Machine Learning Homework 1

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Task 1

Create a data-frame historical daily total returns from January 1st 2000 to December 31st 2016. Descriptive Statistics are shown as follows:

```
##      PERMNO           date                  TICKER          RET
##  Min.   :10107   Min.   :2000-01-03   AA     : 4277   Min.   :-0.3902440
##  1st Qu.:12490   1st Qu.:2004-03-01   AXP    : 4277   1st Qu.:-0.0081240
##  Median :21573   Median :2008-05-27   BA     : 4277   Median : 0.0003040
##  Mean   :28838   Mean   :2008-06-08   C      : 4277   Mean   : 0.0003735
##  3rd Qu.:43449   3rd Qu.:2012-09-12   CAT    : 4277   3rd Qu.: 0.0088180
##  Max.   :70519   Max.   :2016-12-30   DD     : 4277   Max.   : 0.5782490
##                                       (Other):87063   NA's   :2
```

In summary, for each company, we have 4277 daily observations, starting from 2000-01-03 and ending at 2016-12-30. The best return is 57.82% and the worst one is -39.02%. RET has two missing values.

Task 2:

The companies in Training Set 1 is (the first variable in output denotes the date)

```
##  [1] "date" "AA"   "AXP"  "BA"   "C"    "CAT"  "DD"   "DIS"  "GE"   "HD"
## [11] "HON"  "HPQ"  "HWP"  "IBM"  "INTC" "IP"   "JNJ"  "KO"   "MCD"  "MMM"
## [21] "MO"   "MRK"  "MSFT" "PG"   "SBC"  "T"    "UTX"  "WMT"  "XOM"
```

The companies in Training Set 2 is (the first variable in output denotes the date)

```
##  [1] "date" "AA"   "AXP"  "BA"   "C"    "CAT"  "DD"   "DIS"  "GE"   "HD"
## [11] "HON"  "HPQ"  "IBM"  "INTC" "IP"   "JNJ"  "KO"   "MCD"  "MMM"  "MO"
## [21] "MRK"  "MSFT" "PG"   "T"    "UTX"  "WMT"  "XOM"
```

The companies in Test Set is (the first variable in output denotes the date)

```
##  [1] "date" "AA"   "ARNC" "AXP"  "BA"   "C"    "CAT"  "DD"   "DIS"  "GE"
## [11] "HD"   "HON"  "HPQ"  "IBM"  "INTC" "IP"   "JNJ"  "KO"   "MCD"  "MMM"
## [21] "MO"   "MRK"  "MSFT" "PG"   "T"    "UTX"  "WMT"  "XOM"
```

By comparison, we can find that “HWP” “SBC” were excluded from Dow Jones in Training Set 2 (Jan 1st, 2006), and that “ARNC” are added into Test Set (Jan 1st, 2011). In order to make predictions, “HWP” “SBC” are excluded from Training Set 1 and “ARNC” is excluded from Test Set.

```
train1wide = subset(train1wide, select = -c(HWP,SBC))
testwide = subset(testwide, select = -c(ARNC))
```

(a) Perform PCA on the stock returns in the Training Set 1. Print the Principal Component loadings you calculated.

First, I need to deal wth missing values. There are 585 missing values for HP due to ticker change at May 2, 2002. I searched for the stock data with its former ticker "HWP" from Jan 1, 2000 to May 2, 2002.

```
## The following objects are masked from mlfin:
##
##     date, PERMNO, RET, TICKER
```

