Voltage, col ="red")
lines(Time.grid, pred$fit, lwd =2)
lines(Time.grid, pred$fit +2* pred$se, lty ="dashed")
lines(Time.grid, pred$fit -2* pred$se, lty = "dashed")

#using basis function with 6 degrees of freedom
```

```
attr(bs(Time, df = 6), "knots")
fit=lm(Voltage~bs(Time, df=6))
pred=predict (fit ,newdata =list(Time = Time.grid),se=T)
plot(Time, Voltage, col ="red")
lines(Time.grid, pred$fit, lwd =2)
lines(Time.grid, pred$fit +2* pred$se, lty ="dashed")
lines(Time.grid, pred$fit -2* pred$se, lty = "dashed")

#using the natural spline
fit2 = lm(Voltage~ns(Time, df =4))
pred2=predict (fit2, newdata =list(Time = Time.grid),se=T)
lines(Time.grid, pred2$fit, col ="red", lwd =2)

#smooth soline
plot(Time ,Voltage, xlim=timelims, cex =.5, col ="darkgrey")
title ("Smoothing Spline for Energizer")
fit=smooth.spline (Time, Voltage, df =10)
fit2=smooth.spline (Time, Voltage, cv=TRUE)
fit2$df
lines(fit, col ="red", lwd =2)
lines(fit2, col ="blue", lwd =2)
legend ("topright", legend = c("10 DF", "18.1 DF"),col=c("red", "blue"), lty = 1, lwd =2, cex =.8)

#Constructing the above same models for ultracell subset
#For the basis function
attach(battery_ultracell)
timelims <- range(Time)
Time.grid <- seq(from = timelims[1], to = timelims[2])
fit=lm(Voltage~bs(Time, knots =c(2.5, 6.0, 7.5)))
```

```
pred=predict (fit ,newdata =list(Time = Time.grid),se=T)
plot(Time, Voltage, col ="red")
lines(Time.grid, pred$fit, lwd =2)
lines(Time.grid, pred$fit +2* pred$se, lty ="dashed")
lines(Time.grid, pred$fit -2* pred$se, lty = "dashed")

#Basis function with 6 degrees of freedom
attr(bs(Time, df = 6), "knots")
fit=lm(Voltage~bs(Time, df=6))
pred=predict (fit ,newdata =list(Time = Time.grid),se=T)
plot(Time, Voltage, col ="red")
lines(Time.grid, pred$fit, lwd =2)
lines(Time.grid, pred$fit +2* pred$se, lty ="dashed")
lines(Time.grid, pred$fit -2* pred$se, lty = "dashed")

#natural spline
fit2 = lm(Voltage~ns(Time, df =4))
pred2=predict (fit2, newdata =list(Time = Time.grid),se=T)
lines(Time.grid, pred2$fit, col ="red", lwd =2)

#smooth spline
plot(Time ,Voltage, xlim=timelims, cex =.5, col ="darkgrey")
title ("Smoothing Spline for Ultra cell")
fit=smooth.spline (Time, Voltage, df =10)
fit2=smooth.spline (Time, Voltage, cv=TRUE)
fit2$df
lines(fit, col ="red", lwd =2)
lines(fit2, col ="blue", lwd =2)
legend ("topright", legend = c("10 DF", "18.1 DF"),col=c("red", "blue"), lty = 1, lwd =2, cex =.8)
```