Week-5

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```
#Loading the libraries
library(ggplot2)
library(ggthemes)
```

```
## Warning: package 'ggthemes' was built under R version 3.5.2
```

```
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 3.5.2
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(gridExtra)
```

```
## Warning: package 'gridExtra' was built under R version 3.5.2
```

```
##
## Attaching package: 'gridExtra'
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
library(corrplot)
```

```
## Warning: package 'corrplot' was built under R version 3.5.2
```

```
## corrplot 0.84 loaded
```

```
library(GGally)
```

```
## Warning: package 'GGally' was built under R version 3.5.2
```

```
##
## Attaching package: 'GGally'
```

```
## The following object is masked from 'package:dplyr':
##
##     nasa
```

```
library(data.table)
```

```
## Warning: package 'data.table' was built under R version 3.5.2
```

```
##
## Attaching package: 'data.table'
```

```
## The following objects are masked from 'package:dplyr':
##
##     between, first, last
```

```
library(scales)
library(MVA)
```

```
## Warning: package 'MVA' was built under R version 3.5.2
```

```
## Loading required package: HSAUR2
```

```
## Warning: package 'HSAUR2' was built under R version 3.5.2
```

```
## Loading required package: tools
```

```
library(Rmisc)
```

```
## Warning: package 'Rmisc' was built under R version 3.5.2
```

```
## Loading required package: lattice
```

```
## Warning: package 'lattice' was built under R version 3.5.2
```

```
## Loading required package: plyr
```

```
## ------------------------------------------------------------------------------
```

```
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first,
then dplyr:
## library(plyr); library(dplyr)
```

```
## ------------------------------------------------------------------------------
```

```
##
## Attaching package: 'plyr'
```

```
## The following objects are masked from 'package:dplyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
```

```r
# loading the dataset
training <- read.csv("D:/MultiAnalysis/Project/house-prices-advanced-regression-techniques/Data.csv.csv")
View(training)
```

UNDERSTANDING THE DATA

```r
dim(training) # checking the dimensions
```

```
## [1] 1460   81
```

```r
str(training)# checking the structure of dataset
```

```
## 'data.frame':    1460 obs. of  81 variables:
##  $ Id           : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ MSSubClass   : int  60 20 60 70 60 50 20 60 50 190 ...
##  $ MSZoning     : Factor w/ 5 levels "C (all)","FV",..: 4 4 4 4 4 4 4 4 5
4 ...
##  $ LotFrontage  : int  65 80 68 60 84 85 75 NA 51 50 ...
##  $ LotArea      : int  8450 9600 11250 9550 14260 14115 10084 10382 6120
7420 ...
##  $ Street       : Factor w/ 2 levels "Grvl","Pave": 2 2 2 2 2 2 2 2 2 2
...
##  $ Alley        : Factor w/ 2 levels "Grvl","Pave": NA NA NA NA NA NA NA
NA NA NA ...
##  $ LotShape     : Factor w/ 4 levels "IR1","IR2","IR3",..: 4 4 1 1 1 1 4 1
4 4 ...
##  $ LandContour  : Factor w/ 4 levels "Bnk","HLS","Low",..: 4 4 4 4 4 4 4 4
4 4 ...
##  $ Utilities    : Factor w/ 2 levels "AllPub","NoSeWa": 1 1 1 1 1 1 1 1
1 ...
##  $ LotConfig    : Factor w/ 5 levels "Corner","CulDSac",..: 5 3 5 1 3 5 5
1 5 1 ...
##  $ LandSlope    : Factor w/ 3 levels "Gtl","Mod","Sev": 1 1 1 1 1 1 1 1 1
1 ...
##  $ Neighborhood : Factor w/ 25 levels "Blmngtn","Blueste",..: 6 25 6 7 14
12 21 17 18 4 ...
##  $ Condition1   : Factor w/ 9 levels "Artery","Feedr",..: 3 2 3 3 3 3 3 5
1 1 ...
##  $ Condition2   : Factor w/ 8 levels "Artery","Feedr",..: 3 3 3 3 3 3 3 3
3 1 ...
##  $ BldgType     : Factor w/ 5 levels "1Fam","2fmCon",..: 1 1 1 1 1 1 1 1 1
2 ...
##  $ HouseStyle   : Factor w/ 8 levels "1.5Fin","1.5Unf",..: 6 3 6 6 6 1 3 6
1 2 ...
##  $ OverallQual  : int  7 6 7 7 8 5 8 7 7 5 ...
##  $ OverallCond  : int  5 8 5 5 5 5 5 6 5 6 ...
##  $ YearBuilt    : int  2003 1976 2001 1915 2000 1993 2004 1973 1931 1939
...
##  $ YearRemodAdd : int  2003 1976 2002 1970 2000 1995 2005 1973 1950 1950
...
```

```
##  $ RoofStyle    : Factor w/ 6 levels "Flat","Gable",..: 2 2 2 2 2 2 2 2 2
2 ...
##  $ RoofMatl     : Factor w/ 8 levels "ClyTile","CompShg",..: 2 2 2 2 2 2 2
2 2 2 ...
##  $ Exterior1st  : Factor w/ 15 levels "AsbShng","AsphShn",..: 13 9 13 14
13 13 13 7 4 9 ...
##  $ Exterior2nd  : Factor w/ 16 levels "AsbShng","AsphShn",..: 14 9 14 16
14 14 14 7 16 9 ...
##  $ MasVnrType   : Factor w/ 4 levels "BrkCmn","BrkFace",..: 2 3 2 3 2 3 4
4 3 3 ...
##  $ MasVnrArea   : int  196 0 162 0 350 0 186 240 0 0 ...
##  $ ExterQual    : Factor w/ 4 levels "Ex","Fa","Gd",..: 3 4 3 4 3 4 3 4 4
4 ...
##  $ ExterCond    : Factor w/ 5 levels "Ex","Fa","Gd",..: 5 5 5 5 5 5 5 5 5
5 ...
##  $ Foundation   : Factor w/ 6 levels "BrkTil","CBlock",..: 3 2 3 1 3 6 3 2
1 1 ...
##  $ BsmtQual     : Factor w/ 4 levels "Ex","Fa","Gd",..: 3 3 3 4 3 3 1 3 4
4 ...
##  $ BsmtCond     : Factor w/ 4 levels "Fa","Gd","Po",..: 4 4 4 2 4 4 4 4 4
4 ...
##  $ BsmtExposure : Factor w/ 4 levels "Av","Gd","Mn",..: 4 2 3 4 1 4 1 3 4
4 ...
##  $ BsmtFinType1 : Factor w/ 6 levels "ALQ","BLQ","GLQ",..: 3 1 3 1 3 3 3 1
6 3 ...
##  $ BsmtFinSF1   : int  706 978 486 216 655 732 1369 859 0 851 ...
##  $ BsmtFinType2 : Factor w/ 6 levels "ALQ","BLQ","GLQ",..: 6 6 6 6 6 6 6 2
6 6 ...
##  $ BsmtFinSF2   : int  0 0 0 0 0 0 0 32 0 0 ...
##  $ BsmtUnfSF    : int  150 284 434 540 490 64 317 216 952 140 ...
##  $ TotalBsmtSF  : int  856 1262 920 756 1145 796 1686 1107 952 991 ...
##  $ Heating      : Factor w/ 6 levels "Floor","GasA",..: 2 2 2 2 2 2 2 2 2
2 ...
##  $ HeatingQC    : Factor w/ 5 levels "Ex","Fa","Gd",..: 1 1 1 3 1 1 1 1 3
1 ...
##  $ CentralAir   : Factor w/ 2 levels "N","Y": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Electrical   : Factor w/ 5 levels "FuseA","FuseF",..: 5 5 5 5 5 5 5 5 2
5 ...
##  $ X1stFlrSF    : int  856 1262 920 961 1145 796 1694 1107 1022 1077 ...
##  $ X2ndFlrSF    : int  854 0 866 756 1053 566 0 983 752 0 ...
##  $ LowQualFinSF : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ GrLivArea    : int  1710 1262 1786 1717 2198 1362 1694 2090 1774 1077
...
##  $ BsmtFullBath : int  1 0 1 1 1 1 1 1 0 1 ...
##  $ BsmtHalfBath : int  0 1 0 0 0 0 0 0 0 0 ...
##  $ FullBath     : int  2 2 2 1 2 1 2 2 2 1 ...
##  $ HalfBath     : int  1 0 1 0 1 1 0 1 0 0 ...
##  $ BedroomAbvGr : int  3 3 3 3 4 1 3 3 2 2 ...
##  $ KitchenAbvGr : int  1 1 1 1 1 1 1 1 2 2 ...
##  $ KitchenQual  : Factor w/ 4 levels "Ex","Fa","Gd",..: 3 4 3 3 3 4 3 4 4
```

```
4 ...
##  $ TotRmsAbvGrd : int  8 6 6 7 9 5 7 7 8 5 ...
##  $ Functional   : Factor w/ 7 levels "Maj1","Maj2",..: 7 7 7 7 7 7 7 7 3 7
...
##  $ Fireplaces   : int  0 1 1 1 1 0 1 2 2 2 ...
##  $ FireplaceQu  : Factor w/ 5 levels "Ex","Fa","Gd",..: NA 5 5 3 5 NA 3 5
5 5 ...
##  $ GarageType   : Factor w/ 6 levels "2Types","Attchd",..: 2 2 2 6 2 2 2 2
6 2 ...
##  $ GarageYrBlt  : int  2003 1976 2001 1998 2000 1993 2004 1973 1931 1939
...
##  $ GarageFinish : Factor w/ 3 levels "Fin","RFn","Unf": 2 2 2 3 2 3 2 2 3
2 ...
##  $ GarageCars   : int  2 2 2 3 3 2 2 2 2 1 ...
##  $ GarageArea   : int  548 460 608 642 836 480 636 484 468 205 ...
##  $ GarageQual   : Factor w/ 5 levels "Ex","Fa","Gd",..: 5 5 5 5 5 5 5 5 2
3 ...
##  $ GarageCond   : Factor w/ 5 levels "Ex","Fa","Gd",..: 5 5 5 5 5 5 5 5 5
5 ...
##  $ PavedDrive   : Factor w/ 3 levels "N","P","Y": 3 3 3 3 3 3 3 3 3 3 ...
##  $ WoodDeckSF   : int  0 298 0 0 192 40 255 235 90 0 ...
##  $ OpenPorchSF  : int  61 0 42 35 84 30 57 204 0 4 ...
##  $ EnclosedPorch: int  0 0 0 272 0 0 0 228 205 0 ...
##  $ X3SsnPorch   : int  0 0 0 0 0 320 0 0 0 0 ...
##  $ ScreenPorch  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ PoolArea     : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ PoolQC       : Factor w/ 3 levels "Ex","Fa","Gd": NA NA NA NA NA NA NA
NA NA NA ...
##  $ Fence        : Factor w/ 4 levels "GdPrv","GdWo",..: NA NA NA NA NA 3
NA NA NA NA ...
##  $ MiscFeature  : Factor w/ 4 levels "Gar2","Othr",..: NA NA NA NA NA 3 NA
3 NA NA ...
##  $ MiscVal      : int  0 0 0 0 0 700 0 350 0 0 ...
##  $ MoSold       : int  2 5 9 2 12 10 8 11 4 1 ...
##  $ YrSold       : int  2008 2007 2008 2006 2008 2009 2007 2009 2008 2008
...
##  $ SaleType     : Factor w/ 9 levels "COD","Con","ConLD",..: 9 9 9 9 9 9 9
9 9 9 ...
##  $ SaleCondition: Factor w/ 6 levels "Abnorml","AdjLand",..: 5 5 5 1 5 5 5
5 1 5 ...
##  $ SalePrice    : int  208500 181500 223500 140000 250000 143000 307000
200000 129900 118000 ...

summary(training)# checking the summary of dataset

##        Id           MSSubClass       MSZoning     LotFrontage
##  Min.   :   1.0   Min.   : 20.0   C (all):  10   Min.   : 21.00
##  1st Qu.: 365.8   1st Qu.: 20.0   FV     :  65   1st Qu.: 59.00
##  Median : 730.5   Median : 50.0   RH     :  16   Median : 69.00
##  Mean   : 730.5   Mean   : 56.9   RL     :1151   Mean   : 70.05
```

```
##  3rd Qu.:1095.2   3rd Qu.: 70.0   RM     : 218   3rd Qu.: 80.00
##  Max.   :1460.0   Max.   :190.0                  Max.   :313.00
##                                                 NA's   :259
##     LotArea        Street      Alley      LotShape  LandContour
##  Min.   :  1300   Grvl:   6   Grvl:  50   IR1:484   Bnk:  63
##  1st Qu.:  7554   Pave:1454   Pave:  41   IR2: 41   HLS:  50
##  Median :  9478               NA's:1369   IR3: 10   Low:  36
##  Mean   : 10517                           Reg:925   Lvl:1311
##  3rd Qu.: 11602
##  Max.   :215245
##
##   Utilities      LotConfig    LandSlope   Neighborhood   Condition1
##  AllPub:1459   Corner : 263   Gtl:1382   NAmes  :225   Norm   :1260
##  NoSeWa:   1   CulDSac:  94   Mod:  65   CollgCr:150   Feedr  :  81
##                FR2    :  47   Sev:  13   OldTown:113   Artery :  48
##                FR3    :   4              Edwards:100   RRAn   :  26
##                Inside :1052              Somerst: 86   PosN   :  19
##                                          Gilbert: 79   RRAe   :  11
##                                          (Other):707   (Other):  15
##    Condition2     BldgType      HouseStyle   OverallQual
##  Norm   :1445   1Fam  :1220   1Story :726   Min.   : 1.000
##  Feedr  :   6   2fmCon:  31   2Story :445   1st Qu.: 5.000
##  Artery :   2   Duplex:  52   1.5Fin :154   Median : 6.000
##  PosN   :   2   Twnhs :  43   SLvl   : 65   Mean   : 6.099
##  RRNn   :   2   TwnhsE: 114   SFoyer : 37   3rd Qu.: 7.000
##  PosA   :   1                 1.5Unf : 14   Max.   :10.000
##  (Other):   2                 (Other): 19
##   OverallCond      YearBuilt     YearRemodAdd    RoofStyle
##  Min.   :1.000   Min.   :1872   Min.   :1950   Flat   :  13
##  1st Qu.:5.000   1st Qu.:1954   1st Qu.:1967   Gable  :1141
##  Median :5.000   Median :1973   Median :1994   Gambrel:  11
##  Mean   :5.575   Mean   :1971   Mean   :1985   Hip    : 286
##  3rd Qu.:6.000   3rd Qu.:2000   3rd Qu.:2004   Mansard:   7
##  Max.   :9.000   Max.   :2010   Max.   :2010   Shed   :   2
##
##     RoofMatl     Exterior1st   Exterior2nd    MasVnrType    MasVnrArea
##  CompShg:1434   VinylSd:515   VinylSd:504   BrkCmn : 15   Min.   :   0.0
##  Tar&Grv:  11   HdBoard:222   MetalSd:214   BrkFace:445   1st Qu.:   0.0
##  WdShngl:   6   MetalSd:220   HdBoard:207   None   :864   Median :   0.0
##  WdShake:   5   Wd Sdng:206   Wd Sdng:197   Stone  :128   Mean   : 103.7
##  ClyTile:   1   Plywood:108   Plywood:142   NA's   :  8   3rd Qu.: 166.0
##  Membran:   1   CemntBd: 61   CmentBd: 60                 Max.   :1600.0
##  (Other):   2   (Other):128   (Other):136                 NA's   :8
##  ExterQual ExterCond  Foundation  BsmtQual   BsmtCond    BsmtExposure
##  Ex: 52    Ex:   3   BrkTil:146   Ex  :121   Fa  :  45   Av  :221
##  Fa: 14    Fa:  28   CBlock:634   Fa  : 35   Gd  :  65   Gd  :134
##  Gd:488    Gd: 146   PConc :647   Gd  :618   Po  :   2   Mn  :114
##  TA:906    Po:   1   Slab  : 24   TA  :649   TA  :1311   No  :953
##            TA:1282   Stone :  6   NA's: 37   NA's:  37   NA's: 38
##                      Wood  :  3
```

```
##
##  BsmtFinType1   BsmtFinSF1     BsmtFinType2   BsmtFinSF2
##  ALQ :220     Min.   :   0.0   ALQ :  19    Min.   :   0.00
##  BLQ :148     1st Qu.:   0.0   BLQ :  33    1st Qu.:   0.00
##  GLQ :418     Median : 383.5   GLQ :  14    Median :   0.00
##  LwQ : 74     Mean   : 443.6   LwQ :  46    Mean   :  46.55
##  Rec :133     3rd Qu.: 712.2   Rec :  54    3rd Qu.:   0.00
##  Unf :430     Max.   :5644.0   Unf :1256    Max.   :1474.00
##  NA's: 37                      NA's:  38
##    BsmtUnfSF       TotalBsmtSF      Heating     HeatingQC CentralAir
##  Min.   :   0.0   Min.   :   0.0   Floor:   1   Ex:741    N:  95
##  1st Qu.: 223.0   1st Qu.: 795.8   GasA :1428   Fa: 49    Y:1365
##  Median : 477.5   Median : 991.5   GasW :  18   Gd:241
##  Mean   : 567.2   Mean   :1057.4   Grav :   7   Po:  1
##  3rd Qu.: 808.0   3rd Qu.:1298.2   OthW :   2   TA:428
##  Max.   :2336.0   Max.   :6110.0   Wall :   4
##
##  Electrical     X1stFlrSF      X2ndFlrSF     LowQualFinSF
##  FuseA:  94   Min.   : 334   Min.   :   0   Min.   :  0.000
##  FuseF:  27   1st Qu.: 882   1st Qu.:   0   1st Qu.:  0.000
##  FuseP:   3   Median :1087   Median :   0   Median :  0.000
##  Mix  :   1   Mean   :1163   Mean   : 347   Mean   :  5.845
##  SBrkr:1334   3rd Qu.:1391   3rd Qu.: 728   3rd Qu.:  0.000
##  NA's :   1   Max.   :4692   Max.   :2065   Max.   :572.000
##
##    GrLivArea     BsmtFullBath     BsmtHalfBath        FullBath
##  Min.   : 334   Min.   :0.0000   Min.   :0.00000   Min.   :0.000
##  1st Qu.:1130   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:1.000
##  Median :1464   Median :0.0000   Median :0.00000   Median :2.000
##  Mean   :1515   Mean   :0.4253   Mean   :0.05753   Mean   :1.565
##  3rd Qu.:1777   3rd Qu.:1.0000   3rd Qu.:0.00000   3rd Qu.:2.000
##  Max.   :5642   Max.   :3.0000   Max.   :2.00000   Max.   :3.000
##
##     HalfBath       BedroomAbvGr    KitchenAbvGr   KitchenQual
##  Min.   :0.0000   Min.   :0.000   Min.   :0.000   Ex:100
##  1st Qu.:0.0000   1st Qu.:2.000   1st Qu.:1.000   Fa: 39
##  Median :0.0000   Median :3.000   Median :1.000   Gd:586
##  Mean   :0.3829   Mean   :2.866   Mean   :1.047   TA:735
##  3rd Qu.:1.0000   3rd Qu.:3.000   3rd Qu.:1.000
##  Max.   :2.0000   Max.   :8.000   Max.   :3.000
##
##   TotRmsAbvGrd    Functional    Fireplaces    FireplaceQu   GarageType
##  Min.   : 2.000   Maj1:  14   Min.   :0.000   Ex  : 24    2Types :  6
##  1st Qu.: 5.000   Maj2:   5   1st Qu.:0.000   Fa  : 33    Attchd :870
##  Median : 6.000   Min1:  31   Median :1.000   Gd  :380    Basment: 19
##  Mean   : 6.518   Min2:  34   Mean   :0.613   Po  : 20    BuiltIn: 88
##  3rd Qu.: 7.000   Mod :  15   3rd Qu.:1.000   TA  :313    CarPort:  9
##  Max.   :14.000   Sev :   1   Max.   :3.000   NA's:690    Detchd :387
##                   Typ :1360                               NA's   : 81
##   GarageYrBlt   GarageFinish   GarageCars      GarageArea     GarageQual
```