After this major change, the number of missing values in Training Set 1 is

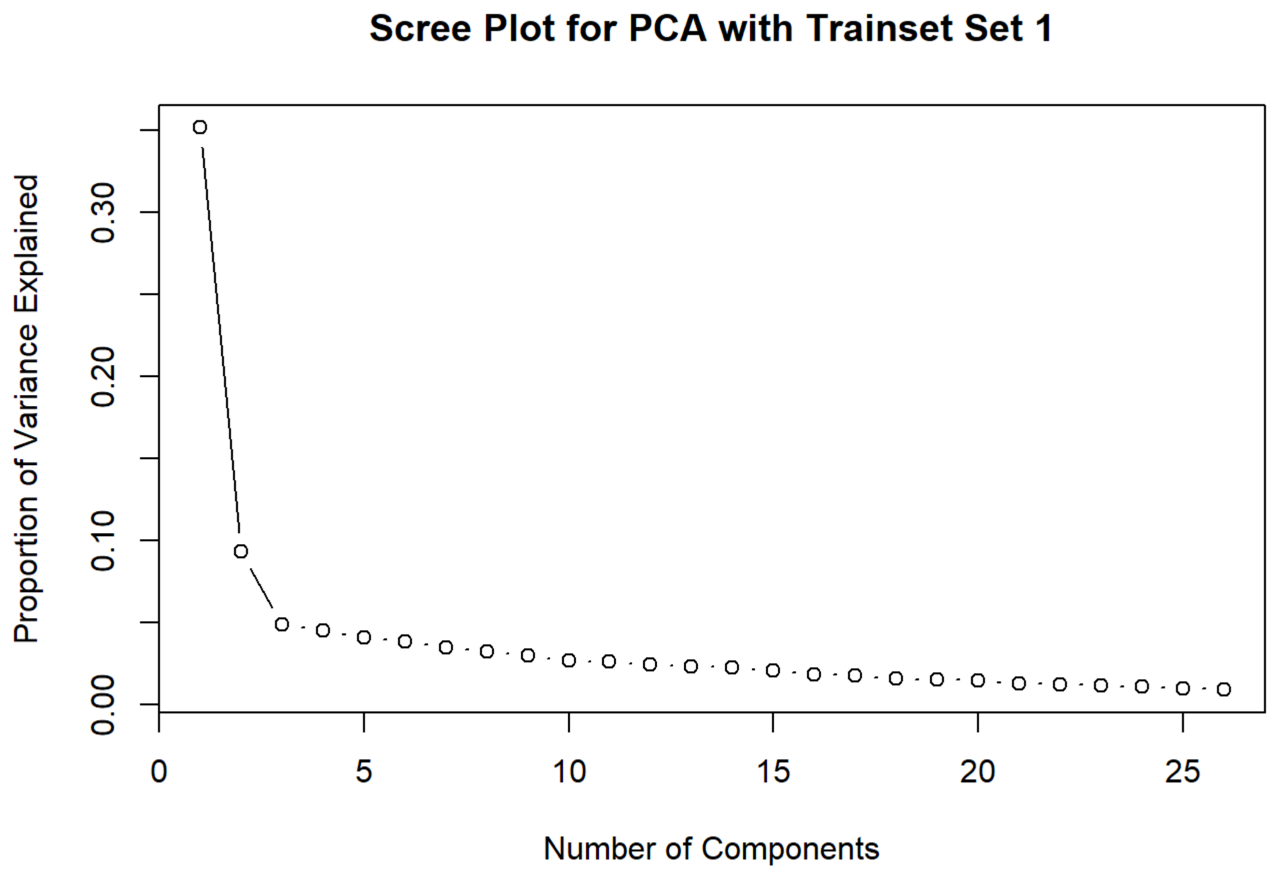
```
## [1] 7
```

I choose to replace these missing values with the mean return. At this time, missing data take up less than 0.5% of the total raining Set 1, the possible bias incurred by this practice is negligible.

```
NA2mean <- function(x) replace(x, is.na(x), mean(x, na.rm = TRUE))
train1_data = replace(train1_data, TRUE, lapply(train1_data, NA2mean))
```

Then I use "prcomp" function in R to conduct Principal Component Analysis. Given that all variables are stock returns, which are comparable to each other, I do not use "scale" option to standardize the data. The Scree Plot can be shown as follows:

```
tr1pca = prcomp(train1_data, scale = FALSE)
tr1pcaVar = tr1pca$sdev^2
tr1pve = tr1pcaVar/sum(tr1pcaVar)
plot(tr1pve, type = "b", main = "Scree Plot for PCA with Trainset Set 1", ylab = "Proportion of
 Variance Explained", xlab = "Number of Components")
```



