PracticeMidterm

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10/13/2020

R Markdown

```
data = read.csv("/Users/jim/Dropbox (GaTech)/Courses/ISyE6402/Midterm/HouseData.csv", header=TRUE)
data.train = data[1:(nrow(data)-4),]
data.test = data[(nrow(data)-3):nrow(data),]
data.train
```

```
##     Sno Timeline Houses_for_Sale Employment_Ratio GDP_Growth Bank_Prime_Rate
## 1     1   Mar-76              314             56.7        3.1            6.75
## 2     2   Jun-76              336             56.8        2.1            7.20
## 3     3   Sep-76              341             56.9        3.0            7.00
## 4     4   Dec-76              358             57.0        4.7            6.35
## 5     5   Mar-77              353             57.4        8.1            6.25
## 6     6   Jun-77              369             57.9        7.3            6.75
## 7     7   Sep-77              392             58.1        0.0            7.13
## 8     8   Dec-77              408             58.7        1.4            7.75
## 9     9   Mar-78              398             58.8       16.5            8.00
## 10   10   Jun-78              422             59.5        4.0            8.63
## 11   11   Sep-78              419             59.5        5.5            9.41
## 12   12   Dec-78              419             59.8        0.8           11.55
## 13   13   Mar-79              416             60.0        0.5           11.75
## 14   14   Jun-79              420             59.9        2.9           11.65
## 15   15   Sep-79              414             60.0        1.0           12.90
## 16   16   Dec-79              402             60.1        1.3           15.30
## 17   17   Mar-80              369             59.7       -7.9           18.31
## 18   18   Jun-80              341             58.9       -0.6           12.63
## 19   19   Sep-80              339             58.9        7.6           12.23
## 20   20   Dec-80              342             59.0        8.5           20.35
## 21   21   Mar-81              323             59.4       -2.9           18.05
## 22   22   Jun-81              318             59.0        4.7           20.03
## 23   23   Sep-81              306             58.7       -4.6           20.08
## 24   24   Dec-81              278             58.2       -6.5           15.75
## 25   25   Mar-82              264             58.1        2.2           16.50
## 26   26   Jun-82              253             57.8       -1.4           16.50
## 27   27   Sep-82              249             57.6        0.4           13.50
## 28   28   Dec-82              255             57.2        5.3           11.50
## 29   29   Mar-83              259             57.1        9.4           10.50
## 30   30   Jun-83              283             57.8        8.1           10.50
## 31   31   Sep-83              302             58.4        8.5           11.00
## 32   32   Dec-83              304             58.8        8.2           11.00
```

```
## 33   33   Mar-84          316          59.1         7.2          11.21
## 34   34   Jun-84          340          59.9         4.0          12.60
## 35   35   Sep-84          345          59.7         3.2          12.97
## 36   36   Dec-84          358          59.9         4.0          11.06
## 37   37   Mar-85          350          60.2         3.7          10.50
## 38   38   Jun-85          354          59.8         6.4           9.78
## 39   39   Sep-85          352          60.3         3.0           9.50
## 40   40   Dec-85          350          60.4         3.8           9.50
## 41   41   Mar-86          331          60.5         1.9           9.10
## 42   42   Jun-86          341          60.7         4.1           8.50
## 43   43   Sep-86          357          60.8         2.1           7.50
## 44   44   Dec-86          361          61.0         2.8           7.50
## 45   45   Mar-87          352          61.2         4.6           7.50
## 46   46   Jun-87          360          61.4         3.7           8.25
## 47   47   Sep-87          364          61.6         6.8           8.70
## 48   48   Dec-87          370          62.0         2.3           8.75
## 49   49   Mar-88          366          61.9         5.4           8.50
## 50   50   Jun-88          367          62.3         2.3           9.00
## 51   51   Sep-88          363          62.4         5.4          10.00
## 52   52   Dec-88          371          62.6         4.1          10.50
## 53   53   Mar-89          371          62.9         3.2          11.50
## 54   54   Jun-89          378          63.0         3.0          11.07
## 55   55   Sep-89          366          62.8         0.9          10.50
## 56   56   Dec-89          366          63.0         4.5          10.50
## 57   57   Mar-90          358          63.2         1.6          10.00
## 58   58   Jun-90          355          62.9         0.1          10.00
## 59   59   Sep-90          339          62.5        -3.4          10.00
## 60   60   Dec-90          321          62.2        -1.9          10.00
## 61   61   Mar-91          304          61.8         3.1           9.00
## 62   62   Jun-91          296          61.7         1.9           8.50
## 63   63   Sep-91          292          61.6         1.8           8.20
## 64   64   Dec-91          284          61.2         4.8           7.21
## 65   65   Mar-92          275          61.5         4.5           6.50
## 66   66   Jun-92          275          61.5         3.9           6.50
## 67   67   Sep-92          268          61.4         4.1           6.00
## 68   68   Dec-92          267          61.4         0.8           6.00
## 69   69   Mar-93          268          61.5         2.4           6.00
## 70   70   Jun-93          276          61.8         2.0           6.00
## 71   71   Sep-93          290          61.7         