```
##  Min.   :1900   Fin :352     Min.   :0.000   Min.   :   0.0   Ex  :   3
##  1st Qu.:1961   RFn :422     1st Qu.:1.000   1st Qu.: 334.5   Fa  :  48
##  Median :1980   Unf :605     Median :2.000   Median : 480.0   Gd  :  14
##  Mean   :1979   NA's: 81     Mean   :1.767   Mean   : 473.0   Po  :   3
##  3rd Qu.:2002                3rd Qu.:2.000   3rd Qu.: 576.0   TA  :1311
##  Max.   :2010                Max.   :4.000   Max.   :1418.0   NA's:  81
##  NA's   :81
##  GarageCond  PavedDrive   WoodDeckSF      OpenPorchSF     EnclosedPorch
##  Ex  :   2   N:  90     Min.   :  0.00   Min.   :  0.00   Min.   :  0.00
##  Fa  :  35   P:  30     1st Qu.:  0.00   1st Qu.:  0.00   1st Qu.:  0.00
##  Gd  :   9   Y:1340     Median :  0.00   Median : 25.00   Median :  0.00
##  Po  :   7              Mean   : 94.24   Mean   : 46.66   Mean   : 21.95
##  TA  :1326              3rd Qu.:168.00   3rd Qu.: 68.00   3rd Qu.:  0.00
##  NA's:  81              Max.   :857.00   Max.   :547.00   Max.   :552.00
##
##    X3SsnPorch      ScreenPorch        PoolArea        PoolQC
##  Min.   :  0.00   Min.   :  0.00   Min.   :  0.000   Ex  :   2
##  1st Qu.:  0.00   1st Qu.:  0.00   1st Qu.:  0.000   Fa  :   2
##  Median :  0.00   Median :  0.00   Median :  0.000   Gd  :   3
##  Mean   :  3.41   Mean   : 15.06   Mean   :  2.759   NA's:1453
##  3rd Qu.:  0.00   3rd Qu.:  0.00   3rd Qu.:  0.000
##  Max.   :508.00   Max.   :480.00   Max.   :738.000
##
##    Fence      MiscFeature    MiscVal             MoSold
##  GdPrv:  59   Gar2:   2   Min.   :    0.00   Min.   : 1.000
##  GdWo :  54   Othr:   2   1st Qu.:    0.00   1st Qu.: 5.000
##  MnPrv: 157   Shed:  49   Median :    0.00   Median : 6.000
##  MnWw :  11   TenC:   1   Mean   :   43.49   Mean   : 6.322
##  NA's :1179   NA's:1406   3rd Qu.:    0.00   3rd Qu.: 8.000
##                           Max.   :15500.00   Max.   :12.000
##
##      YrSold        SaleType    SaleCondition    SalePrice
##  Min.   :2006   WD     :1267   Abnorml: 101   Min.   : 34900
##  1st Qu.:2007   New    : 122   AdjLand:   4   1st Qu.:129975
##  Median :2008   COD    :  43   Alloca :  12   Median :163000
##  Mean   :2008   ConLD  :   9   Family :  20   Mean   :180921
##  3rd Qu.:2009   ConLI  :   5   Normal :1198   3rd Qu.:214000
##  Max.   :2010   ConLw  :   5   Partial: 125   Max.   :755000
##                 (Other):   9
```

Checking for MISSING VALUES

```
#Missing data
sum(is.na(training)/(nrow(training)*nrow(training)))# printing percentage of
missing data

## [1] 0.003267499

unique(nrow(training)) # printing all the unique values

## [1] 1460
```

```r
colSums(sapply(training,is.na))# prinitng number of missing values in each
column
```

```
##            Id    MSSubClass      MSZoning   LotFrontage       LotArea
##             0             0             0           259             0
##        Street         Alley      LotShape   LandContour     Utilities
##             0          1369             0             0             0
##     LotConfig     LandSlope  Neighborhood    Condition1    Condition2
##             0             0             0             0             0
##      BldgType    HouseStyle   OverallQual   OverallCond     YearBuilt
##             0             0             0             0             0
##  YearRemodAdd     RoofStyle      RoofMatl   Exterior1st   Exterior2nd
##             0             0             0             0             0
##    MasVnrType    MasVnrArea     ExterQual     ExterCond    Foundation
##             8             8             0             0             0
##      BsmtQual      BsmtCond  BsmtExposure  BsmtFinType1    BsmtFinSF1
##            37            37            38            37             0
##  BsmtFinType2    BsmtFinSF2     BsmtUnfSF   TotalBsmtSF       Heating
##            38             0             0             0             0
##     HeatingQC    CentralAir    Electrical     X1stFlrSF     X2ndFlrSF
##             0             0             1             0             0
##  LowQualFinSF     GrLivArea  BsmtFullBath  BsmtHalfBath      FullBath
##             0             0             0             0             0
##      HalfBath  BedroomAbvGr  KitchenAbvGr   KitchenQual  TotRmsAbvGrd
##             0             0             0             0             0
##    Functional    Fireplaces   FireplaceQu    GarageType   GarageYrBlt
##             0             0           690            81            81
##  GarageFinish    GarageCars    GarageArea    GarageQual    GarageCond
##            81             0             0            81            81
##    PavedDrive    WoodDeckSF   OpenPorchSF EnclosedPorch    X3SsnPorch
##             0             0             0             0             0
##   ScreenPorch      PoolArea        PoolQC         Fence   MiscFeature
##             0             0          1453          1179          1406
##       MiscVal        MoSold        YrSold      SaleType SaleCondition
##             0             0             0             0             0
##     SalePrice
##             0
```

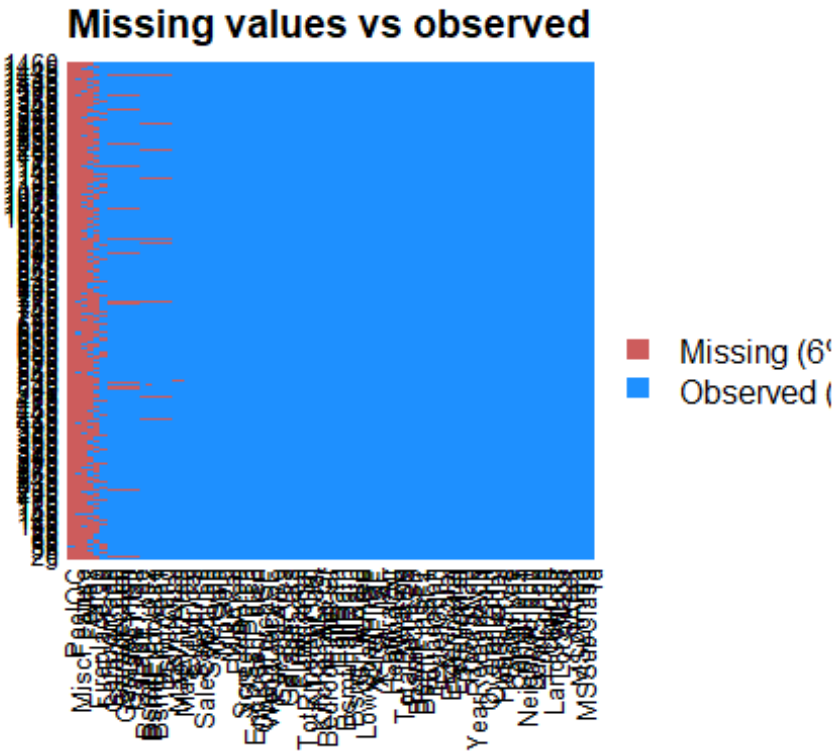
```r
library(Amelia)
```

```
## Warning: package 'Amelia' was built under R version 3.5.2
```

```
## Loading required package: Rcpp
```

```
## ##
## ## Amelia II: Multiple Imputation
## ## (Version 1.7.5, built: 2018-05-07)
## ## Copyright (C) 2005-2019 James Honaker, Gary King and Matthew Blackwell
## ## Refer to http://gking.harvard.edu/amelia/ for more information
## ##
```

```
missmap(training, main ="Missing values vs observed")
```




```
# creating dataframe of categorical and numerical variables
catvar <- c('MSZoning','Street', 'Neighborhood', 'LandContour','BldgType',
'LandSlope', 'RoofStyle',

'HouseStyle','CentralAir','PavedDrive','SaleCondition','OverallCond' )
numvar<-
c('LotArea','TotalBsmtSF','GrLivArea','BedroomAbvGr','GarageCars','GarageArea
','OpenPorchSF','EnclosedPorch','WoodDeckSF','PoolArea')

unique(nrow(training$SalePrice))

## NULL
```

Removing columns with NA values

```
training$Alley = NULL
training$LotFrontage = NULL
training$FireplaceQu = NULL
training$Fence = NULL
training$PoolQC = NULL
training$MiscFeature = NULL
training$BsmtQual = NULL
training$BsmtCond = NULL
training$BsmtExposure = NULL
training$BsmtFinType1 = NULL
training$BsmtFinType2 = NULL
```

```
training$GarageType = NULL
training$GarageYrBlt = NULL
training$MasVnrType = NULL
training$MasVnrArea = NULL
training$GarageQual = NULL
training$GarageFinish = NULL
training$GarageCond = NULL
training$Id=NULL

training[!complete.cases(training),]

##      MSSubClass MSZoning LotArea Street LotShape LandContour Utilities
## 1380         80       RL    9735   Pave      Reg         Lvl    AllPub
##      LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType
## 1380    Inside       Gtl       Timber       Norm       Norm     1Fam
##      HouseStyle OverallQual OverallCond YearBuilt YearRemodAdd RoofStyle
## 1380       SLvl           5           5      2006         2007     Gable
##      RoofMatl Exterior1st Exterior2nd ExterQual ExterCond Foundation
## 1380  CompShg     VinylSd     VinylSd        TA        TA      PConc
##      BsmtFinSF1 BsmtFinSF2 BsmtUnfSF TotalBsmtSF Heating HeatingQC
## 1380          0          0       384         384    GasA        Gd
##      CentralAir Electrical X1stFlrSF X2ndFlrSF LowQualFinSF GrLivArea
## 1380          Y       <NA>       754       640            0      1394
##      BsmtFullBath BsmtHalfBath FullBath HalfBath BedroomAbvGr KitchenAbvGr
## 1380            0            0        2        1            3            1
##      KitchenQual TotRmsAbvGrd Functional Fireplaces GarageCars GarageArea
## 1380          Gd            7        Typ          0          2        400
##      PavedDrive WoodDeckSF OpenPorchSF EnclosedPorch X3SsnPorch
## 1380          Y        100           0             0          0
##      ScreenPorch PoolArea MiscVal MoSold YrSold SaleType SaleCondition
## 1380           0        0       0      5   2008       WD        Normal
##      SalePrice
## 1380    167500

head(training)

##   MSSubClass MSZoning LotArea Street LotShape LandContour Utilities
## 1         60       RL    8450   Pave      Reg         Lvl    AllPub
## 2         20       RL    9600   Pave      Reg         Lvl    AllPub
## 3         60       RL   11250   Pave      IR1         Lvl    AllPub
## 4         70       RL    9550   Pave      IR1         Lvl    AllPub
## 5         60       RL   14260   Pave      IR1         Lvl    AllPub
## 6         50       RL   14115   Pave      IR1         Lvl    AllPub
##   LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType
## 1    Inside       Gtl      CollgCr       Norm       Norm     1Fam
## 2       FR2       Gtl      Veenker      Feedr       Norm     1Fam
## 3    Inside       Gtl      CollgCr       Norm       Norm     1Fam
## 4    Corner       Gtl      Crawfor       Norm       Norm     1Fam
## 5       FR2       Gtl      NoRidge       Norm       Norm     1Fam
## 6    Inside       Gtl      Mitchel       Norm       Norm     1Fam
##   HouseStyle OverallQual OverallCond YearBuilt YearRemodAdd RoofStyle
```

```
## 1     2Story           7           5      2003         2003     Gable
## 2     1Story           6           8      1976         1976     Gable
## 3     2Story           7           5      2001         2002     Gable
## 4     2Story           7           5      1915         1970     Gable
## 5     2Story           8           5      2000         2000     Gable
## 6     1.5Fin           5           5      1993         1995     Gable
##   RoofMatl Exterior1st Exterior2nd ExterQual ExterCond Foundation
## 1  CompShg     VinylSd     VinylSd        Gd        TA      PConc
## 2  CompShg     MetalSd     MetalSd        TA        TA     CBlock
## 3  CompShg     VinylSd     VinylSd        Gd        TA      PConc
## 4  CompShg     Wd Sdng     Wd Shng        TA        TA     BrkTil
## 5  CompShg     VinylSd     VinylSd        Gd        TA      PConc
## 6  CompShg     VinylSd     VinylSd        TA        TA       Wood
##   BsmtFinSF1 BsmtFinSF2 BsmtUnfSF TotalBsmtSF Heating HeatingQC CentralAir
## 1        706          0       150         856    GasA        Ex          Y
## 2        978          0       284        1262    GasA        Ex          Y
## 3        486          0       434         920    GasA        Ex          Y
## 4        216          0       540         756    GasA        Gd          Y
## 5        655          0       490        1145    GasA        Ex          Y
## 6        732          0        64         796    GasA        Ex          Y
##   Electrical X1stFlrSF X2ndFlrSF LowQualFinSF GrLivArea BsmtFullBath
## 1      SBrkr       856       854            0      1710            1
## 2      SBrkr      1262         0            0      1262            0
## 3      SBrkr       920       866            0      1786            1
## 4      SBrkr       961       756            0      1717            1
## 5      SBrkr      1145      1053            0      2198            1
## 6      SBrkr       796       566            0      1362            1
##   BsmtHalfBath FullBath HalfBath BedroomAbvGr KitchenAbvGr KitchenQual
## 1            0        2        1            3            1          Gd
## 2            1        2        0            3            1          TA
## 3            0        2        1            3            1          Gd
## 4            0        1        0            3            1          Gd
## 5            0        2        1            4            1          Gd
## 6            0        1        1            1            1          TA
##   TotRmsAbvGrd Functional Fireplaces GarageCars GarageArea PavedDrive
## 1            8        Typ          0          2        548          Y
## 2            6        Typ          1          2        460          Y
## 3            6        Typ          1          2        608          Y
## 4            7        Typ          1          3        642          Y
## 5            9        Typ          1          3        836          Y
## 6            5        Typ          0          2        480          Y
##   WoodDeckSF OpenPorchSF EnclosedPorch X3SsnPorch ScreenPorch PoolArea
## 1          0          61             0          0           0        0
## 2        298           0             0          0           0        0
## 3          0          42             0          0           0        0
## 4          0          35           272          0           0        0
## 5        192          84             0          0           0        0
## 6         40          30             0        320           0        0
##   MiscVal MoSold YrSold SaleType SaleCondition SalePrice
## 1       0      2   2008       WD        Normal    208500
```

```
## 2       0      5   2007       WD         Normal    181500
## 3       0      9   2008       WD         Normal    223500
## 4       0      2   2006       WD        Abnorml    140000
## 5       0     12   2008       WD         Normal    250000
## 6     700     10   2009       WD         Normal    143000
```

```
#Missing data
sum(is.na(training)/(nrow(training)*nrow(training)))# printing percentage of
missing data
```

```
## [1] 4.691312e-07
```

```
unique(nrow(training)) # printing all the unique values
```

```
## [1] 1460
```

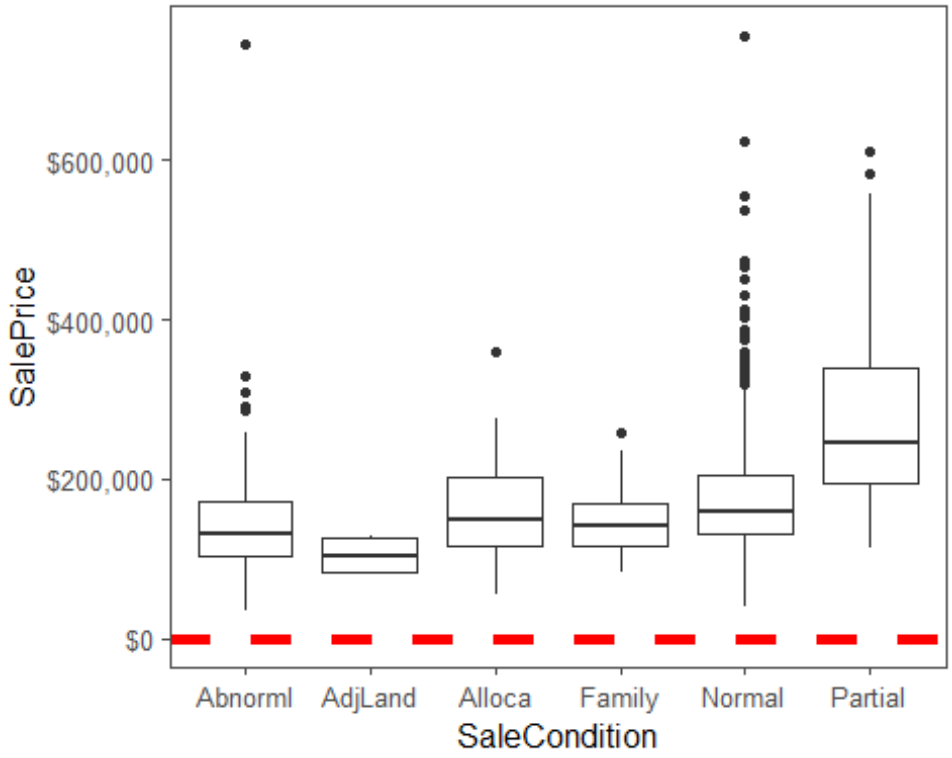
```
colSums(sapply(training,is.na))# prinitng number of missing values in each
column
```