Based on the explained variance, I choose the first three principal components, whose loading matrix is shown as follows:

```
tr1rot = tr1pca$rotation
tra1loading = tr1rot[,1:3]
round(tra1loading,4)
```

```
##         PC1     PC2     PC3
## AA   0.2368  0.1874 -0.0468
## AXP  0.2416  0.0490  0.0911
## BA   0.1803  0.1189 -0.1319
## C    0.2401  0.0195  0.1298
## CAT  0.2018  0.1562 -0.0906
## DD   0.1824  0.1939 -0.0644
## DIS  0.2148 -0.0276  0.0591
## GE   0.2334  0.0552  0.0040
## HD   0.2431  0.1386  0.2561
## HON  0.2623  0.1169 -0.1999
## HPQ  0.2787 -0.4285 -0.3094
## IBM  0.1965 -0.1924 -0.0303
## INTC 0.3225 -0.5415 -0.1012
## IP   0.1919  0.2000 -0.0013
## JNJ  0.0800  0.1212 -0.0222
## KO   0.0818  0.1354 -0.0309
## MCD  0.1109  0.1261 -0.0235
## MMM  0.1529  0.1492 -0.0340
## MO   0.0678  0.1521 -0.0419
## MRK  0.1057  0.1449  0.0019
## MSFT 0.2231 -0.2712 -0.0132
## PG   0.0772  0.1801 -0.0484
## T    0.1753 -0.1575  0.8195
## UTX  0.2104  0.1476 -0.1688
## WMT  0.1689  0.1228  0.1349
## XOM  0.1095  0.1115  0.0354
```

(b) Then use the estimated Principal Components loadings and apply them to Training Set 2 to create daily data for all the Principal Components for the dates in Training Set 2.

First, I check the missing values.

```
sum(is.na(train2wide))
```

```
## [1] 0
```

Then, I predict the daily return using the loading matrix from PCA with Training Set 1. The first 20 days in the Training Set 2 are shown as follows:

```
train2_data = train2wide[,2:length(train2wide[1,])]
train2_daily_predict = as.matrix(train2_data) %*% tra1loading
round(head(train2_daily_predict,20),4)
```

```
##        PC1     PC2     PC3
## 1   0.0575  0.0052  0.0056
## 2   0.0095 -0.0140 -0.0156
## 3   0.0025 -0.0133  0.0032
## 4   0.0385 -0.0043 -0.0001
## 5   0.0203  0.0065  0.0011
## 6  -0.0015  0.0001  0.0043
## 7   0.0150 -0.0140  0.0141
## 8  -0.0353 -0.0122  0.0026
## 9   0.0022 -0.0099 -0.0120
## 10 -0.0228  0.0057 -0.0051
## 11 -0.0454  0.0566  0.0138
## 12  0.0168  0.0023 -0.0058
## 13 -0.1039 -0.0102  0.0031
## 14 -0.0055  0.0241 -0.0062
## 15  0.0206  0.0073  0.0077
## 16  0.0024 -0.0142  0.0097
## 17  0.0513  0.0319 -0.0009
## 18  0.0354  0.0064 -0.0012
## 19 -0.0008 -0.0123  0.0103
## 20 -0.0048  0.0108 -0.0009
```

(b)Then create a data-frame where the Y variable is the first stock’s return at time t + 1 and the X variables are all the lagged Principal Components from time t to time t □ - 30.

```
lth = length(train2_data[,1])
full = c()
k = 2
for (i in 31:(lth - 1))
  {
    df = c()
    dat = train2wide[i,1]
    value = train2wide[i + 1,2]
    firm = names(train2wide)[k]
    df = cbind(df, dat, value, firm)
    for (j in (i - 1):(i - 30))
    {
      df = cbind(df, train2_daily_predict[j,1], train2_daily_predict[j,2], train2_daily_predict[
j,3])
    }
    full = rbind(full,df)
  }
```

(c) Repeat this for all the stocks and stack these data-frames vertically (across stocks) to produce one such big data frame.

```r
lth = length(train2_data[,1])
full = c()
ful = c()
for (k in 2:length(names(train2wide)))
{
  for (i in 31:(lth - 1))
  {
    df = c()
    dat = train2wide[i,1]
    value = train2wide[i + 1,2]
    firm = names(train2wide)[k]
    df = cbind(df, dat, value, firm)
    for (j in (i - 1):(i - 30))
    {
      df = cbind(df, train2_daily_predict[j,1], train2_daily_predict[j,2], train2_daily_predict[
j,3])
    }
    full = rbind(full,df)
  }
  ful = rbind(ful, full)
}
```

Add dummy variables describing the different stocks.

```r
ful = as.data.frame(ful)
ful[,1] = as.Date(as.numeric(ful[,1]), origin = "1970-01-01")
ful[,2] = as.double(as.character(ful[,2]))
ful[,3] = as.character(ful[,3])

for (a in 4:93)
{
  ful[,a] = as.double(as.character(ful[,a]))
}

library(dummies)
```

```
## dummies-1.5.6 provided by Decision Patterns
```

```r
dful = dummy.data.frame(ful)
```

What is the dimensionality of your data-frame? Provide a printout of its ‘summary()’.

```r
dim(dful)
```

```
## [1] 431028    118
```

```r
summary(dful)
```

```
##       dat                   value                firmAA       
##  Min.   :1970-01-02   Min.   :-0.1605390   Min.   :0.00000  
##  1st Qu.:1970-11-04   1st Qu.:-0.0146707   1st Qu.:0.00000  
##  Median :1971-09-07   Median : 0.0006280   Median :0.00000  
##  Mean   :1971-09-07   Mean   : 0.0001255   Mean   :0.07407  
##  3rd Qu.:1972-07-10   3rd Qu.: 0.0159450   3rd Qu.:0.00000  
##  Max.   :1973-05-13   Max.   : 0.2321170   Max.   :1.00000  
##     firmAXP            firmBA            firmC            firmCAT       
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000  
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000  
##  Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000  
##  Mean   :0.07123   Mean   :0.06838   Mean   :0.06553   Mean   :0.06268  
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000  
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.00000   Max.   :1.00000  
##      firmDD           firmDIS           firmGE            firmHD       
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000  
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000  
##  Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000  
##  Mean   :0.05983   Mean   :0.05698   Mean   :0.05413   Mean   :0.05128  
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000  
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.00000   Max.   :1.00000  
##     firmHON           firmHPQ           firmIBM          firmINTC      
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000  
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000  
##  Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000  
##  Mean   :0.04843   Mean   :0.04558   Mean   :0.04274   Mean   :0.03989  
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000  
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.00000   Max.   :1.00000  
##      firmIP           firmJNJ           firmKO          firmMCD       
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000  
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000  
##  Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000  
##  Mean   :0.03704   Mean   :0.03419   Mean   :0.03134   Mean   :0.02849  
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000  
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.00000   Max.   :1.00000  
##     firmMMM            firmMO           firmMRK          firmMSFT      
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000  
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000  
##  Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000  
##  Mean   :0.02564   Mean   :0.02279   Mean   :0.01994   Mean   :0.01709  
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000  
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.00000   Max.   :1.00000  
##      firmPG            firmT           firmUTX            firmWMT        
##  Min.   :0.00000   Min.   :0.0000   Min.   :0.000000   Min.   :0.000000  
##  1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.000000   1st Qu.:0.000000  
##  Median :0.00000   Median :0.0000   Median :0.000000   Median :0.000000  
##  Mean   :0.01425   Mean   :0.0114   Mean   :0.008547   Mean   :0.005698  
##  3rd Qu.:0.00000   3rd Qu.:0.0000   3rd Qu.:0.000000   3rd Qu.:0.000000  
##  Max.   :1.00000   Max.   :1.0000   Max.   :1.000000   Max.   :1.000000  
##     firmXOM                V4                   V5            
##  Min.   :0.000000   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:0.000000   1st Qu.:-0.027646   1st Qu.:-0.0116842  
##  Median :0.000000   Median : 0.004572   Median : 0.0009967  
```

```
##  Mean   :0.002849   Mean   : 0.001766   Mean   : 0.0004290
##  3rd Qu.:0.000000   3rd Qu.: 0.033727   3rd Qu.: 0.0129009
##  Max.   :1.000000   Max.   : 0.577298   Max.   : 0.1192071
##        V6                  V7                  V8
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0116842
##  Median :-0.0004858   Median : 0.004572   Median : 0.0009967
##  Mean   :-0.0001685   Mean   : 0.001757   Mean   : 0.0004327
##  3rd Qu.: 0.0076489   3rd Qu.: 0.033727   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##        V9                 V10                 V11
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0116842
##  Median :-0.0004858   Median : 0.004572   Median : 0.0009967
##  Mean   :-0.0001657   Mean   : 0.001769   Mean   : 0.0004327
##  3rd Qu.: 0.0076489   3rd Qu.: 0.033727   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V12                 V13                 V14
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0116842
##  Median :-0.0004615   Median : 0.004649   Median : 0.0010116
##  Mean   :-0.0001553   Mean   : 0.001777   Mean   : 0.0004421
##  3rd Qu.: 0.0076489   3rd Qu.: 0.033727   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V15                 V16                 V17
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0116842