```
##    MSSubClass      MSZoning       LotArea        Street      LotShape
##             0             0             0             0             0
##   LandContour     Utilities     LotConfig     LandSlope  Neighborhood
##             0             0             0             0             0
##    Condition1    Condition2      BldgType    HouseStyle   OverallQual
##             0             0             0             0             0
##   OverallCond     YearBuilt  YearRemodAdd     RoofStyle      RoofMatl
##             0             0             0             0             0
##   Exterior1st   Exterior2nd     ExterQual     ExterCond    Foundation
##             0             0             0             0             0
##    BsmtFinSF1    BsmtFinSF2     BsmtUnfSF   TotalBsmtSF       Heating
##             0             0             0             0             0
##     HeatingQC    CentralAir    Electrical     X1stFlrSF     X2ndFlrSF
##             0             0             1             0             0
##  LowQualFinSF     GrLivArea  BsmtFullBath  BsmtHalfBath      FullBath
##             0             0             0             0             0
##      HalfBath  BedroomAbvGr  KitchenAbvGr   KitchenQual  TotRmsAbvGrd
##             0             0             0             0             0
##    Functional    Fireplaces    GarageCars    GarageArea    PavedDrive
##             0             0             0             0             0
##    WoodDeckSF   OpenPorchSF EnclosedPorch    X3SsnPorch   ScreenPorch
##             0             0             0             0             0
##      PoolArea       MiscVal        MoSold        YrSold      SaleType
##             0             0             0             0             0
## SaleCondition     SalePrice
##             0             0
```

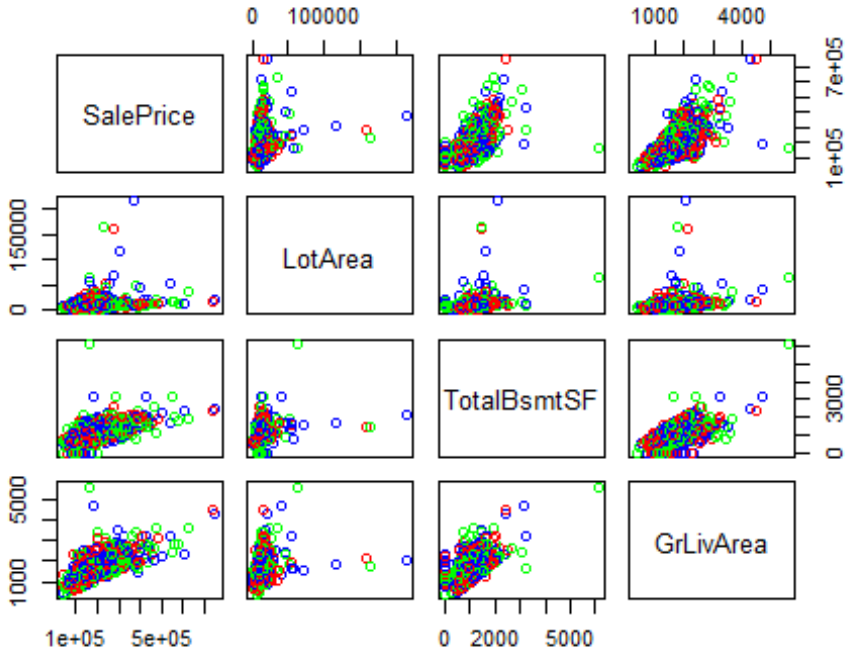
```
attach(training)
catdf<-training[,catvar]
numdf<-training[,numvar]
```

VISUALIZING THE DATA

```
ggplot(training, aes(x = SaleCondition, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```




```
pairs(~SalePrice+LotArea+TotalBsmtSF+GrLivArea,
data=training,col=c('red','blue','green'))
```




```
as.factor(training$SalePrice)
```

```
##    [1] 208500 181500 223500 140000 250000 143000 307000 200000 129900
##   [10] 118000 129500 345000 144000 279500 157000 132000 149000 90000
##   [19] 159000 139000 325300 139400 230000 129900 154000 256300 134800
##   [28] 306000 207500 68500  40000  149350 179900 165500 277500 309000
##   [37] 145000 153000 109000 82000  160000 170000 144000 130250 141000
##   [46] 319900 239686 249700 113000 127000 177000 114500 110000 385000
##   [55] 130000 180500 172500 196500 438780 124900 158000 101000 202500
##   [64] 140000 219500 317000 180000 226000 80000  225000 244000 129500
##   [73] 185000 144900 107400 91000  135750 127000 136500 110000 193500
##   [82] 153500 245000 126500 168500 260000 174000 164500 85000  123600
##   [91] 109900 98600  163500 133900 204750 185000 214000 94750  83000
##  [100] 128950 205000 178000 118964 198900 169500 250000 100000 115000
##  [109] 115000 190000 136900 180000 383970 217000 259500 176000 139000
##  [118] 155000 320000 163990 180000 100000 136000 153900 181000 84500
##  [127] 128000 87000  155000 150000 226000 244000 150750 220000 180000
##  [136] 174000 143000 171000 230000 231500 115000 260000 166000 204000
##  [145] 125000 130000 105000 222500 141000 115000 122000 372402 190000
##  [154] 235000 125000 79000  109500 269500 254900 320000 162500 412500
##  [163] 220000 103200 152000 127500 190000 325624 183500 228000 128500
##  [172] 215000 239000 163000 184000 243000 211000 172500 501837 100000
##  [181] 177000 200100 120000 200000 127000 475000 173000 135000 153337
##  [190] 286000 315000 184000 192000 130000 127000 148500 311872 235000
##  [199] 104000 274900 140000 171500 112000 149000 110000 180500 143900
##  [208] 141000 277000 145000 98000  186000 252678 156000 161750 134450
##  [217] 210000 107000 311500 167240 204900 200000 179900 97000  386250
```

```
##  [226] 112000 290000 106000 125000 192500 148000 403000 94500  128200
##  [235] 216500 89500  185500 194500 318000 113000 262500 110500 79000
##  [244] 120000 205000 241500 137000 140000 180000 277000 76500  235000
##  [253] 173000 158000 145000 230000 207500 220000 231500 97000  176000
##  [262] 276000 151000 130000 73000  175500 185000 179500 120500 148000
##  [271] 266000 241500 290000 139000 124500 205000 201000 141000 415298
##  [280] 192000 228500 185000 207500 244600 179200 164700 159000 88000
##  [289] 122000 153575 233230 135900 131000 235000 167000 142500 152000
##  [298] 239000 175000 158500 157000 267000 205000 149900 295000 305900
##  [307] 225000 89500  82500  360000 165600 132000 119900 375000 178000
##  [316] 188500 260000 270000 260000 187500 342643 354000 301000 126175
##  [325] 242000 87000  324000 145250 214500 78000  119000 139000 284000
##  [334] 207000 192000 228950 377426 214000 202500 155000 202900 82000
##  [343] 87500  266000 85000  140200 151500 157500 154000 437154 318061
##  [352] 190000 95000  105900 140000 177500 173000 134000 130000 280000
##  [361] 156000 145000 198500 118000 190000 147000 159000 165000 132000
##  [370] 162000 172400 134432 125000 123000 219500 61000  148000 340000
##  [379] 394432 179000 127000 187750 213500 76000  240000 192000 81000
##  [388] 125000 191000 426000 119000 215000 106500 100000 109000 129000
##  [397] 123000 169500 67000  241000 245500 164990 108000 258000 168000
##  [406] 150000 115000 177000 280000 339750 60000  145000 222000 115000
##  [415] 228000 181134 149500 239000 126000 142000 206300 215000 113000
##  [424] 315000 139000 135000 275000 109008 195400 175000 85400  79900
##  [433] 122500 181000 81000  212000 116000 119000 90350  110000 555000
##  [442] 118000 162900 172500 210000 127500 190000 199900 119500 120000
##  [451] 110000 280000 204000 210000 188000 175500 98000  256000 161000
##  [460] 110000 263435 155000 62383  188700 124000 178740 167000 146500
##  [469] 250000 187000 212000 190000 148000 440000 251000 132500 208900
##  [478] 380000 297000 89471  326000 374000 155000 164000 132500 147000
##  [487] 156000 175000 160000 86000  115000 133000 172785 155000 91300
##  [496] 34900  430000 184000 130000 120000 113000 226700 140000 289000
##  [505] 147000 124500 215000 208300 161000 124500 164900 202665 129900
##  [514] 134000 96500  402861 158000 265000 211000 234000 106250 150000
##  [523] 159000 184750 315750 176000 132000 446261 86000  200624 175000
##  [532] 128000 107500 39300  178000 107500 188000 111250 158000 272000
##  [541] 315000 248000 213250 133000 179665 229000 210000 129500 125000
##  [550] 263000 140000 112500 255500 108000 284000 113000 141000 108000
##  [559] 175000 234000 121500 170000 108000 185000 268000 128000 325000
##  [568] 214000 316600 135960 142600 120000 224500 170000 139000 118500
##  [577] 145000 164500 146000 131500 181900 253293 118500 325000 133000
##  [586] 369900 130000 137000 143000 79500  185900 451950 138000 140000
##  [595] 110000 319000 114504 194201 217500 151000 275000 141000 220000
##  [604] 151000 221000 205000 152000 225000 359100 118500 313000 148000
##  [613] 261500 147000 75500  137500 183200 105500 314813 305000 67000
##  [622] 240000 135000 168500 165150 160000 139900 153000 135000 168500
##  [631] 124000 209500 82500  139400 144000 200000 60000  93000  85000
##  [640] 264561 274000 226000 345000 152000 370878 143250 98300  155000
##  [649] 155000 84500  205950 108000 191000 135000 350000 88000  145500
##  [658] 149000 97500  167000 197900 402000 110000 137500 423000 230500
##  [667] 129000 193500 168000 137500 173500 103600 165000 257500 140000
```

```
##  [676] 148500 87000  109500 372500 128500 143000 159434 173000 285000
##  [685] 221000 207500 227875 148800 392000 194700 141000 755000 335000
##  [694] 108480 141500 176000 89000  123500 138500 196000 312500 140000
##  [703] 361919 140000 213000 55000  302000 254000 179540 109900 52000
##  [712] 102776 189000 129000 130500 165000 159500 157000 341000 128500
##  [721] 275000 143000 124500 135000 320000 120500 222000 194500 110000
##  [730] 103000 236500 187500 222500 131400 108000 163000 93500  239900
##  [739] 179000 190000 132000 142000 179000 175000 180000 299800 236000
##  [748] 265979 260400 98000  96500  162000 217000 275500 156000 172500
##  [757] 212000 158900 179400 290000 127500 100000 215200 337000 270000
##  [766] 264132 196500 160000 216837 538000 134900 102000 107000 114500
##  [775] 395000 162000 221500 142500 144000 135000 176000 175900 187100
##  [784] 165500 128000 161500 139000 233000 107900 187500 160200 146800
##  [793] 269790 225000 194500 171000 143500 110000 485000 175000 200000
##  [802] 109900 189000 582933 118000 227680 135500 223500 159950 106000
##  [811] 181000 144500 55993  157900 116000 224900 137000 271000 155000
##  [820] 224000 183000 93000  225000 139500 232600 385000 109500 189000
##  [829] 185000 147400 166000 151000 237000 167000 139950 128000 153500
##  [838] 100000 144000 130500 140000 157500 174900 141000 153900 171000
##  [847] 213000 133500 240000 187000 131500 215000 164000 158000 170000
##  [856] 127000 147000 174000 152000 250000 189950 131500 152000 132500
##  [865] 250580 148500 248900 129000 169000 236000 109500 200500 116000
##  [874] 133000 66500  303477 132250 350000 148000 136500 157000 187500
##  [883] 178000 118500 100000 328900 145000 135500 268000 149500 122900
##  [892] 172500 154500 165000 118858 140000 106500 142953 611657 135000
##  [901] 110000 153000 180000 240000 125500 128000 255000 250000 131000
##  [910] 174000 154300 143500 88000  145000 173733 75000  35311  135000
##  [919] 238000 176500 201000 145900 169990 193000 207500 175000 285000
##  [928] 176000 236500 222000 201000 117500 320000 190000 242000 79900
##  [937] 184900 253000 239799 244400 150900 214000 150000 143000 137500
##  [946] 124900 143000 270000 192500 197500 129000 119900 133900 172000
##  [955] 127500 145000 124000 132000 185000 155000 116500 272000 155000
##  [964] 239000 214900 178900 160000 135000 37900  140000 135000 173000
##  [973] 99500  182000 167500 165000 85500  199900 110000 139000 178400
##  [982] 336000 159895 255900 126000 125000 117000 395192 195000 197000
##  [991] 348000 168000 187000 173900 337500 121600 136500 185000 91000
## [1000] 206000 82000  86000  232000 136905 181000 149900 163500 88000
## [1009] 240000 102000 135000 100000 165000 85000  119200 227000 203000
## [1018] 187500 160000 213490 176000 194000 87000  191000 287000 112500
## [1027] 167500 293077 105000 118000 160000 197000 310000 230000 119750
## [1036] 84000  315500 287000 97000  80000  155000 173000 196000 262280
## [1045] 278000 139600 556581 145000 115000 84900  176485 200141 165000
## [1054] 144500 255000 180000 185850 248000 335000 220000 213500 81000
## [1063] 90000  110500 154000 328000 178000 167900 151400 135000 135000
## [1072] 154000 91500  159500 194000 219500 170000 138800 155900 126000
## [1081] 145000 133000 192000 160000 187500 147000 83500  252000 137500
## [1090] 197000 92900  160000 136500 146000 129000 176432 127000 170000
## [1099] 128000 157000 60000  119500 135000 159500 106000 325000 179900
## [1108] 274725 181000 280000 188000 205000 129900 134500 117000 318000
## [1117] 184100 130000 140000 133700 118400 212900 112000 118000 163900
```

```
## [1126] 115000 174000 259000 215000 140000 135000 93500  117500 239500
## [1135] 169000 102000 119000 94000  196000 144000 139000 197500 424870
## [1144] 80000  80000  149000 180000 174500 116900 143000 124000 149900
## [1153] 230000 120500 201800 218000 179900 230000 235128 185000 146000
## [1162] 224000 129000 108959 194000 233170 245350 173000 235000 625000
## [1171] 171000 163000 171900 200500 239000 285000 119500 115000 154900
## [1180] 93000  250000 392500 745000 120000 186700 104900 95000  262000
## [1189] 195000 189000 168000 174000 125000 165000 158000 176000 219210
## [1198] 144000 178000 148000 116050 197900 117000 213000 153500 271900
## [1207] 107000 200000 140000 290000 189000 164000 113000 145000 134500
## [1216] 125000 112000 229456 80500  91500  115000 134000 143000 137900
## [1225] 184000 145000 214000 147000 367294 127000 190000 132500 101800
## [1234] 142000 130000 138887 175500 195000 142500 265900 224900 248328
## [1243] 170000 465000 230000 178000 186500 169900 129500 119000 244000
## [1252] 171750 130000 294000 165400 127500 301500 99900  190000 151000
## [1261] 181000 128900 161500 180500 181000 183900 122000 378500 381000
## [1270] 144000 260000 185750 137000 177000 139000 137000 162000 197900
## [1279] 237000 68400  227000 180000 150500 139000 169000 132500 143000
## [1288] 190000 278000 281000 180500 119500 107500 162900 115000 138500
## [1297] 155000 140000 160000 154000 225000 177500 290000 232000 130000
## [1306] 325000 202500 138000 147000 179200 335000 203000 302000 333168
## [1315] 119000 206900 295493 208900 275000 111000 156500 72500  190000
## [1324] 82500  147000 55000  79000  130500 256000 176500 227000 132500
## [1333] 100000 125500 125000 167900 135000 52500  200000 128500 123000
## [1342] 155000 228500 177000 155835 108500 262500 283463 215000 122000
## [1351] 200000 171000 134900 410000 235000 170000 110000 149900 177500
## [1360] 315000 189000 260000 104900 156932 144152 216000 193000 127000
## [1369] 144000 232000 105000 165500 274300 466500 250000 239000 91000
## [1378] 117000 83000  167500 58500  237500 157000 112000 105000 125500
## [1387] 250000 136000 377500 131000 235000 124000 123000 163000 246578
## [1396] 281213 160000 137500 138000 137450 120000 193000 193879 282922
## [1405] 105000 275000 133000 112000 125500 215000 230000 140000 90000
## [1414] 257000 207000 175900 122500 340000 124000 223000 179900 127500
## [1423] 136500 274970 144000 142000 271000 140000 119000 182900 192140
## [1432] 143750 64500  186500 160000 174000 120500 394617 149700 197000
## [1441] 191000 149300 310000 121000 179600 129000 157900 240000 112000
## [1450] 92000  136000 287090 145000 84500  185000 175000 210000 266500
## [1459] 142125 147500
## 663 Levels: 34900 35311 37900 39300 40000 52000 52500 55000 55993 ...
755000

hist(training$SalePrice / 1000, xlab = "Saleprice in thousands")
```

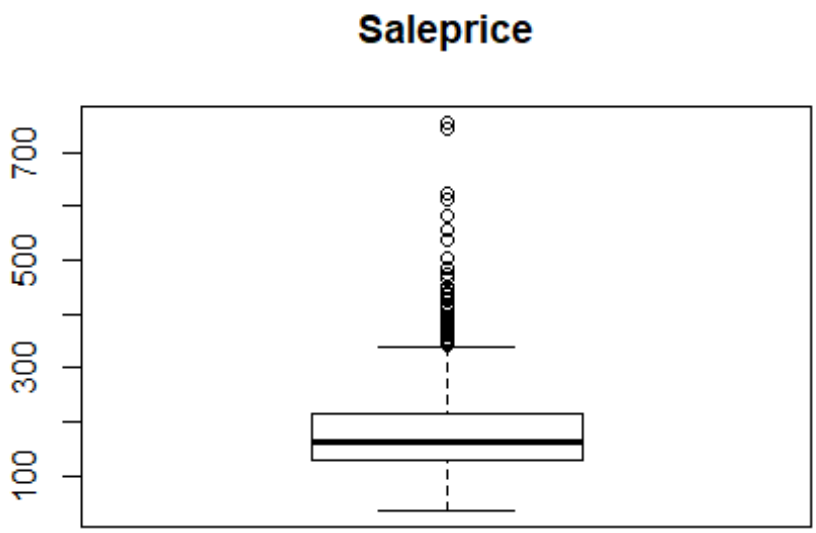

```
library(moments)
```

```
## Warning: package 'moments' was built under R version 3.5.2
```

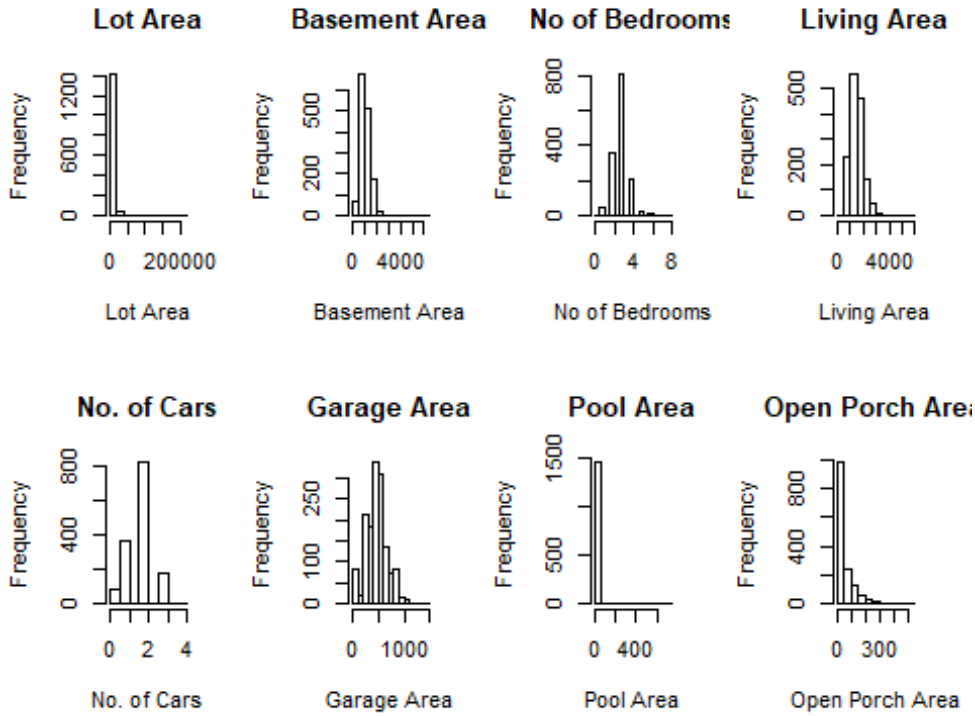
```
skewness(SalePrice)
```

```
## [1] 1.880941
```

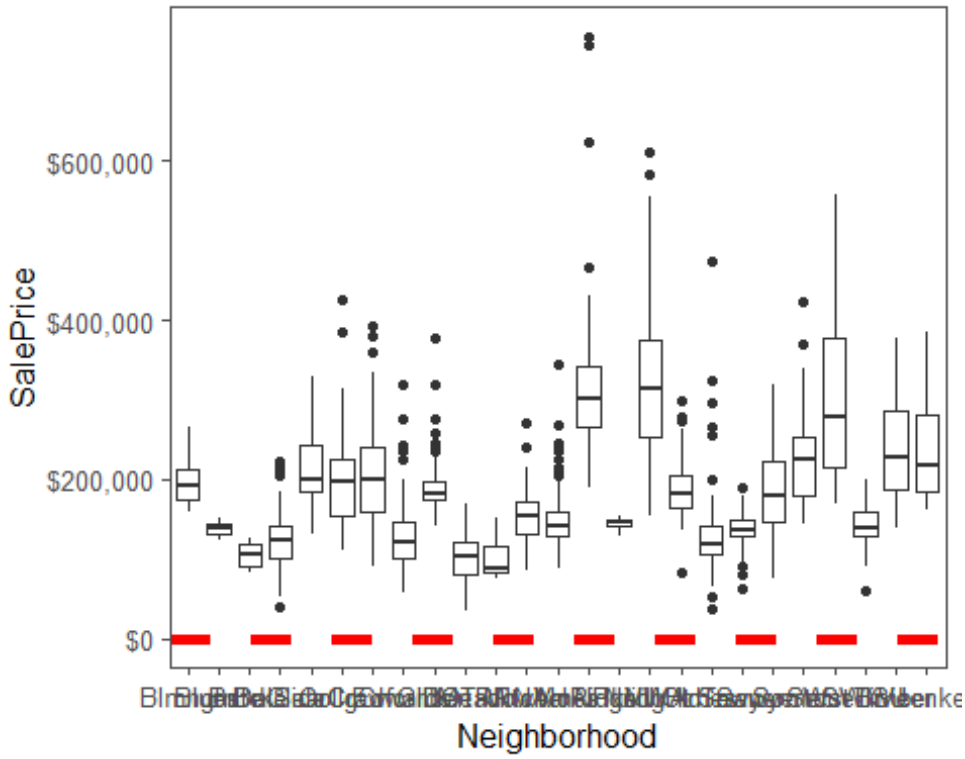
```
boxplot(training$SalePrice/ 1000, main = "Saleprice")
```



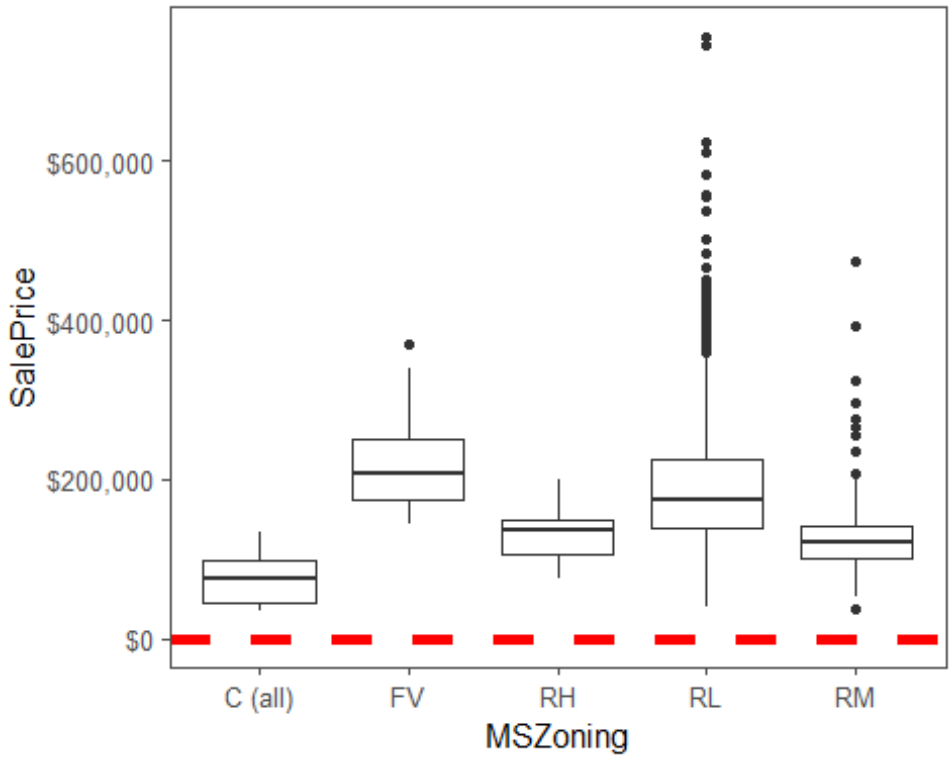

```
par(mfrow=c(2,4))
hist(training$LotArea,xlab="Lot Area", main="Lot Area")
hist(training$TotalBsmtSF, xlab="Basement Area", main="Basement Area")
hist(training$BedroomAbvGr, xlab="No of Bedrooms", main="No of Bedrooms")
hist(training$GrLivArea, xlab="Living Area",main="Living Area")
hist(training$GarageCars, xlab="No. of Cars",main="No. of Cars")
hist(training$GarageArea, xlab="Garage Area",main="Garage Area")
hist(training$PoolArea, xlab="Pool Area",main="Pool Area")
hist(training$OpenPorchSF, xlab="Open Porch Area",main="Open Porch Area")
```



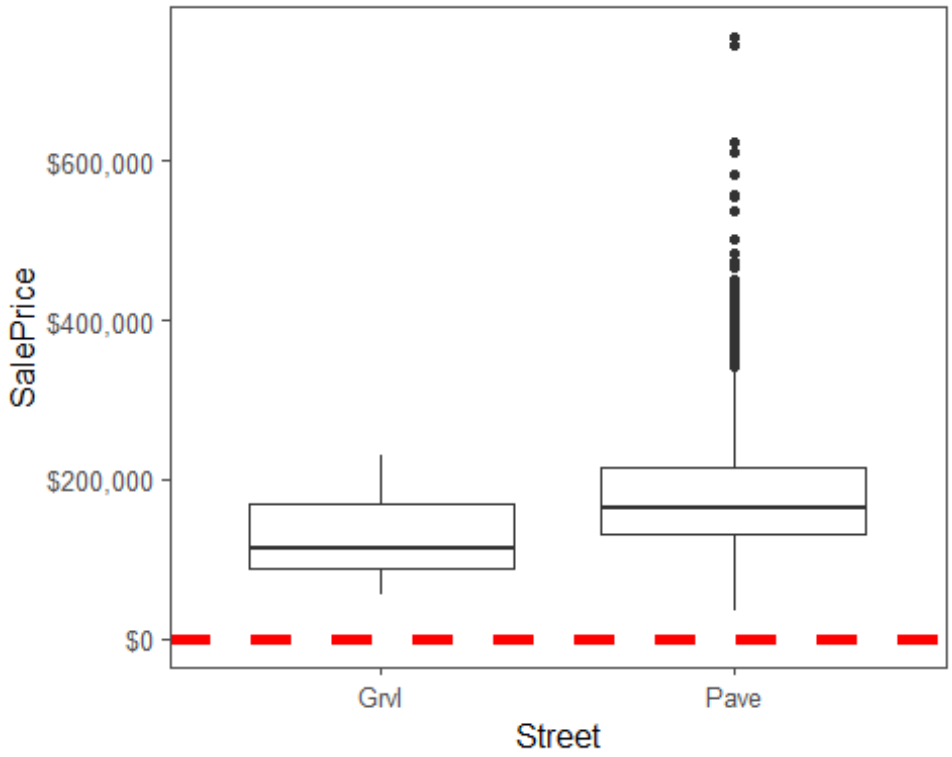

```
ggplot(training, aes(x = Neighborhood, y = SalePrice)) +
  geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



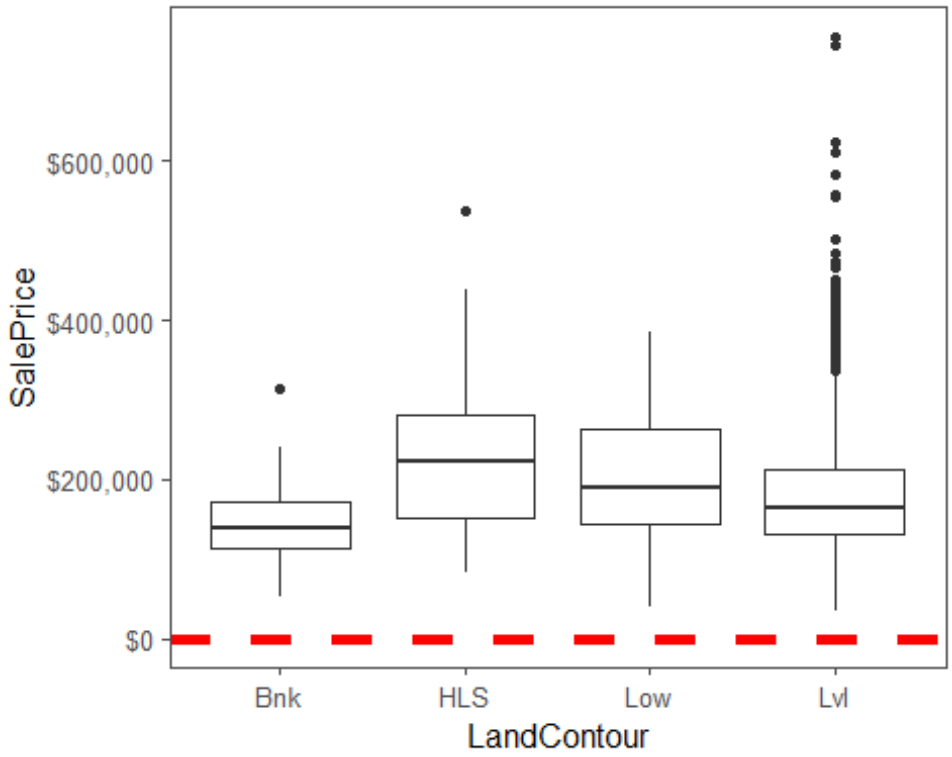

```
ggplot(training, aes(x = MSZoning, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



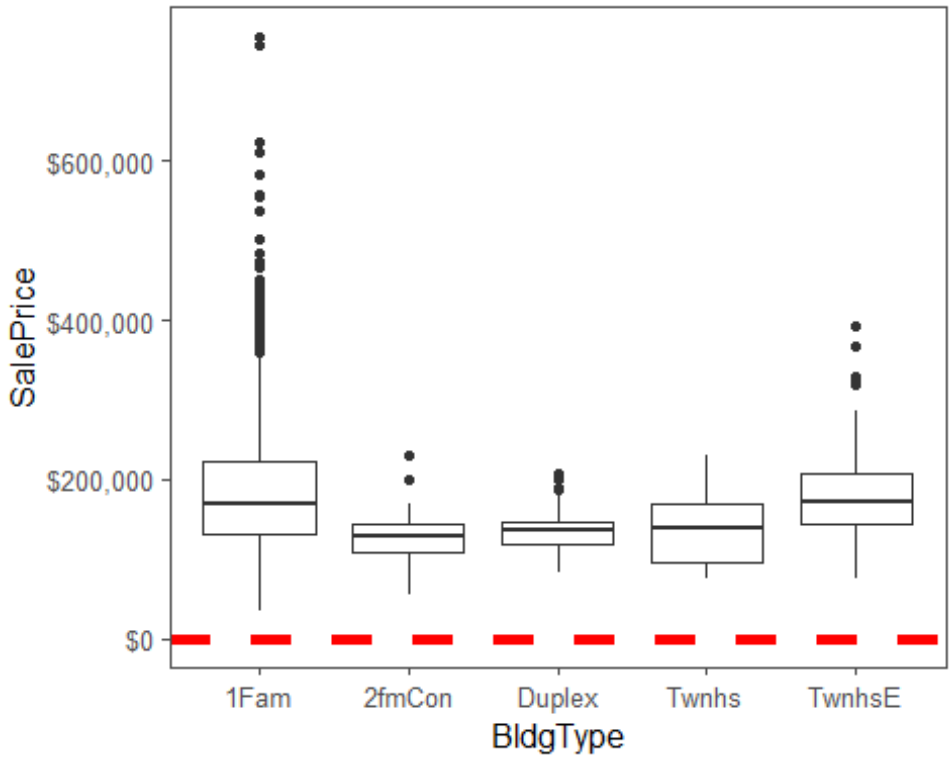

```
ggplot(training, aes(x = Street, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



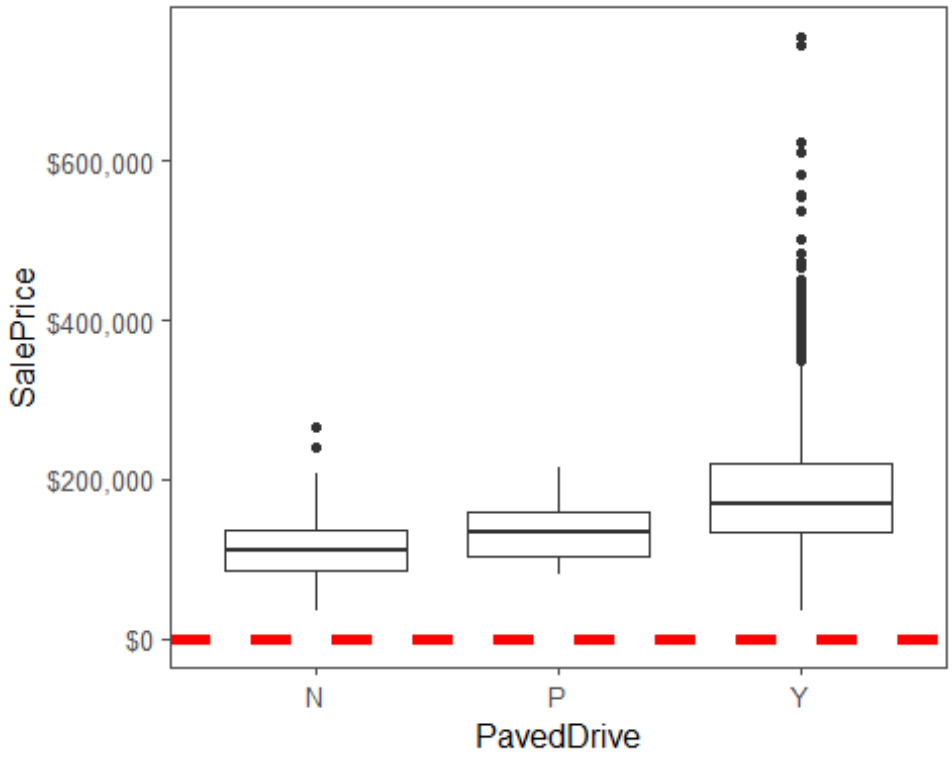

```
ggplot(training, aes(x = LandContour, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



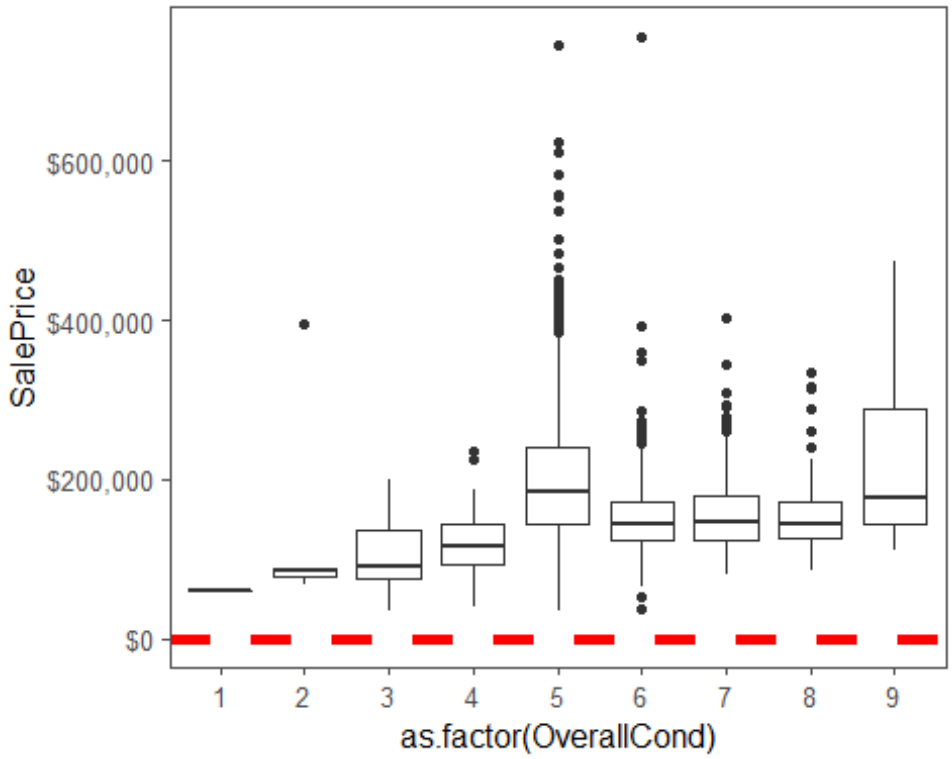

```
ggplot(training, aes(x = BldgType, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



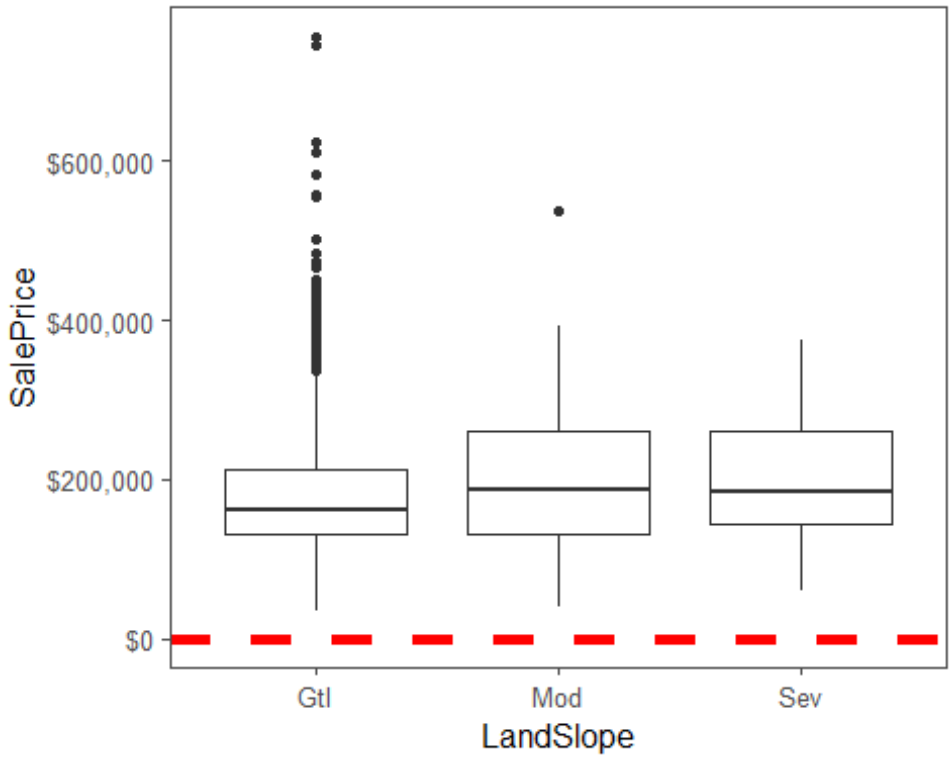

```
ggplot(training, aes(x = PavedDrive, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