##  Median :-0.0004858   Median : 0.004683   Median : 0.0009967
##  Mean   :-0.0001625   Mean   : 0.001815   Mean   : 0.0004366
##  3rd Qu.: 0.0076145   3rd Qu.: 0.033905   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V18                 V19                 V20
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0117239
##  Median :-0.0004858   Median : 0.004649   Median : 0.0009678
##  Mean   :-0.0001668   Mean   : 0.001797   Mean   : 0.0004055
##  3rd Qu.: 0.0076145   3rd Qu.: 0.033905   3rd Qu.: 0.0128873
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V21                 V22                 V23
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0117239
##  Median :-0.0005018   Median : 0.004572   Median : 0.0009678
##  Mean   :-0.0001719   Mean   : 0.001779   Mean   : 0.0004116
##  3rd Qu.: 0.0076145   3rd Qu.: 0.033905   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V24                 V25                 V26
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027646   1st Qu.:-0.0117239
##  Median :-0.0004858   Median : 0.004572   Median : 0.0009678
##  Mean   :-0.0001626   Mean   : 0.001770   Mean   : 0.0004097
##  3rd Qu.: 0.0076145   3rd Qu.: 0.033905   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V27                 V28                 V29
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
```

```
##  1st Qu.:-0.0086415   1st Qu.:-0.027756   1st Qu.:-0.0117239  
##  Median :-0.0004615   Median : 0.004399   Median : 0.0008854  
##  Mean   :-0.0001523   Mean   : 0.001727   Mean   : 0.0004044  
##  3rd Qu.: 0.0076489   3rd Qu.: 0.033905   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V30                  V31                  V32            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086415   1st Qu.:-0.027756   1st Qu.:-0.0117239  
##  Median :-0.0004615   Median : 0.004399   Median : 0.0008854  
##  Mean   :-0.0001441   Mean   : 0.001733   Mean   : 0.0004047  
##  3rd Qu.: 0.0076768   3rd Qu.: 0.034057   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V33                  V34                  V35            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0117239  
##  Median :-0.0004246   Median : 0.004399   Median : 0.0009678  
##  Mean   :-0.0001334   Mean   : 0.001752   Mean   : 0.0004145  
##  3rd Qu.: 0.0076768   3rd Qu.: 0.034057   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V36                  V37                  V38            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0117637  
##  Median :-0.0004246   Median : 0.004193   Median : 0.0008854  
##  Mean   :-0.0001320   Mean   : 0.001741   Mean   : 0.0004037  
##  3rd Qu.: 0.0076768   3rd Qu.: 0.034057   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V39                  V40                  V41            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0117637  
##  Median :-0.0004246   Median : 0.004399   Median : 0.0008854  
##  Mean   :-0.0001306   Mean   : 0.001773   Mean   : 0.0003876  
##  3rd Qu.: 0.0076768   3rd Qu.: 0.034227   3rd Qu.: 0.0128873  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V42                  V43                  V44            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0117637  
##  Median :-0.0004615   Median : 0.004399   Median : 0.0008854  
##  Mean   :-0.0001378   Mean   : 0.001789   Mean   : 0.0004085  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034304   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V45                  V46                  V47            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0118465  
##  Median :-0.0004858   Median : 0.004399   Median : 0.0007977  
##  Mean   :-0.0001382   Mean   : 0.001790   Mean   : 0.0003947  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034304   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V48                  V49                  V50            
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0117637  
##  Median :-0.0004858   Median : 0.004399   Median : 0.0008854  
##  Mean   :-0.0001405   Mean   : 0.001798   Mean   : 0.0004140  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034304   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
```

```
##       V51                  V52                 V53           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027646   1st Qu.:-0.0117637  
##  Median :-0.0004858   Median : 0.004193   Median : 0.0008854  
##  Mean   :-0.0001396   Mean   : 0.001785   Mean   : 0.0004218  
##  3rd Qu.: 0.0077147   3rd Qu.: 0.034304   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V54                  V55                 V56           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027757   1st Qu.:-0.0117637  
##  Median :-0.0005018   Median : 0.004193   Median : 0.0007977  
##  Mean   :-0.0001601   Mean   : 0.001708   Mean   : 0.0004126  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034304   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V57                  V58                 V59           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.027757   1st Qu.:-0.0117637  
##  Median :-0.0004858   Median : 0.004193   Median : 0.0007977  
##  Mean   :-0.0001554   Mean   : 0.001710   Mean   : 0.0004069  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034304   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V60                  V61                 V62           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.028165   1st Qu.:-0.0117637  
##  Median :-0.0004858   Median : 0.004038   Median : 0.0007977  
##  Mean   :-0.0001579   Mean   : 0.001615   Mean   : 0.0004485  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034227   3rd Qu.: 0.0129356  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V63                  V64                 V65           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.028165   1st Qu.:-0.0117637  
##  Median :-0.0004858   Median : 0.003966   Median : 0.0007977  
##  Mean   :-0.0001588   Mean   : 0.001501   Mean   : 0.0004254  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034057   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V66                  V67                 V68           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086002   1st Qu.:-0.028165   1st Qu.:-0.0117637  
##  Median :-0.0005018   Median : 0.003966   Median : 0.0007977  
##  Mean   :-0.0001651   Mean   : 0.001517   Mean   : 0.0004169  
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034057   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V69                  V70                 V71           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086415   1st Qu.:-0.028824   1st Qu.:-0.0118465  
##  Median :-0.0005108   Median : 0.003966   Median : 0.0007618  
##  Mean   :-0.0001840   Mean   : 0.001492   Mean   : 0.0003990  
##  3rd Qu.: 0.0076145   3rd Qu.: 0.034057   3rd Qu.: 0.0129009  
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071  
##       V72                  V73                 V74           
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194  
##  1st Qu.:-0.0086415   1st Qu.:-0.028165   1st Qu.:-0.0118465  
##  Median :-0.0005018   Median : 0.004038   Median : 0.0007618  
##  Mean   :-0.0001812   Mean   : 0.001535   Mean   : 0.0003975  
```

```
##  3rd Qu.: 0.0076145   3rd Qu.: 0.034057   3rd Qu.: 0.0129009
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V75                  V76                 V77
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.028165   1st Qu.:-0.0118465
##  Median :-0.0005018   Median : 0.003966   Median : 0.0007438
##  Mean   :-0.0001712   Mean   : 0.001477   Mean   : 0.0003734
##  3rd Qu.: 0.0076590   3rd Qu.: 0.033905   3rd Qu.: 0.0128873
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V78                  V79                 V80
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086415   1st Qu.:-0.027757   1st Qu.:-0.0117637
##  Median :-0.0004858   Median : 0.004038   Median : 0.0007618
##  Mean   :-0.0001647   Mean   : 0.001537   Mean   : 0.0004014
##  3rd Qu.: 0.0076590   3rd Qu.: 0.033905   3rd Qu.: 0.0128873
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V81                  V82                 V83
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086002   1st Qu.:-0.027757   1st Qu.:-0.0117239
##  Median :-0.0004337   Median : 0.004193   Median : 0.0007618
##  Mean   :-0.0001533   Mean   : 0.001572   Mean   : 0.0004097
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034057   3rd Qu.: 0.0128873
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V84                  V85                 V86
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0085663   1st Qu.:-0.027757   1st Qu.:-0.0117637
##  Median :-0.0003962   Median : 0.004038   Median : 0.0007618
##  Mean   :-0.0001449   Mean   : 0.001563   Mean   : 0.0004005
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034057   3rd Qu.: 0.0128873
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V87                  V88                 V89
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0085663   1st Qu.:-0.027757   1st Qu.:-0.0118465
##  Median :-0.0003914   Median : 0.004038   Median : 0.0007438
##  Mean   :-0.0001363   Mean   : 0.001508   Mean   : 0.0003634
##  3rd Qu.: 0.0076590   3rd Qu.: 0.033905   3rd Qu.: 0.0127038
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V90                  V91                 V92
##  Min.   :-0.0736256   Min.   :-0.430921   Min.   :-0.1444194
##  1st Qu.:-0.0086002   1st Qu.:-0.027757   1st Qu.:-0.0118465
##  Median :-0.0003914   Median : 0.004193   Median : 0.0007438
##  Mean   :-0.0001461   Mean   : 0.001568   Mean   : 0.0003586
##  3rd Qu.: 0.0076590   3rd Qu.: 0.034057   3rd Qu.: 0.0127038
##  Max.   : 0.1267421   Max.   : 0.577298   Max.   : 0.1192071
##       V93
##  Min.   :-0.0736256
##  1st Qu.:-0.0085663
##  Median :-0.0003793
##  Mean   :-0.0001295
##  3rd Qu.: 0.0076590
##  Max.   : 0.1267421
```