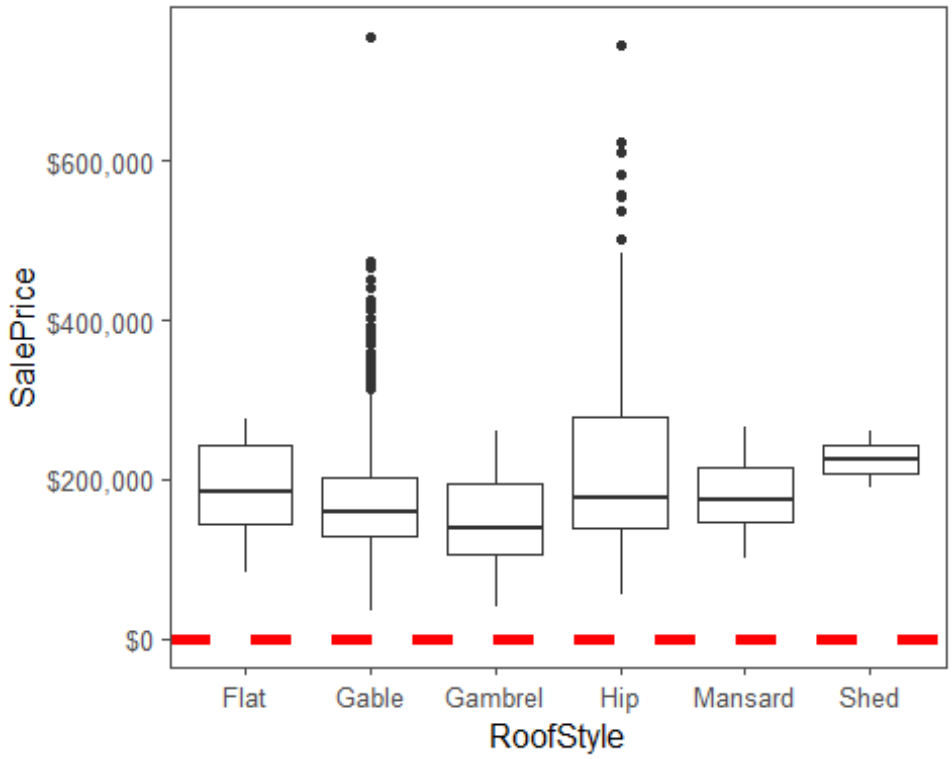

```
ggplot(training, aes(x = as.factor(OverallCond), y = SalePrice))
+geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



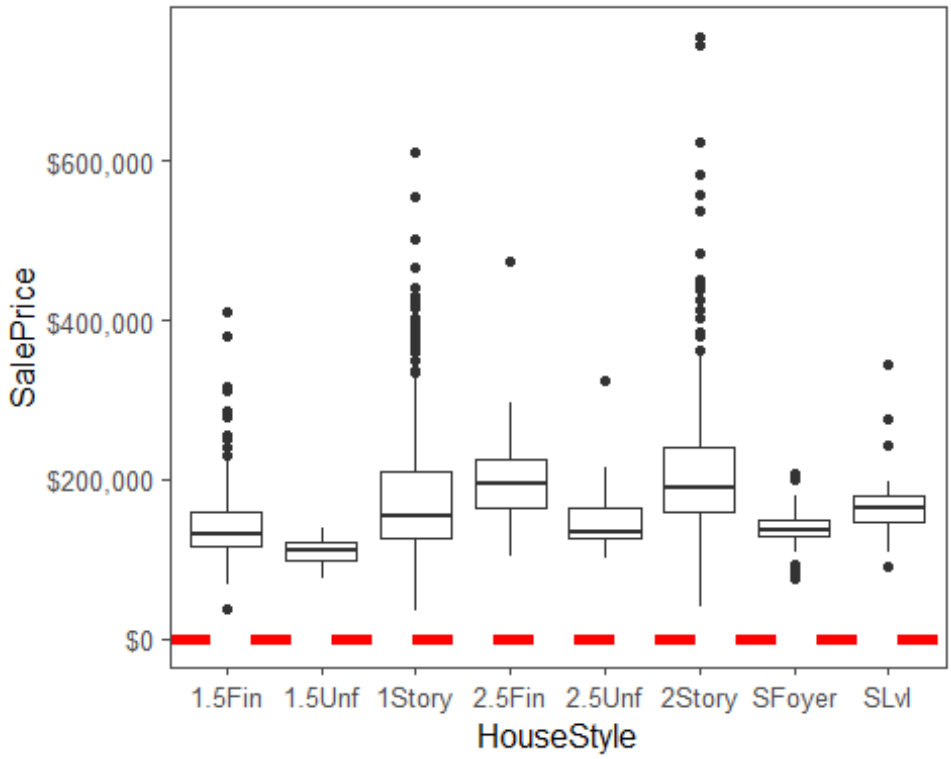

```
ggplot(training, aes(x = LandSlope, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```



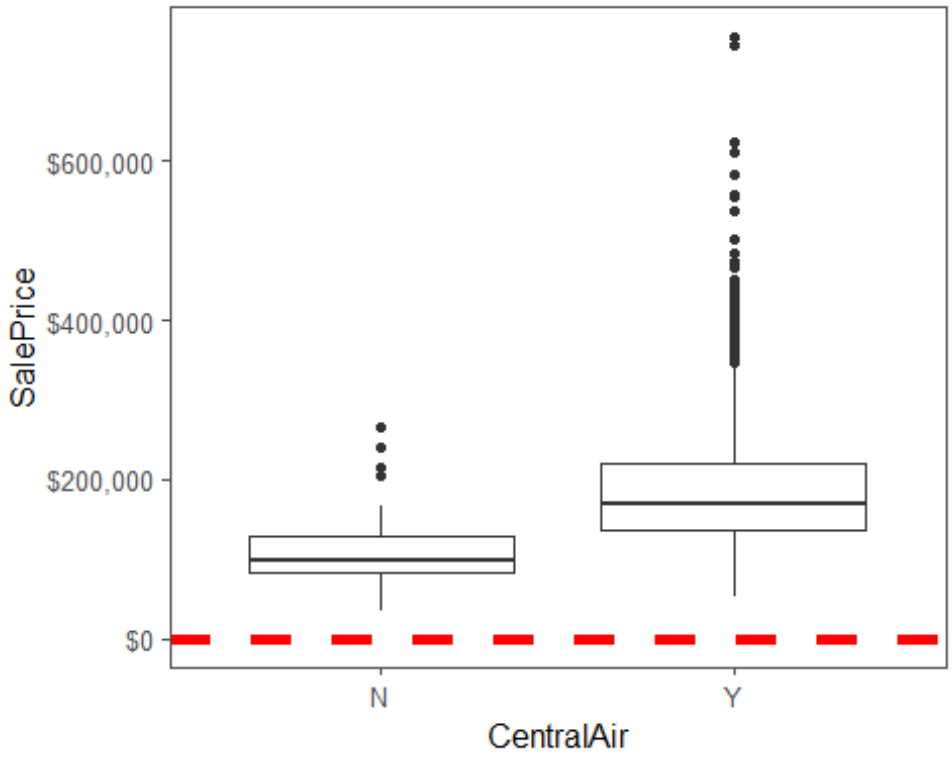

```
ggplot(training, aes(x = RoofStyle, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```




```
ggplot(training, aes(x = HouseStyle, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```




```
ggplot(training, aes(x = CentralAir, y = SalePrice)) +geom_boxplot() +
  geom_hline(aes(yintercept=80),
             colour='red', linetype='dashed', lwd=2) +
  scale_y_continuous(labels=dollar_format()) +
  theme_few()
```




```
library(PerformanceAnalytics)
```

```
## Warning: package 'PerformanceAnalytics' was built under R version 3.5.2
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

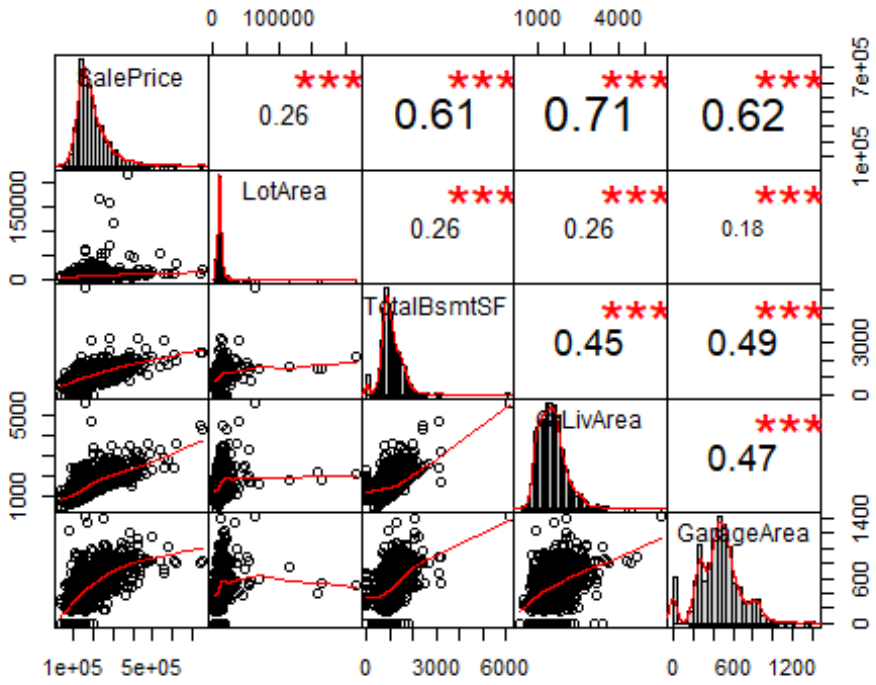
```
##
## Attaching package: 'xts'
```

```
## The following objects are masked from 'package:data.table':
##
##     first, last
```

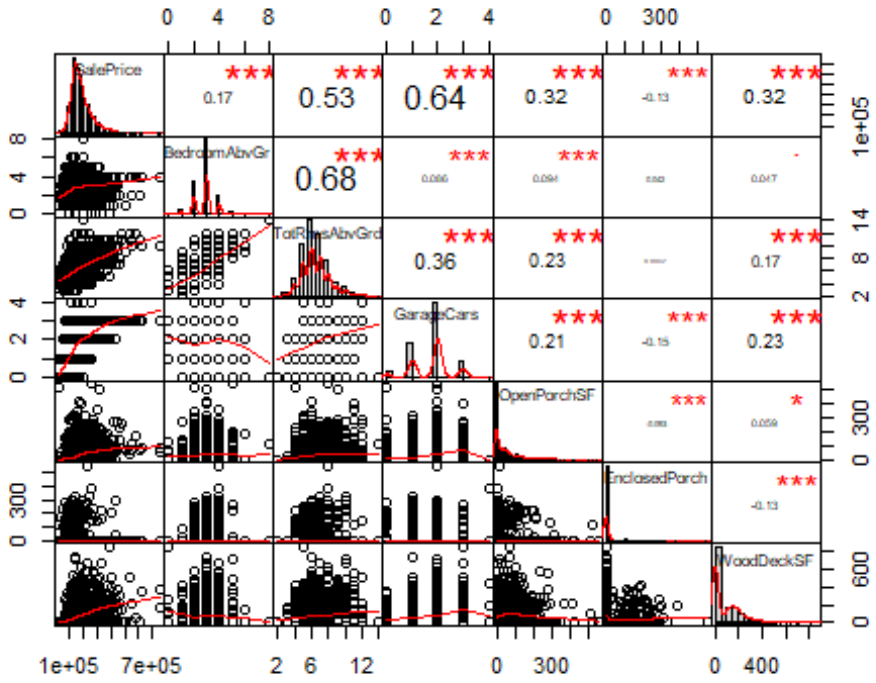
```
## The following objects are masked from 'package:dplyr':
##
##     first, last
```

```
##
## Attaching package: 'PerformanceAnalytics'
```

```
## The following objects are masked from 'package:moments':
##
##     kurtosis, skewness

## The following object is masked from 'package:graphics':
##
##     legend

my_data <- training[,
c('SalePrice','LotArea','TotalBsmtSF','GrLivArea','GarageArea')]

chart.Correlation(my_data, histogram=TRUE, pch=19)
```




```
my_data <- training[,
c('SalePrice','BedroomAbvGr','TotRmsAbvGrd','GarageCars','OpenPorchSF','Enclo
sedPorch','WoodDeckSF')]

chart.Correlation(my_data, histogram=TRUE, pch=19)
```




```
library(forecast)
linear <- lm(SalePrice~., data=training, metric="RMSE", maximize=FALSE)

## Warning: In lm.fit(x, y, offset = offset, singular.ok = singular.ok, ...)
:
##  extra arguments 'metric', 'maximize' will be disregarded

summary(linear)

##
## Call:
## lm(formula = SalePrice ~ ., data = training, metric = "RMSE",
##     maximize = FALSE)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -174391  -10619      56    9756  174391
##
## Coefficients: (3 not defined because of singularities)
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)          -1.193e+06  1.065e+06  -1.120 0.262752
## MSSubClass           -8.938e+00  8.546e+01  -0.105 0.916718
## MSZoningFV            3.093e+04  1.224e+04   2.526 0.011645 *
## MSZoningRH            2.384e+04  1.231e+04   1.937 0.053021 .
## MSZoningRL            2.593e+04  1.050e+04   2.469 0.013689 *
## MSZoningRM            2.507e+04  9.849e+03   2.545 0.011037 *
## LotArea               6.986e-01  1.081e-01   6.460 1.48e-10 ***
```

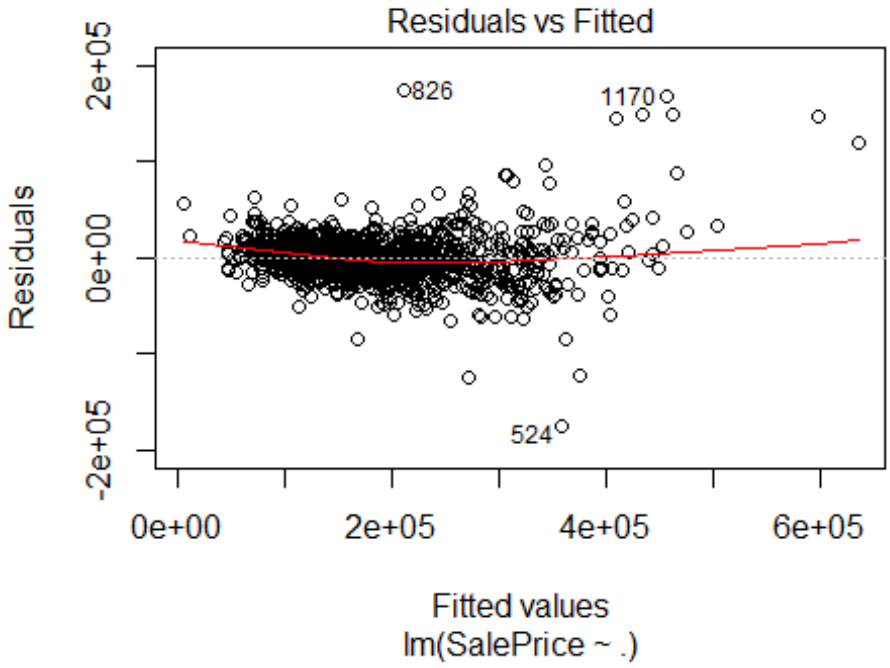
```
## StreetPave             3.867e+04  1.228e+04   3.148 0.001680 **
## LotShapeIR2            4.576e+03  4.320e+03   1.059 0.289725
## LotShapeIR3            4.803e+03  9.043e+03   0.531 0.595398
## LotShapeReg            5.767e+02  1.666e+03   0.346 0.729302
## LandContourHLS         1.352e+04  5.305e+03   2.549 0.010916 *
## LandContourLow        -4.225e+03  6.528e+03  -0.647 0.517604
## LandContourLvl         7.058e+03  3.820e+03   1.848 0.064898 .
## UtilitiesNoSeWa       -3.031e+04  2.662e+04  -1.139 0.255026
## LotConfigCulDSac       7.679e+03  3.324e+03   2.310 0.021050 *
## LotConfigFR2          -5.773e+03  4.154e+03  -1.390 0.164864
## LotConfigFR3          -1.330e+04  1.307e+04  -1.018 0.309109
## LotConfigInside       -1.203e+03  1.808e+03  -0.665 0.505920
## LandSlopeMod           1.052e+04  4.040e+03   2.605 0.009300 **
## LandSlopeSev          -2.552e+04  1.110e+04  -2.299 0.021673 *
## NeighborhoodBlueste   -2.654e+03  1.935e+04  -0.137 0.890911
## NeighborhoodBrDale     8.375e+03  1.113e+04   0.752 0.451912
## NeighborhoodBrkSide   -2.043e+03  9.505e+03  -0.215 0.829841
## NeighborhoodClearCr   -1.275e+04  9.428e+03  -1.352 0.176510
## NeighborhoodCollgCr   -9.666e+03  7.333e+03  -1.318 0.187712
## NeighborhoodCrawfor    9.620e+03  8.671e+03   1.110 0.267404
## NeighborhoodEdwards   -1.672e+04  8.082e+03  -2.069 0.038755 *
## NeighborhoodGilbert   -1.376e+04  7.846e+03  -1.754 0.079666 .
## NeighborhoodIDOTRR    -7.858e+03  1.087e+04  -0.723 0.469721
## NeighborhoodMeadowV   -1.427e+03  1.140e+04  -0.125 0.900428
## NeighborhoodMitchel   -2.033e+04  8.277e+03  -2.456 0.014191 *
## NeighborhoodNAmes     -1.445e+04  7.902e+03  -1.828 0.067751 .
## NeighborhoodNoRidge    2.890e+04  8.397e+03   3.441 0.000598 ***
## NeighborhoodNPkVill    8.282e+03  1.433e+04   0.578 0.563421
## NeighborhoodNridgHt    2.453e+04  7.379e+03   3.324 0.000912 ***
## NeighborhoodNWAmes    -2.040e+04  8.145e+03  -2.505 0.012384 *
## NeighborhoodOldTown   -1.302e+04  9.678e+03  -1.345 0.178726
## NeighborhoodSawyer    -1.004e+04  8.233e+03  -1.220 0.222806
## NeighborhoodSawyerW   -6.130e+03  7.854e+03  -0.780 0.435278
## NeighborhoodSomerst    1.281e+02  8.973e+03   0.014 0.988611
## NeighborhoodStoneBr    3.893e+04  8.387e+03   4.642 3.81e-06 ***
## NeighborhoodSWISU     -9.528e+03  9.833e+03  -0.969 0.332740
## NeighborhoodTimber    -6.024e+03  8.413e+03  -0.716 0.474088
## NeighborhoodVeenker    3.098e+03  1.073e+04   0.289 0.772903
## Condition1Feedr        2.859e+03  5.116e+03   0.559 0.576291
## Condition1Norm         1.210e+04  4.225e+03   2.865 0.004244 **
## Condition1PosA         7.351e+03  1.031e+04   0.713 0.475886
## Condition1PosN         7.855e+03  7.632e+03   1.029 0.303568
## Condition1RRAe        -1.708e+04  9.378e+03  -1.822 0.068739 .
## Condition1RRAn         6.208e+03  7.038e+03   0.882 0.377872
## Condition1RRNe        -7.457e+03  1.838e+04  -0.406 0.684983
## Condition1RRNn         3.816e+03  1.312e+04   0.291 0.771210
## Condition2Feedr       -9.753e+03  2.306e+04  -0.423 0.672332
## Condition2Norm        -7.569e+03  1.966e+04  -0.385 0.700300
## Condition2PosA         1.989e+04  3.801e+04   0.523 0.600827
## Condition2PosN        -2.303e+05  2.763e+04  -8.333  < 2e-16 ***
```

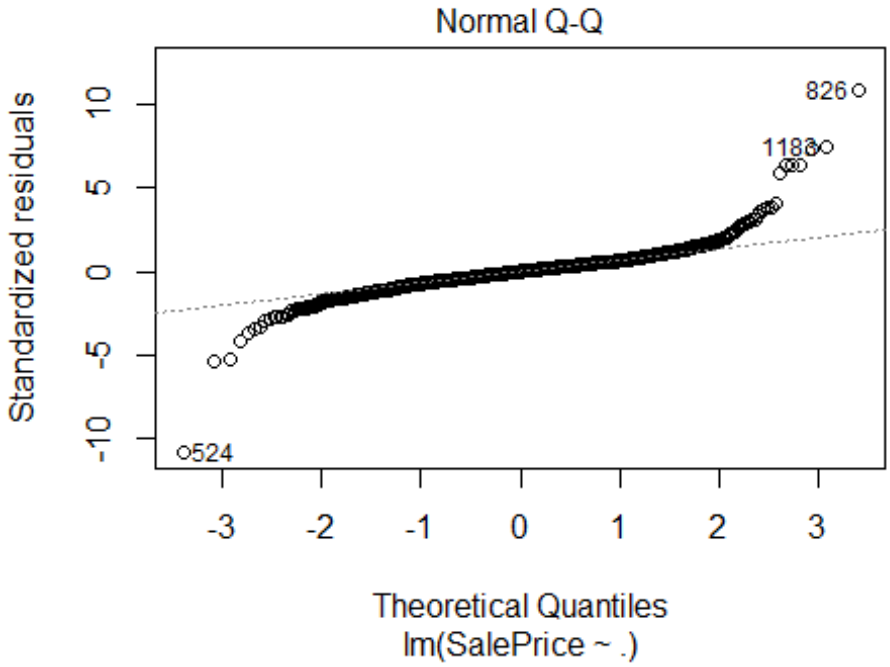
```
## Condition2RRAe       -1.289e+05  4.686e+04  -2.751 0.006034 **
## Condition2RRAn       -1.201e+04  3.196e+04  -0.376 0.707057
## Condition2RRNn       -9.079e+03  2.710e+04  -0.335 0.737680
## BldgType2fmCon       -6.151e+03  1.287e+04  -0.478 0.632832
## BldgTypeDuplex       -8.995e+02  7.457e+03  -0.121 0.904008
## BldgTypeTwnhs        -2.544e+04  1.016e+04  -2.504 0.012405 *
## BldgTypeTwnhsE       -2.322e+04  9.198e+03  -2.525 0.011697 *
## HouseStyle1.5Unf      1.093e+04  7.917e+03   1.380 0.167750
## HouseStyle1Story      8.849e+03  4.360e+03   2.029 0.042619 *
## HouseStyle2.5Fin     -1.718e+04  1.232e+04  -1.395 0.163390
## HouseStyle2.5Unf     -1.185e+04  9.393e+03  -1.262 0.207199
## HouseStyle2Story     -6.363e+03  3.557e+03  -1.789 0.073832 .
## HouseStyleSFoyer      7.689e+03  6.201e+03   1.240 0.215225
## HouseStyleSLvl        7.301e+03  5.497e+03   1.328 0.184333
## OverallQual           8.026e+03  1.021e+03   7.861 8.11e-15 ***
## OverallCond           5.439e+03  8.756e+02   6.212 7.08e-10 ***
## YearBuilt             3.287e+02  7.381e+01   4.454 9.18e-06 ***
## YearRemodAdd          1.058e+02  5.567e+01   1.901 0.057496 .
## RoofStyleGable        1.530e+03  1.876e+04   0.082 0.934996
## RoofStyleGambrel      4.258e+03  2.051e+04   0.208 0.835583
## RoofStyleHip          3.159e+03  1.881e+04   0.168 0.866662
## RoofStyleMansard      1.714e+04  2.185e+04   0.785 0.432799
## RoofStyleShed         8.808e+04  3.551e+04   2.481 0.013242 *
## RoofMatlCompShg       6.501e+05  3.304e+04  19.674  < 2e-16 ***
## RoofMatlMembran       7.371e+05  4.778e+04  15.427  < 2e-16 ***
## RoofMatlMetal         6.971e+05  4.720e+04  14.770  < 2e-16 ***
## RoofMatlRoll          6.496e+05  4.167e+04  15.589  < 2e-16 ***
## RoofMatlTar&Grv       6.556e+05  3.799e+04  17.258  < 2e-16 ***
## RoofMatlWdShake       6.305e+05  3.680e+04  17.133  < 2e-16 ***
## RoofMatlWdShngl       7.278e+05  3.428e+04  21.233  < 2e-16 ***
## Exterior1stAsphShn   -1.233e+04  3.420e+04  -0.361 0.718455
## Exterior1stBrkComm   -1.312e+04  2.868e+04  -0.458 0.647308
## Exterior1stBrkFace    5.389e+03  1.287e+04   0.419 0.675425
## Exterior1stCBlock    -2.778e+04  2.759e+04  -1.007 0.314220
## Exterior1stCemntBd   -1.499e+04  1.946e+04  -0.770 0.441238
## Exterior1stHdBoard   -1.383e+04  1.299e+04  -1.065 0.287064
## Exterior1stImStucc   -6.889e+04  2.861e+04  -2.408 0.016182 *
## Exterior1stMetalSd   -3.066e+03  1.483e+04  -0.207 0.836187
## Exterior1stPlywood   -1.804e+04  1.287e+04  -1.401 0.161366
## Exterior1stStone     -1.496e+04  2.437e+04  -0.614 0.539296
## Exterior1stStucco    -5.054e+03  1.417e+04  -0.357 0.721436
## Exterior1stVinylSd   -1.752e+04  1.346e+04  -1.301 0.193376
## Exterior1stWd Sdng   -1.360e+04  1.243e+04  -1.095 0.273923
## Exterior1stWdShing   -6.500e+03  1.344e+04  -0.484 0.628651
## Exterior2ndAsphShn    7.872e+03  2.281e+04   0.345 0.730070
## Exterior2ndBrk Cmn    1.484e+04  2.074e+04   0.716 0.474376
## Exterior2ndBrkFace   -7.826e+02  1.330e+04  -0.059 0.953086
## Exterior2ndCBlock            NA         NA      NA       NA
## Exterior2ndCmentBd    1.311e+04  1.919e+04   0.683 0.494595
## Exterior2ndHdBoard    8.093e+03  1.251e+04   0.647 0.517684
```