Thus, there are 431028 Columns and 118 rows.

Task 2

(a)Fit a Lasso model to predict the t + 1 return using the Principal Components from t to t - 30 as explanatory variables. In your data-frame above, for each each row the “Y” should be the return of a stock at t+1 and the “X”s should be all the principal components from t to t - 30 plus the stock dummy variable.

```
x <- model.matrix(value~.,dful)[,-c(1,2)]
y <- dful$value
library(ISLR)
```

```
## Warning: package 'ISLR' was built under R version 3.3.3
```

```
library(glmnet)
```

```
## Warning: package 'glmnet' was built under R version 3.3.3
```

```
## Loading required package: Matrix
```

```
## Warning: package 'Matrix' was built under R version 3.3.3
```

```
##
## Attaching package: 'Matrix'
```

```
## The following object is masked from 'package:tidyr':
##
##     expand
```

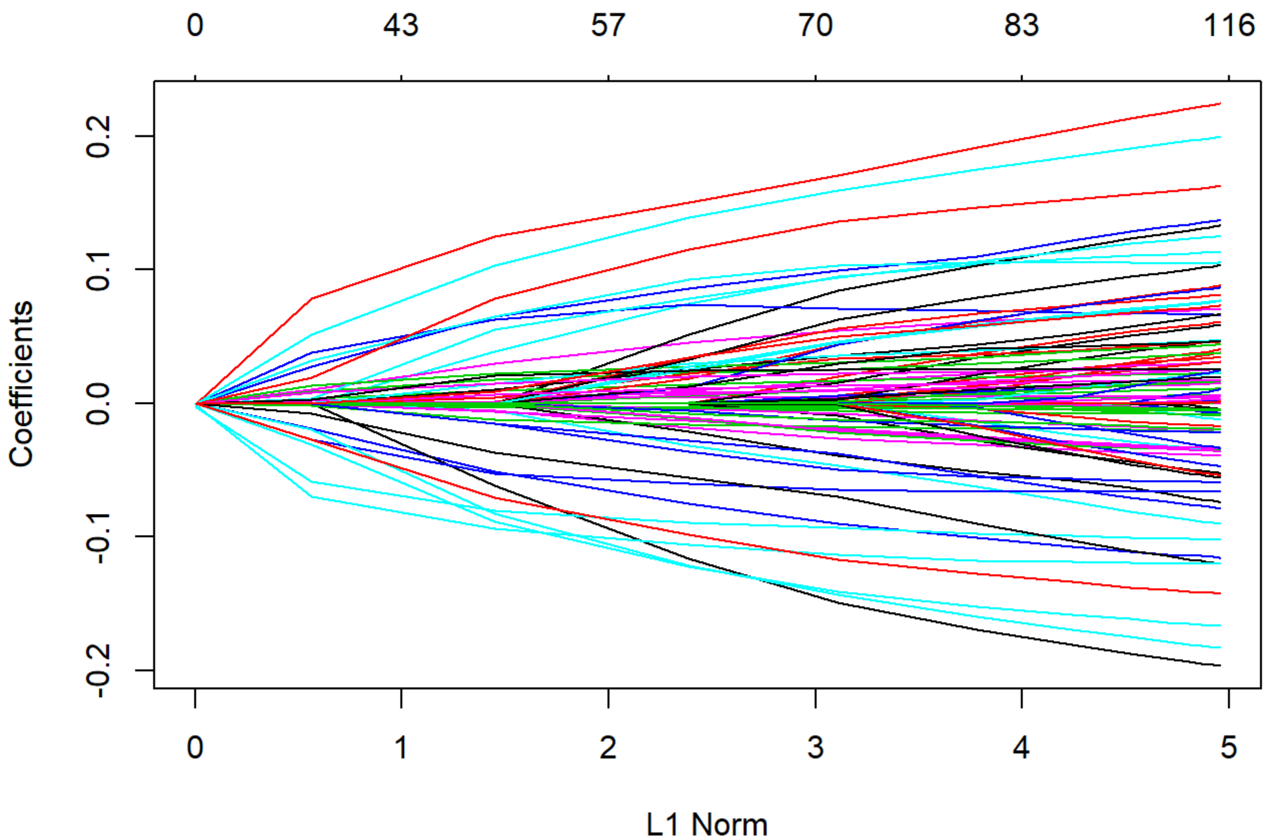
```
## Loading required package: foreach
```

```
## Warning: package 'foreach' was built under R version 3.3.3
```

```
## Loaded glmnet 2.0-13
```