```
## Exterior2ndImStucc    3.360e+04  1.447e+04   2.323 0.020359 *
## Exterior2ndMetalSd    2.714e+03  1.447e+04   0.188 0.851230
## Exterior2ndOther     -6.345e+03  2.821e+04  -0.225 0.822084
## Exterior2ndPlywood    9.203e+03  1.215e+04   0.757 0.448915
## Exterior2ndStone     -9.978e+03  1.737e+04  -0.574 0.565811
## Exterior2ndStucco     2.382e+03  1.365e+04   0.174 0.861561
## Exterior2ndVinylSd    1.630e+04  1.300e+04   1.254 0.209933
## Exterior2ndWd Sdng    1.049e+04  1.199e+04   0.875 0.381793
## Exterior2ndWd Shng    3.418e+03  1.250e+04   0.273 0.784655
## ExterQualFa          -8.686e+03  1.089e+04  -0.798 0.425052
## ExterQualGd          -3.080e+04  4.792e+03  -6.428 1.83e-10 ***
## ExterQualTA          -3.074e+04  5.362e+03  -5.734 1.23e-08 ***
## ExterCondFa          -2.825e+03  1.887e+04  -0.150 0.881022
## ExterCondGd          -8.101e+03  1.802e+04  -0.450 0.653048
## ExterCondPo           1.160e+04  3.282e+04   0.354 0.723716
## ExterCondTA          -5.453e+03  1.798e+04  -0.303 0.761747
## FoundationCBlock      1.744e+03  3.198e+03   0.545 0.585564
## FoundationPConc       4.818e+03  3.507e+03   1.374 0.169794
## FoundationSlab        8.487e+03  7.862e+03   1.080 0.280554
## FoundationStone       2.693e+03  1.116e+04   0.241 0.809459
## FoundationWood       -3.324e+04  1.512e+04  -2.198 0.028133 *
## BsmtFinSF1            3.704e+01  4.420e+00   8.380  < 2e-16 ***
## BsmtFinSF2            2.453e+01  5.797e+00   4.232 2.48e-05 ***
## BsmtUnfSF             1.492e+01  4.069e+00   3.668 0.000255 ***
## TotalBsmtSF                  NA         NA      NA       NA
## HeatingGasA          -7.328e+03  2.546e+04  -0.288 0.773499
## HeatingGasW          -1.591e+04  2.625e+04  -0.606 0.544477
## HeatingGrav          -1.550e+04  2.764e+04  -0.561 0.575086
## HeatingOthW          -4.569e+04  3.173e+04  -1.440 0.150032
## HeatingWall           8.058e+03  2.950e+04   0.273 0.784775
## HeatingQCFa          -1.588e+03  4.831e+03  -0.329 0.742432
## HeatingQCGd          -3.671e+03  2.149e+03  -1.708 0.087792 .
## HeatingQCPo           8.416e+03  2.774e+04   0.303 0.761604
## HeatingQCTA          -4.397e+03  2.122e+03  -2.072 0.038449 *
## CentralAirY          -3.634e+03  3.996e+03  -0.909 0.363285
## ElectricalFuseF      -1.244e+03  5.991e+03  -0.208 0.835574
## ElectricalFuseP      -1.038e+04  1.743e+04  -0.595 0.551653
## ElectricalMix         3.613e+03  2.892e+04   0.125 0.900595
## ElectricalSBrkr      -1.294e+03  3.025e+03  -0.428 0.668809
## X1stFlrSF             5.503e+01  5.335e+00  10.316  < 2e-16 ***
## X2ndFlrSF             6.990e+01  5.272e+00  13.257  < 2e-16 ***
## LowQualFinSF          2.482e+01  1.871e+01   1.327 0.184866
## GrLivArea                    NA         NA      NA       NA
## BsmtFullBath          1.554e+03  1.968e+03   0.789 0.430031
## BsmtHalfBath          3.207e+02  3.116e+03   0.103 0.918049
## FullBath              2.603e+03  2.246e+03   1.159 0.246760
## HalfBath             -1.328e+02  2.140e+03  -0.062 0.950553
## BedroomAbvGr         -5.495e+03  1.384e+03  -3.969 7.62e-05 ***
## KitchenAbvGr         -1.584e+04  5.771e+03  -2.745 0.006138 **
## KitchenQualFa        -2.069e+04  6.413e+03  -3.226 0.001286 **
```

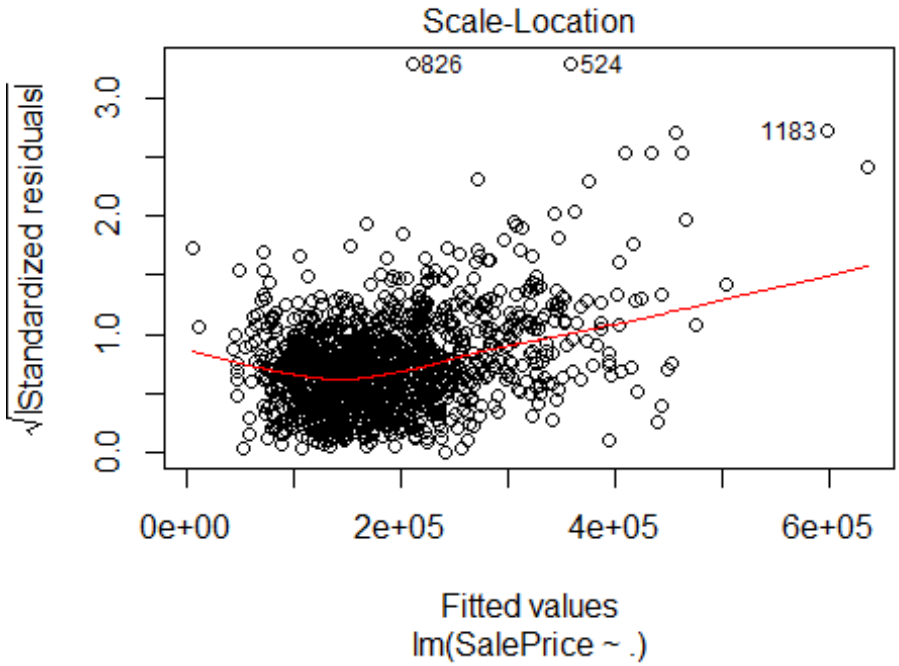
```
## KitchenQualGd        -2.779e+04  3.487e+03  -7.968 3.55e-15 ***
## KitchenQualTA        -2.530e+04  3.993e+03  -6.334 3.30e-10 ***
## TotRmsAbvGrd          1.360e+03  9.753e+02   1.394 0.163564
## FunctionalMaj2       -5.360e+02  1.480e+04  -0.036 0.971111
## FunctionalMin1        4.401e+03  8.666e+03   0.508 0.611610
## FunctionalMin2        8.577e+03  8.581e+03   1.000 0.317726
## FunctionalMod        -7.196e+03  1.056e+04  -0.681 0.495815
## FunctionalSev        -5.986e+04  2.758e+04  -2.170 0.030174 *
## FunctionalTyp         1.971e+04  7.420e+03   2.656 0.008003 **
## Fireplaces            2.806e+03  1.374e+03   2.043 0.041253 *
## GarageCars            4.257e+03  2.221e+03   1.916 0.055556 .
## GarageArea            1.347e+01  7.647e+00   1.761 0.078488 .
## PavedDriveP          -3.300e+03  5.574e+03  -0.592 0.553913
## PavedDriveY          -2.103e+03  3.458e+03  -0.608 0.543253
## WoodDeckSF            1.365e+01  5.954e+00   2.292 0.022065 *
## OpenPorchSF           1.219e+01  1.184e+01   1.029 0.303668
## EnclosedPorch         5.565e+00  1.285e+01   0.433 0.664986
## X3SsnPorch            2.380e+01  2.312e+01   1.029 0.303549
## ScreenPorch           3.714e+01  1.260e+01   2.948 0.003252 **
## PoolArea              7.168e+01  1.832e+01   3.913 9.62e-05 ***
## MiscVal              -3.293e-01  1.469e+00  -0.224 0.822608
## MoSold               -6.362e+02  2.539e+02  -2.505 0.012357 *
## YrSold               -1.753e+02  5.248e+02  -0.334 0.738462
## SaleTypeCon           3.533e+04  1.838e+04   1.922 0.054800 .
## SaleTypeConLD         1.681e+04  1.002e+04   1.678 0.093529 .
## SaleTypeConLI         9.741e+03  1.190e+04   0.818 0.413351
## SaleTypeConLw        -2.484e+03  1.243e+04  -0.200 0.841598
## SaleTypeCWD           2.333e+04  1.336e+04   1.746 0.081044 .
## SaleTypeNew           3.459e+04  1.604e+04   2.156 0.031294 *
## SaleTypeOth           1.888e+04  1.502e+04   1.257 0.208952
## SaleTypeWD            4.925e+02  4.341e+03   0.113 0.909689
## SaleConditionAdjLand  1.036e+04  1.505e+04   0.688 0.491294
## SaleConditionAlloca   4.966e+03  8.781e+03   0.566 0.571776
## SaleConditionFamily  -1.351e+03  6.328e+03  -0.213 0.830984
## SaleConditionNormal   6.627e+03  2.993e+03   2.214 0.027003 *
## SaleConditionPartial -9.293e+03  1.546e+04  -0.601 0.547944
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 24000 on 1269 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.9206, Adjusted R-squared:  0.9088
## F-statistic: 77.83 on 189 and 1269 DF,  p-value: < 2.2e-16

accuracy(linear)

##                        ME     RMSE      MAE        MPE     MAPE      MASE
## Training set 1.816243e-13 22387.36 14533.37 -0.5889875 8.494719 0.2528991

plot(linear)
```

```
## Warning: not plotting observations with leverage one:
##   121, 251, 326, 399, 584, 596, 667, 945, 1004, 1012, 1188, 1231, 1271,
1276, 1299, 1322, 1371
```

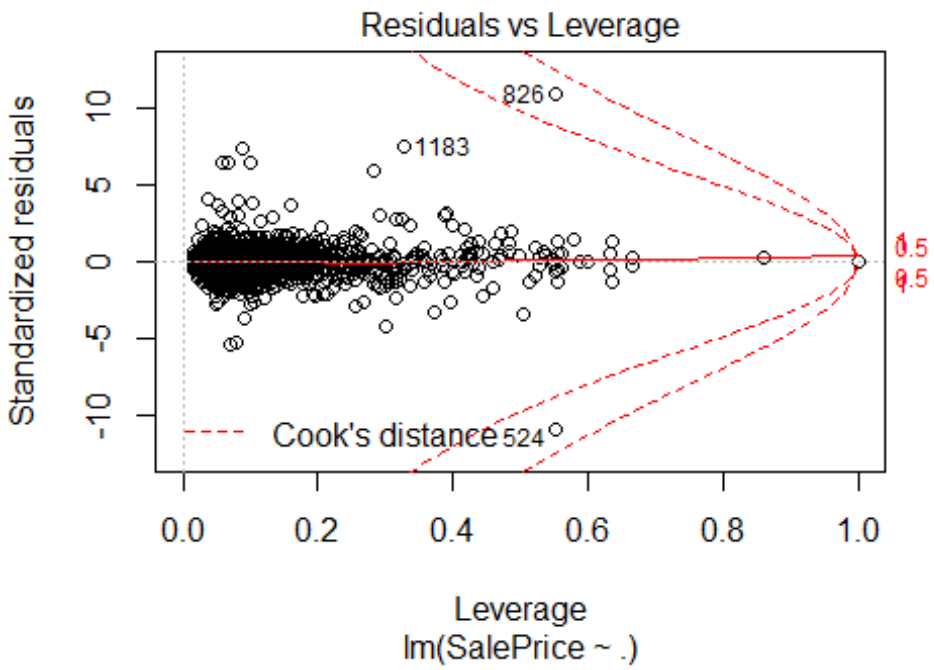




```
## Warning: not plotting observations with leverage one:
##   121, 251, 326, 399, 584, 596, 667, 945, 1004, 1012, 1188, 1231, 1271,
1276, 1299, 1322, 1371
```




```
## Warning in sqrt(crit * p * (1 - hh)/hh): NaNs produced

## Warning in sqrt(crit * p * (1 - hh)/hh): NaNs produced
```




```
library(car)
```

```
## Warning: package 'car' was built under R version 3.5.2
```

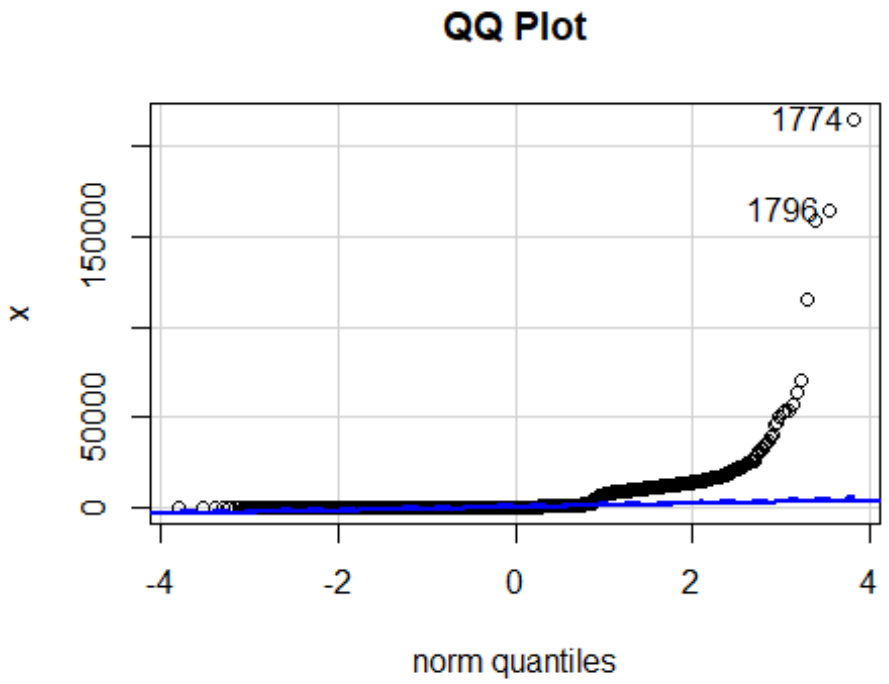
```
## Loading required package: carData
```