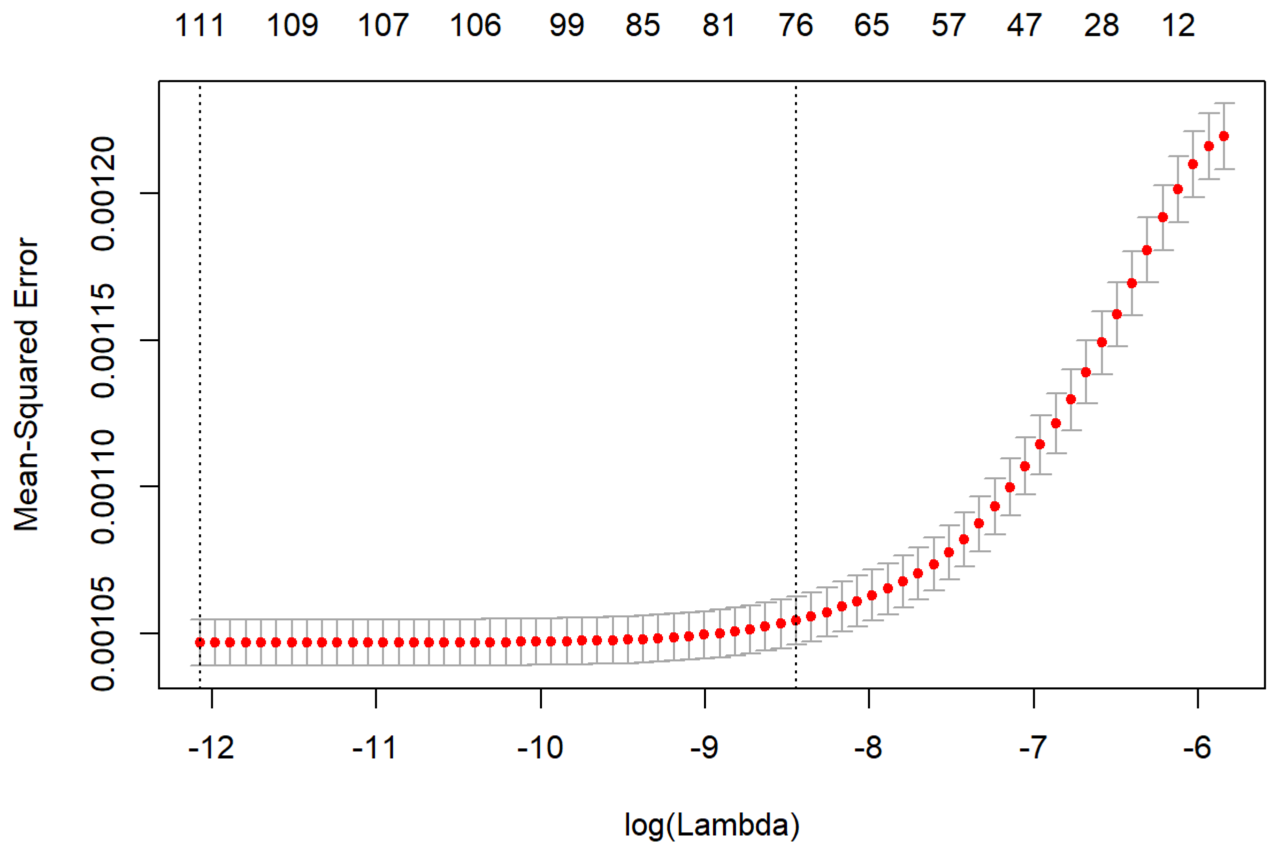
```
grd <- 0.01^seq( 10, -2, length = 100)
set.seed(1)
train <- sample( 1 : nrow(x),nrow(x)/2)
test <- -train
y.test <- y[test]

lasso.mod <- glmnet( x[train, ], y[train], alpha = 1, lambda = grd)
plot(lasso.mod)
```



(b) Use 5-fold cross validation to do feature selection. Create a plot of the Lasso parameter vs. the MSE.

```
cv.out <- cv.glmnet(x[train,], y[train], alpha = 1, nfolds = 5)
plot(cv.out)
```



Report your optimal Lasso parameter. Fit the model using the optimal Lasso lambda parameter calculated above to the whole training data and report your results.

```
bestlam = cv.out$lambda.min
sprintf("bestlam is %.10f", bestlam)
```

```
## [1] "bestlam is 0.0000057029"
```

```
trlasso.pred <- predict(cv.out, s = bestlam, newx <- x)
sprintf("MSE is %.10f", mean((trlasso.pred - y)^2))
```

```
## [1] "MSE is 0.0010448062"
```

(c)Are there any issues with using cross validation in a time series setting?