```
## Warning: package 'carData' was built under R version 3.5.2
```

```
##
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
##
##     recode
```

```
x <- c( BedroomAbvGr, LotArea, PoolArea, TotalBsmtSF, TotRmsAbvGrd)
qqPlot(x , main="QQ Plot")
```




```
## [1] 1774 1796
```

```
library(ggpubr)
```

```
## Warning: package 'ggpubr' was built under R version 3.5.2
```

```
## Loading required package: magrittr
```

```
##
## Attaching package: 'ggpubr'
```

```
## The following object is masked from 'package:forecast':
##
##     gghistogram
```

```
## The following object is masked from 'package:plyr':
##
##     mutate
```

```
t.test(SalePrice, x, data = training)
```

```
##
##  Welch Two Sample t-test
##
## data:  SalePrice and x
## t = 85.854, df = 1462.4, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
```

```
##  174523.2 182684.6
## sample estimates:
## mean of x mean of y
## 180921.20   2317.28
```

```
library(Hmisc)
```

```
## Warning: package 'Hmisc' was built under R version 3.5.2
```

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

```
## Warning: package 'Formula' was built under R version 3.5.2
```

```
##
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:plyr':
##
##     is.discrete, summarize
```

```
## The following objects are masked from 'package:dplyr':
##
##     src, summarize
```

```
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

```
describe(training)
```

```
## training
##
##  62  Variables      1460  Observations
## ---------------------------------------------------------------------------
-
## MSSubClass
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       15     0.94     56.9    43.19       20       20
##      .25      .50      .75      .90      .95
##       20       50       70      120      160
##
## Value         20    30    40    45    50    60    70    75    80    85
## Frequency    536    69     4    12   144   299    60    16    58    20
## Proportion 0.367 0.047 0.003 0.008 0.099 0.205 0.041 0.011 0.040 0.014
##
## Value         90   120   160   180   190
## Frequency     52    87    63    10    30
## Proportion 0.036 0.060 0.043 0.007 0.021
## ---------------------------------------------------------------------------
-
```

```
## MSZoning
##        n  missing distinct
##     1460        0        5
##
## Value      C (all)      FV      RH      RL      RM
## Frequency       10      65      16    1151     218
## Proportion   0.007   0.045   0.011   0.788   0.149
## ------------------------------------------------------------------------
-
## LotArea
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0     1073        1    10517     5718     3312     5000
##      .25      .50      .75      .90      .95
##     7554     9478    11602    14382    17401
##
## lowest :   1300   1477   1491   1526   1533, highest:  70761 115149 159000
164660 215245
## ------------------------------------------------------------------------
-
## Street
##        n  missing distinct
##     1460        0        2
##
## Value       Grvl  Pave
## Frequency      6  1454
## Proportion 0.004 0.996
## ------------------------------------------------------------------------
-
## LotShape
##        n  missing distinct
##     1460        0        4
##
## Value        IR1   IR2   IR3   Reg
## Frequency    484    41    10   925
## Proportion 0.332 0.028 0.007 0.634
## ------------------------------------------------------------------------
-
## LandContour
##        n  missing distinct
##     1460        0        4
##
## Value        Bnk   HLS   Low   Lvl
## Frequency     63    50    36  1311
## Proportion 0.043 0.034 0.025 0.898
## ------------------------------------------------------------------------
-
## Utilities
##        n  missing distinct
##     1460        0        2
##
```

```
## Value      AllPub NoSeWa
## Frequency    1459      1
## Proportion  0.999  0.001
## ------------------------------------------------------------------------
-
## LotConfig
##        n  missing distinct
##     1460        0        5
##
## Value       Corner CulDSac     FR2     FR3  Inside
## Frequency      263      94      47       4    1052
## Proportion   0.180   0.064   0.032   0.003   0.721
## ------------------------------------------------------------------------
-
## LandSlope
##        n  missing distinct
##     1460        0        3
##
## Value        Gtl   Mod   Sev
## Frequency   1382    65    13
## Proportion 0.947 0.045 0.009
## ------------------------------------------------------------------------
-
## Neighborhood
##        n  missing distinct
##     1460        0       25
##
## lowest : Blmngtn Blueste BrDale  BrkSide ClearCr
## highest: Somerst StoneBr SWISU   Timber  Veenker
## ------------------------------------------------------------------------
-
## Condition1
##        n  missing distinct
##     1460        0        9
##
## Value      Artery  Feedr   Norm   PosA   PosN   RRAe   RRAn   RRNe   RRNn
## Frequency      48     81   1260      8     19     11     26      2      5
## Proportion  0.033  0.055  0.863  0.005  0.013  0.008  0.018  0.001  0.003
## ------------------------------------------------------------------------
-
## Condition2
##        n  missing distinct
##     1460        0        8
##
## Value      Artery  Feedr   Norm   PosA   PosN   RRAe   RRAn   RRNn
## Frequency       2      6   1445      1      2      1      1      2
## Proportion  0.001  0.004  0.990  0.001  0.001  0.001  0.001  0.001
## ------------------------------------------------------------------------
-
## BldgType
```

```
##        n  missing distinct
##     1460        0        5
##
## Value        1Fam 2fmCon Duplex  Twnhs TwnhsE
## Frequency    1220     31     52     43    114
## Proportion  0.836  0.021  0.036  0.029  0.078
## ------------------------------------------------------------------------
-
## HouseStyle
##        n  missing distinct
##     1460        0        8
##
## Value      1.5Fin 1.5Unf 1Story 2.5Fin 2.5Unf 2Story SFoyer   SLvl
## Frequency     154     14    726      8     11    445     37     65
## Proportion  0.105  0.010  0.497  0.005  0.008  0.305  0.025  0.045
## ------------------------------------------------------------------------
-
## OverallQual
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       10    0.951    6.099    1.522        4        5
##      .25      .50      .75      .90      .95
##        5        6        7        8        8
##
## Value          1     2     3     4     5     6     7     8     9    10
## Frequency      2     3    20   116   397   374   319   168    43    18
## Proportion 0.001 0.002 0.014 0.079 0.272 0.256 0.218 0.115 0.029 0.012
## ------------------------------------------------------------------------
-
## OverallCond
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        9    0.814    5.575    1.111
##
## Value          1     2     3     4     5     6     7     8     9
## Frequency      1     5    25    57   821   252   205    72    22
## Proportion 0.001 0.003 0.017 0.039 0.562 0.173 0.140 0.049 0.015
## ------------------------------------------------------------------------
-
## YearBuilt
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      112        1     1971    33.88     1916     1925
##      .25      .50      .75      .90      .95
##     1954     1973     2000     2006     2007
##
## lowest : 1872 1875 1880 1882 1885, highest: 2006 2007 2008 2009 2010
## ------------------------------------------------------------------------
-
## YearRemodAdd
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       61    0.997     1985    23.05     1950     1950
##      .25      .50      .75      .90      .95
```

```
##     1967     1994     2004     2006     2007
##
## lowest : 1950 1951 1952 1953 1954, highest: 2006 2007 2008 2009 2010
## ---------------------------------------------------------------------------
-
## RoofStyle
##        n  missing distinct
##     1460        0        6
##
## Value          Flat   Gable Gambrel     Hip Mansard    Shed
## Frequency        13    1141      11     286       7       2
## Proportion    0.009   0.782   0.008   0.196   0.005   0.001
## ---------------------------------------------------------------------------
-
## RoofMatl
##        n  missing distinct
##     1460        0        8
##
## Value      ClyTile CompShg Membran   Metal    Roll Tar&Grv WdShake WdShngl
## Frequency        1    1434       1       1       1      11       5       6
## Proportion   0.001   0.982   0.001   0.001   0.001   0.008   0.003   0.004
## ---------------------------------------------------------------------------
-
## Exterior1st
##        n  missing distinct
##     1460        0       15
##
## Value      AsbShng AsphShn BrkComm BrkFace  CBlock CemntBd HdBoard ImStucc
## Frequency       20       1       2      50       1      61     222       1
## Proportion   0.014   0.001   0.001   0.034   0.001   0.042   0.152   0.001
##
## Value      MetalSd Plywood   Stone  Stucco VinylSd Wd Sdng WdShing
## Frequency      220     108       2      25     515     206      26
## Proportion   0.151   0.074   0.001   0.017   0.353   0.141   0.018
## ---------------------------------------------------------------------------
-
## Exterior2nd
##        n  missing distinct
##     1460        0       16
##
## Value      AsbShng AsphShn Brk Cmn BrkFace  CBlock CmentBd HdBoard ImStucc
## Frequency       20       3       7      25       1      60     207      10
## Proportion   0.014   0.002   0.005   0.017   0.001   0.041   0.142   0.007
##
## Value      MetalSd   Other Plywood   Stone  Stucco VinylSd Wd Sdng Wd Shng
## Frequency      214       1     142       5      26     504     197      38
## Proportion   0.147   0.001   0.097   0.003   0.018   0.345   0.135   0.026
## ---------------------------------------------------------------------------
-
## ExterQual
```

```
##        n  missing distinct
##     1460        0        4
##
## Value         Ex    Fa    Gd    TA
## Frequency     52    14   488   906
## Proportion 0.036 0.010 0.334 0.621
## ------------------------------------------------------------------------
-
## ExterCond
##        n  missing distinct
##     1460        0        5
##
## Value         Ex    Fa    Gd    Po    TA
## Frequency      3    28   146     1  1282
## Proportion 0.002 0.019 0.100 0.001 0.878
## ------------------------------------------------------------------------
-
## Foundation
##        n  missing distinct
##     1460        0        6
##
## Value      BrkTil CBlock  PConc   Slab  Stone   Wood
## Frequency     146    634    647     24      6      3
## Proportion  0.100  0.434  0.443  0.016  0.004  0.002
## ------------------------------------------------------------------------
-
## BsmtFinSF1
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      637    0.967    443.6    484.5      0.0      0.0
##      .25      .50      .75      .90      .95
##      0.0    383.5    712.2   1065.5   1274.0
##
## lowest :    0    2   16   20   24, highest: 1904 2096 2188 2260 5644
## ------------------------------------------------------------------------
-
## BsmtFinSF2
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      144    0.305    46.55    86.58      0.0      0.0
##      .25      .50      .75      .90      .95
##      0.0      0.0      0.0    117.2    396.2
##
## lowest :    0   28   32   35   40, highest: 1080 1085 1120 1127 1474
## ------------------------------------------------------------------------
-
## BsmtUnfSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      780    0.999    567.2    486.6      0.0     74.9
##      .25      .50      .75      .90      .95
##    223.0    477.5    808.0   1232.0   1468.0
##
```

```
## lowest :    0   14   15   23   26, highest: 2042 2046 2121 2153 2336
## ------------------------------------------------------------------------
-
## TotalBsmtSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      721        1     1057    459.5    519.3    636.9
##      .25      .50      .75      .90      .95
##    795.8    991.5   1298.2   1602.2   1753.0
##
## lowest :    0  105  190  264  270, highest: 3094 3138 3200 3206 6110
## ------------------------------------------------------------------------
-
## Heating
##        n  missing distinct
##     1460        0        6
##
## Value      Floor  GasA  GasW  Grav  OthW  Wall
## Frequency      1  1428    18     7     2     4
## Proportion 0.001 0.978 0.012 0.005 0.001 0.003
## ------------------------------------------------------------------------
-
## HeatingQC
##        n  missing distinct
##     1460        0        5
##
## Value         Ex    Fa    Gd    Po    TA
## Frequency    741    49   241     1   428
## Proportion 0.508 0.034 0.165 0.001 0.293
## ------------------------------------------------------------------------
-
## CentralAir
##        n  missing distinct
##     1460        0        2
##
## Value          N     Y
## Frequency     95  1365
## Proportion 0.065 0.935
## ------------------------------------------------------------------------
-
## Electrical
##        n  missing distinct
##     1459        1        5
##
## Value      FuseA FuseF FuseP   Mix SBrkr
## Frequency     94    27     3     1  1334
## Proportion 0.064 0.019 0.002 0.001 0.914
## ------------------------------------------------------------------------
-
## X1stFlrSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
```

```
##     1460        0      753        1     1163    416.4    673.0    756.9
##      .25      .50      .75      .90      .95
##    882.0   1087.0   1391.2   1680.0   1831.2
##
## lowest :  334  372  438  480  483, highest: 2633 2898 3138 3228 4692
## ------------------------------------------------------------------------
-
## X2ndFlrSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      417    0.817      347    450.2      0.0      0.0
##      .25      .50      .75      .90      .95
##      0.0      0.0    728.0    954.2   1141.0
##
## lowest :    0  110  167  192  208, highest: 1611 1796 1818 1872 2065
## ------------------------------------------------------------------------
-
## LowQualFinSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       24    0.052    5.845    11.55        0        0
##      .25      .50      .75      .90      .95
##        0        0        0        0        0
##
## lowest :   0  53  80 120 144, highest: 513 514 515 528 572
## ------------------------------------------------------------------------
-
## GrLivArea
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      861        1     1515    563.1      848      912
##      .25      .50      .75      .90      .95
##     1130     1464     1777     2158     2466
##
## lowest :  334  438  480  520  605, highest: 3627 4316 4476 4676 5642
## ------------------------------------------------------------------------
-
## BsmtFullBath
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        4    0.733   0.4253   0.5085
##
## Value          0     1     2     3
## Frequency    856   588    15     1
## Proportion 0.586 0.403 0.010 0.001
## ------------------------------------------------------------------------
-
## BsmtHalfBath
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        3    0.159  0.05753   0.1088
##
## Value          0     1     2
## Frequency   1378    80     2
## Proportion 0.944 0.055 0.001
```

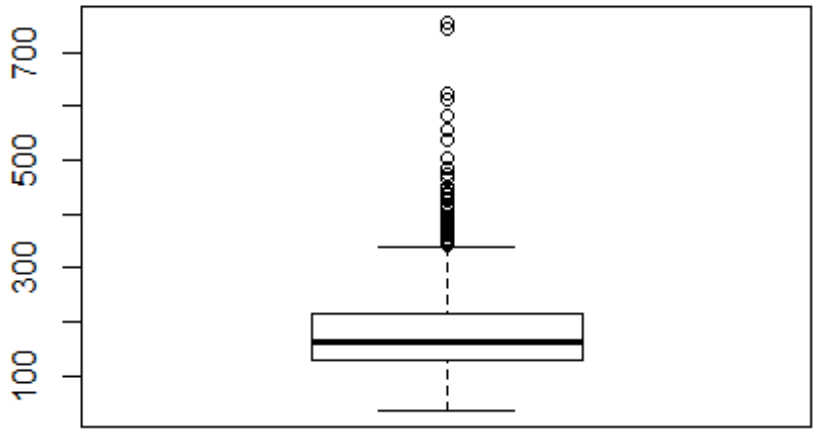
```
## ------------------------------------------------------------------------
-
## FullBath
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        4    0.766    1.565   0.5521
##
## Value          0     1     2     3
## Frequency      9   650   768    33
## Proportion 0.006 0.445 0.526 0.023
## ------------------------------------------------------------------------
-
## HalfBath
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        3    0.706   0.3829   0.4852
##
## Value          0     1     2
## Frequency    913   535    12
## Proportion 0.625 0.366 0.008
## ------------------------------------------------------------------------
-
## BedroomAbvGr
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        8    0.815    2.866    0.818
##
## Value          0     1     2     3     4     5     6     8
## Frequency      6    50   358   804   213    21     7     1
## Proportion 0.004 0.034 0.245 0.551 0.146 0.014 0.005 0.001
## ------------------------------------------------------------------------
-
## KitchenAbvGr
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        4    0.133    1.047  0.09174
##
## Value          0     1     2     3
## Frequency      1  1392    65     2
## Proportion 0.001 0.953 0.045 0.001
## ------------------------------------------------------------------------
-
## KitchenQual
##        n  missing distinct
##     1460        0        4
##
## Value         Ex    Fa    Gd    TA
## Frequency    100    39   586   735
## Proportion 0.068 0.027 0.401 0.503
## ------------------------------------------------------------------------
-
## TotRmsAbvGrd
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       12    0.958    6.518    1.762        4        5
```

```
##      .25      .50      .75      .90      .95
##        5        6        7        9       10
##
## Value          2     3     4     5     6     7     8     9    10    11
## Frequency      1    17    97   275   402   329   187    75    47    18
## Proportion 0.001 0.012 0.066 0.188 0.275 0.225 0.128 0.051 0.032 0.012
##
## Value         12    14
## Frequency     11     1
## Proportion 0.008 0.001
## ------------------------------------------------------------------------
-
## Functional
##        n  missing distinct
##     1460        0        7
##
## Value       Maj1  Maj2  Min1  Min2   Mod   Sev   Typ
## Frequency     14     5    31    34    15     1  1360
## Proportion 0.010 0.003 0.021 0.023 0.010 0.001 0.932
## ------------------------------------------------------------------------
-
## Fireplaces
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        4    0.806    0.613   0.6566
##
## Value          0     1     2     3
## Frequency    690   650   115     5
## Proportion 0.473 0.445 0.079 0.003
## ------------------------------------------------------------------------
-
## GarageCars
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        5    0.802    1.767   0.7609
##
## Value          0     1     2     3     4
## Frequency     81   369   824   181     5
## Proportion 0.055 0.253 0.564 0.124 0.003
## ------------------------------------------------------------------------
-
## GarageArea
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      441        1      473    234.9      0.0    240.0
##      .25      .50      .75      .90      .95
##    334.5    480.0    576.0    757.1    850.1
##
## lowest :    0  160  164  180  186, highest: 1220 1248 1356 1390 1418
## ------------------------------------------------------------------------
-
## PavedDrive
##        n  missing distinct
```

```
##     1460        0        3
##
## Value          N     P     Y
## Frequency     90    30  1340
## Proportion 0.062 0.021 0.918
## ------------------------------------------------------------------------
-
## WoodDeckSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      274    0.858    94.24      125        0        0
##      .25      .50      .75      .90      .95
##        0        0      168      262      335
##
## lowest :   0  12  24  26  28, highest: 668 670 728 736 857
## ------------------------------------------------------------------------
-
## OpenPorchSF
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      202    0.909    46.66    62.43        0        0
##      .25      .50      .75      .90      .95
##        0       25       68      130      175
##
## lowest :   0   4   8  10  11, highest: 406 418 502 523 547
## ------------------------------------------------------------------------
-
## EnclosedPorch
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      120    0.369    21.95    39.39      0.0      0.0
##      .25      .50      .75      .90      .95
##      0.0      0.0      0.0    112.0    180.1
##
## lowest :   0  19  20  24  30, highest: 301 318 330 386 552
## ------------------------------------------------------------------------
-
## X3SsnPorch
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       20    0.049     3.41    6.739        0        0
##      .25      .50      .75      .90      .95
##        0        0        0        0        0
##
## Value          0    23    96   130   140   144   153   162   168   180
## Frequency   1436     1     1     1     1     2     1     1     3     2
## Proportion 0.984 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.001
##
## Value        182   196   216   238   245   290   304   320   407   508
## Frequency      1     1     2     1     1     1     1     1     1     1
## Proportion 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
## ------------------------------------------------------------------------
-
## ScreenPorch
```

```
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       76     0.22    15.06    28.27        0        0
##      .25      .50      .75      .90      .95
##        0        0        0        0      160
##
## lowest :   0  40  53  60  63, highest: 385 396 410 440 480
## ------------------------------------------------------------------------
-
## PoolArea
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        8    0.014    2.759    5.497
##
## Value          0   480   512   519   555   576   648   738
## Frequency   1453     1     1     1     1     1     1     1
## Proportion 0.995 0.001 0.001 0.001 0.001 0.001 0.001 0.001
## ------------------------------------------------------------------------
-
## MiscVal
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       21    0.103    43.49    85.67        0        0
##      .25      .50      .75      .90      .95
##        0        0        0        0        0
##
## Value          0    50   350   400   450   500   550   600   700   800
## Frequency   1408     1     1    11     4    10     1     5     5     1
## Proportion 0.964 0.001 0.001 0.008 0.003 0.007 0.001 0.003 0.003 0.001
##
## Value       1150  1200  1300  1400  2000  2500  3500  8300 15500
## Frequency      1     2     1     1     4     1     1     1     1
## Proportion 0.001 0.001 0.001 0.001 0.003 0.001 0.001 0.001 0.001
## ------------------------------------------------------------------------
-
## MoSold
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0       12    0.985    6.322    3.041        2        3
##      .25      .50      .75      .90      .95
##        5        6        8       10       11
##
## Value          1     2     3     4     5     6     7     8     9    10
## Frequency     58    52   106   141   204   253   234   122    63    89
## Proportion 0.040 0.036 0.073 0.097 0.140 0.173 0.160 0.084 0.043 0.061
##
## Value         11    12
## Frequency     79    59
## Proportion 0.054 0.040
## ------------------------------------------------------------------------
-
## YrSold
##        n  missing distinct     Info     Mean      Gmd
##     1460        0        5    0.955     2008    1.498
```

```
##
## Value       2006  2007  2008  2009  2010
## Frequency    314   329   304   338   175
## Proportion 0.215 0.225 0.208 0.232 0.120
## ------------------------------------------------------------------------
-
## SaleType
##        n  missing distinct
##     1460        0        9
##
## Value        COD   Con ConLD ConLI ConLw   CWD   New   Oth    WD
## Frequency     43     2     9     5     5     4   122     3  1267
## Proportion 0.029 0.001 0.006 0.003 0.003 0.003 0.084 0.002 0.868
## ------------------------------------------------------------------------
-
## SaleCondition
##        n  missing distinct
##     1460        0        6
##
## Value      Abnorml AdjLand  Alloca  Family  Normal Partial
## Frequency      101       4      12      20    1198     125
## Proportion   0.069   0.003   0.008   0.014   0.821   0.086
## ------------------------------------------------------------------------
-
## SalePrice
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1460        0      663        1   180921    81086    88000   106475
##      .25      .50      .75      .90      .95
##   129975   163000   214000   278000   326100
##
## lowest :  34900  35311  37900  39300  40000, highest: 582933 611657 625000
745000 755000
## ------------------------------------------------------------------------
-

boxplot(training$SalePrice / 1000 )
```




```
cat_var <- names(training)[which(sapply(training, is.factor))]
cat_var
```

```
##  [1] "MSZoning"      "Street"        "LotShape"      "LandContour"
##  [5] "Utilities"     "LotConfig"     "LandSlope"     "Neighborhood"
##  [9] "Condition1"    "Condition2"    "BldgType"      "HouseStyle"
## [13] "RoofStyle"     "RoofMatl"      "Exterior1st"   "Exterior2nd"
## [17] "ExterQual"     "ExterCond"     "Foundation"    "Heating"
## [21] "HeatingQC"     "CentralAir"    "Electrical"    "KitchenQual"
## [25] "Functional"    "PavedDrive"    "SaleType"      "SaleCondition"
```

```
num_var <-
c('SalePrice','LotArea','TotalBsmtSF','GrLivArea','BsmtFinSF1','BsmtFinSF2','
X1stFlrSF','X2ndFlrSF','GarageArea','WoodDeckSF','OpenPorchSF')
training_pca<-training[,num_var]
training_pca<-training_pca[,-1]
head(training_pca)
```

```
##   LotArea TotalBsmtSF GrLivArea BsmtFinSF1 BsmtFinSF2 X1stFlrSF X2ndFlrSF
## 1    8450         856      1710        706          0       856       854
## 2    9600        1262      1262        978          0      1262         0
## 3   11250         920      1786        486          0       920       866
## 4    9550         756      1717        216          0       961       756
## 5   14260        1145      2198        655          0      1145      1053
## 6   14115         796      1362        732          0       796       566
##   GarageArea WoodDeckSF OpenPorchSF
## 1        548          0          61
```

```
## 2        460        298           0
## 3        608          0          42
## 4        642          0          35
## 5        836        192          84
## 6        480         40          30
```

```
library(stats)
library(factoextra)
```

```
## Warning: package 'factoextra' was built under R version 3.5.2
```

```
## Welcome! Related Books: `Practical Guide To Cluster Analysis in R` at
https://goo.gl/13EFCZ
```

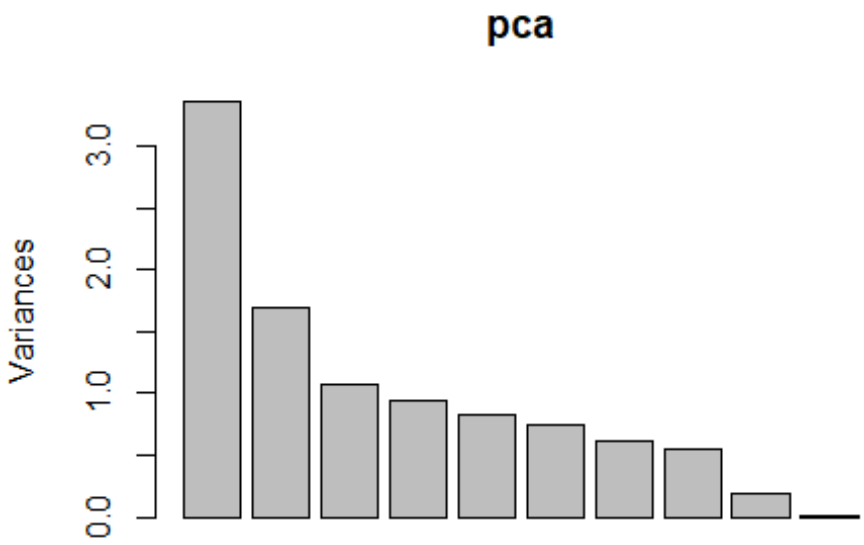
```
pca <- prcomp(training_pca, scale. = T, center = T)
pca
```

```
## Standard deviations (1, .., p=10):
##  [1] 1.83243422 1.30429534 1.03548877 0.97248759 0.90793164 0.86649566
##  [7] 0.77941503 0.73794318 0.43830438 0.06096042
##
## Rotation (n x k) = (10 x 10):
##                    PC1         PC2         PC3         PC4         PC5
## LotArea     0.24082621 -0.03031059 -0.40321015  0.23822964  0.77267425
## TotalBsmtSF 0.45634490 -0.25721946  0.08271935 -0.13355898 -0.04317210
## GrLivArea   0.40759887  0.43900569 -0.03989019 -0.01123075  0.03799954
## BsmtFinSF1  0.31864938 -0.26991749  0.24502299  0.21866216  0.08778484
## BsmtFinSF2  0.04272502 -0.16236957 -0.79944538 -0.39689989 -0.21229754
## X1stFlrSF   0.46316944 -0.23031329  0.04318594 -0.11537263  0.00025177
## X2ndFlrSF   0.08073359  0.72388109 -0.08170676  0.09248418  0.04172027
## GarageArea  0.37860907  0.07132877  0.14820597 -0.02714632 -0.16463297
## WoodDeckSF  0.22506337  0.02882402 -0.28991205  0.61195709 -0.55929762
## OpenPorchSF 0.22183369  0.24084730  0.12362708 -0.56819651 -0.07233113
##                    PC6         PC7         PC8          PC9          PC10
## LotArea      0.2458665 -0.24325647  0.05908480  0.040144360 -0.0003067372
## TotalBsmtSF -0.1173180  0.03307807 -0.23823061  0.792089692 -0.0050582128
## GrLivArea   -0.2699258  0.16012622 -0.23801319 -0.210405689 -0.6622346195
## BsmtFinSF1   0.1946590  0.70572976  0.39400253 -0.137325978 -0.0029135324
## BsmtFinSF2  -0.1266822  0.24663944  0.22835668 -0.032725184  0.0009599222
## X1stFlrSF   -0.2162628 -0.09485291 -0.39200004 -0.508365329  0.4993875181
## X2ndFlrSF   -0.1288099  0.27091579  0.07695150  0.211276857  0.5585351789
## GarageArea  -0.2348152 -0.49980027  0.70433203 -0.026111169 -0.0075857437
## WoodDeckSF   0.3733019 -0.13413661 -0.14074732  0.001222033 -0.0017692250
## OpenPorchSF  0.7356165 -0.07085779 -0.01552828 -0.055008452  0.0003257185
```

```
eigenvalues <- get_eigenvalue(pca)
eigenvalues <- pca$sdev^2
sum(eigenvalues)
```

```
## [1] 10
```

```
plot(pca)
```




```
summary(pca)
```

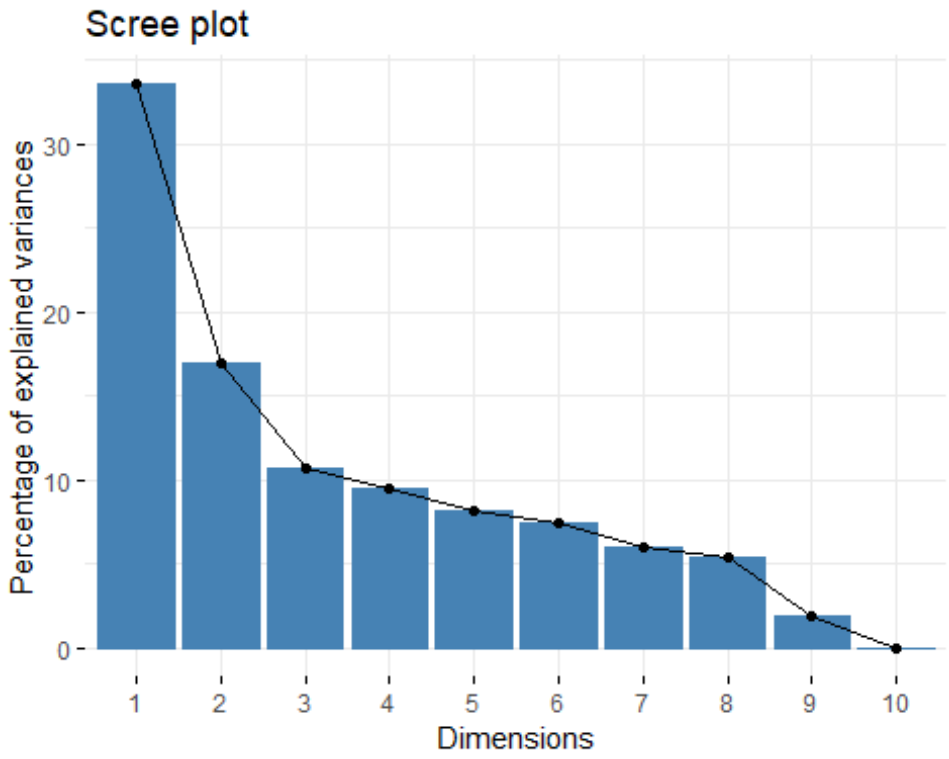
```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6
## Standard deviation     1.8324 1.3043 1.0355 0.97249 0.90793 0.86650
## Proportion of Variance 0.3358 0.1701 0.1072 0.09457 0.08243 0.07508
## Cumulative Proportion  0.3358 0.5059 0.6131 0.70770 0.79013 0.86521
##                           PC7     PC8     PC9    PC10
## Standard deviation     0.77942 0.73794 0.43830 0.06096
## Proportion of Variance 0.06075 0.05446 0.01921 0.00037
## Cumulative Proportion  0.92596 0.98042 0.99963 1.00000
```

```
head(pca$x)
```

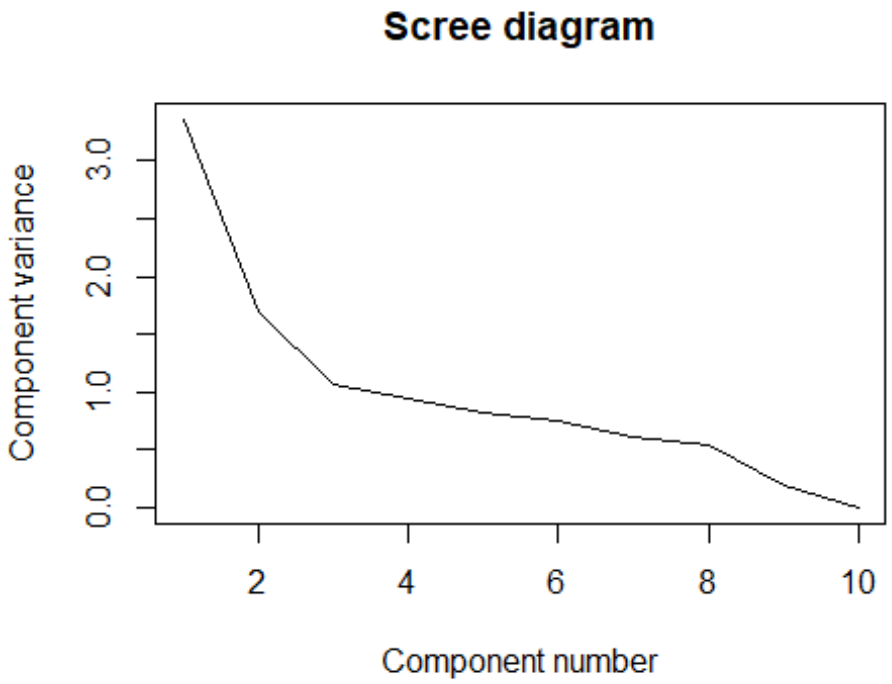
```
##              PC1        PC2       PC3         PC4        PC5         PC6
## [1,] -0.19950507  1.2573996 0.5699695 -0.14557326  0.3810288 -0.13039710
## [2,]  0.59661501 -1.3599887 0.1212960  1.58540971 -0.8267072  0.46737933
## [3,] -0.03859223  1.3377818 0.3560117 -0.06656048  0.5303680 -0.52766323
## [4,] -0.42680935  1.3203016 0.2896293 -0.16500343  0.3289244 -0.71100966
## [5,]  1.89901231  1.8898496 0.1188016  0.52976295 -0.2565965 -0.04649434
## [6,] -0.65453329  0.4012457 0.2198969  0.45447540  0.6854618  0.18322966
##             PC7         PC8         PC9         PC10
## [1,]  0.7292940  0.91968255  0.10717694  0.006626031
## [2,]  0.3386459 -0.02855527  0.05940217 -0.004845053
## [3,]  0.2204336  0.81636043  0.19989466  0.007234564
## [4,] -0.3396242  0.74604766 -0.09962054  0.008837563
```

```
## [5,] -0.1714445  1.00183713  0.13617801  0.003570218
## [6,]  0.5061831  0.91429199  0.12708586  0.001237862
```

```
library(factoextra)
fviz_screeplot(pca, ncp = 35)
```




```
#plot(pca, type = "l", main = "Scree diagram")
plot(eigenvalues, xlab = "Component number", ylab = "Component variance",
type = "l", main ="Scree diagram")
```

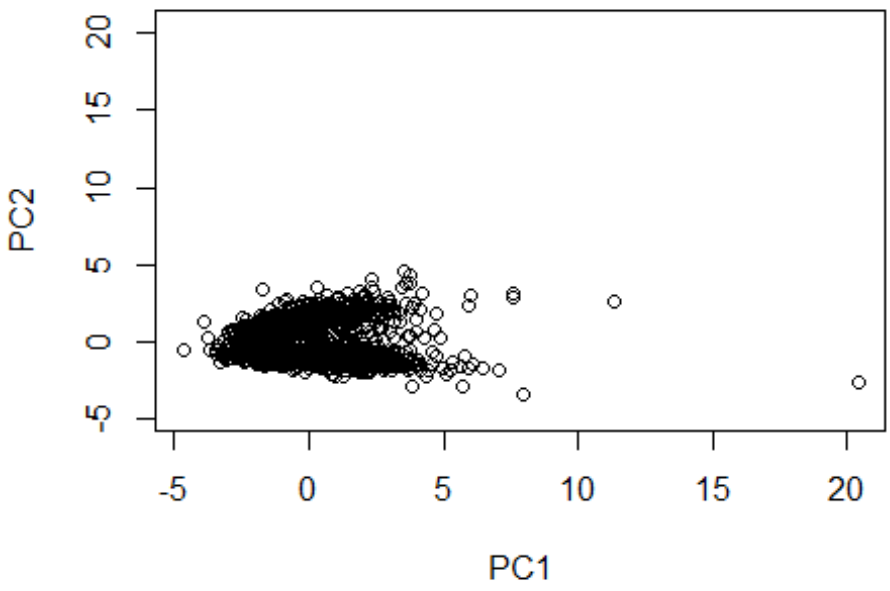



```
diag(cov(pca$x))
```

```
##         PC1         PC2         PC3         PC4         PC5         PC6
## 3.357815156 1.701186327 1.072236997 0.945732115 0.824339863 0.750814721
##         PC7         PC8         PC9        PC10
## 0.607487793 0.544560130 0.192110725 0.003716173
```

```
xlim <- range(pca$x[,1])
```

```
plot(pca$x,xlim=xlim,ylim=xlim)
```




```
pca$rotation[,1]
```

```
##     LotArea TotalBsmtSF   GrLivArea  BsmtFinSF1  BsmtFinSF2   X1stFlrSF
##  0.24082621  0.45634490  0.40759887  0.31864938  0.04272502  0.46316944
##   X2ndFlrSF  GarageArea  WoodDeckSF OpenPorchSF
##  0.08073359  0.37860907  0.22506337  0.22183369
```

```
pca$rotation[,2]
```

```
##     LotArea TotalBsmtSF   GrLivArea  BsmtFinSF1  BsmtFinSF2   X1stFlrSF
## -0.03031059 -0.25721946  0.43900569 -0.26991749 -0.16236957 -0.23031329
##   X2ndFlrSF  GarageArea  WoodDeckSF OpenPorchSF
##  0.72388109  0.07132877  0.02882402  0.24084730
```

```
pca$rotation[,3]
```

```
##     LotArea TotalBsmtSF   GrLivArea  BsmtFinSF1  BsmtFinSF2   X1stFlrSF
## -0.40321015  0.08271935 -0.03989019  0.24502299 -0.79944538  0.04318594
##   X2ndFlrSF  GarageArea  WoodDeckSF OpenPorchSF
## -0.08170676  0.14820597 -0.28991205  0.12362708
```

```
pca$rotation[,4]
```

```
##     LotArea TotalBsmtSF   GrLivArea  BsmtFinSF1  BsmtFinSF2   X1stFlrSF
##  0.23822964 -0.13355898 -0.01123075  0.21866216 -0.39689989 -0.11537263
##   X2ndFlrSF  GarageArea  WoodDeckSF OpenPorchSF
##  0.09248418 -0.02714632  0.61195709 -0.56819651
```

```
pca$rotation[,5]
```

```
##     LotArea TotalBsmtSF   GrLivArea  BsmtFinSF1  BsmtFinSF2   X1stFlrSF
##  0.77267425 -0.04317210  0.03799954  0.08778484 -0.21229754  0.00025177
##   X2ndFlrSF  GarageArea  WoodDeckSF OpenPorchSF
##  0.04172027 -0.16463297 -0.55929762 -0.07233113
```