5.4           6.00
## 72   72   Dec-93          295          62.0         4.0           6.00
## 73   73   Mar-94          296          62.1         5.6           6.06
## 74   74   Jun-94          316          62.3         2.4           7.25
## 75   75   Sep-94          332          62.7         4.6           7.75
## 76   76   Dec-94          340          63.1         1.4           8.50
## 77   77   Mar-95          343          63.1         1.4           9.00
## 78   78   Jun-95          349          62.7         3.5           9.00
## 79   79   Sep-95          354          62.9         2.9           8.75
## 80   80   Dec-95          374          62.7         2.7           8.65
## 81   81   Mar-96          362          63.0         7.2           8.25
## 82   82   Jun-96          355          63.2         3.7           8.25
## 83   83   Sep-96          332          63.4         4.3           8.25
## 84   84   Dec-96          326          63.4         3.1           8.25
## 85   85   Mar-97          284          63.6         6.2           8.30
## 86   86   Jun-97          288          63.7         5.2           8.50
```

```
## 87   87   Sep-97          285          63.9          3.1          8.50
## 88   88   Dec-97          287          64.0          4.0          8.50
## 89   89   Mar-98          281          64.0          3.9          8.50
## 90   90   Jun-98          287          64.0          5.3          8.50
## 91   91   Sep-98          291          64.2          6.7          8.49
## 92   92   Dec-98          300          64.3          3.2          7.75
## 93   93   Mar-99          286          64.2          3.3          7.75
## 94   94   Jun-99          296          64.2          5.1          7.75
## 95   95   Sep-99          303          64.2          7.1          8.25
## 96   96   Dec-99          315          64.4          1.2          8.50
## 97   97   Mar-00          310          64.6          7.8          8.83
## 98   98   Jun-00          308          64.5          0.5          9.50
## 99   99   Sep-00          301          64.2          2.3          9.50
## 100 100   Dec-00          301          64.4         -1.1          9.50
## 101 101   Mar-01          286          64.3          2.1          8.32
## 102 102   Jun-01          302          63.7         -1.3          6.98
## 103 103   Sep-01          310          63.5          1.1          6.28
## 104 104   Dec-01          310          62.9          3.7          4.84
## 105 105   Mar-02          307          62.8          2.2          4.75
## 106 106   Jun-02          328          62.7          2.0          4.75
## 107 107   Sep-02          332          63.0          0.3          4.75
## 108 108   Dec-02          344          62.4          2.1          4.25
## 109 109   Mar-03          330          62.4          3.8          4.25
## 110 110   Jun-03          342          62.3          6.9          4.22
## 111 111   Sep-03          350          62.0          4.8          4.00
## 112 112   Dec-03          377          62.2          2.3          4.00
## 113 113   Mar-04          375          62.2          3.0          4.00
## 114 114   Jun-04          385          62.4          3.7          4.01
## 115 115   Sep-04          413          62.3          3.5          4.58
## 116 116   Dec-04          431          62.4          4.3          5.15
## 117 117   Mar-05          441          62.4          2.1          5.58
## 118 118   Jun-05          458          62.7          3.4          6.01
## 119 119   Sep-05          491          62.8          2.3          6.59
## 120 120   Dec-05          515          62.8          4.9          7.15
## 121 121   Mar-06          550          63.1          1.2          7.53
## 122 122   Jun-06          570          63.1          0.4          8.02
## 123 123   Sep-06          561          63.1          3.2          8.25
## 124 124   Dec-06          537          63.4          0.2          8.25
## 125 125   Mar-07          542          63.3          3.1          8.25
## 126 126   Jun-07          543          63.0          2.7          8.25
## 127 127   Sep-07          527          62.9          1.4          8.03
## 128 128   Dec-07          496          62.7         -2.7          7.33
## 129 129   Mar-08          465          62.7          2.0          5.66
## 130 130   Jun-08          435          62.4         -1.9          5.00
## 131 131   Sep-08          398          61.9         -8.2          5.00
## 132 132   Dec-08          352          61.0         -5.4          3.61
## 133 133   Mar-09          311          59.9         -0.5          3.25
## 134 134   Jun-09          282          59.4          1.3          3.25
## 135 135   Sep-09          254          58.7          3.9          3.25
## 136 136   Dec-09          232          58.3          1.7          3.25
## 137 137   Mar-10          227          58.5          3.9          3.25
## 138 138   Jun-10          213          58.5          2.7          3.25
## 139 139   Sep-10          204          58.5          2.5          3.25
## 140 140   Dec-10          188          58.3         -1.5          3.25
```

```
## 141 141   Mar-11            179            58.4        2.9           3.25
## 142 142   Jun-11            167            58.2        0.8           3.25
## 143 143   Sep-11            163            58.4        4.6           3.25
## 144 144   Dec-11            150            58.6        2.7           3.25
## 145 145   Mar-12            144            58.5        1.9           3.25
## 146 146   Jun-12            145            58.6        0.5           3.25
## 147 147   Sep-12            146            58.7        0.1           3.25
## 148 148   Dec-12            148            58.7        2.8           3.25
## 149 149   Mar-13            152            58.5        0.8           3.25
## 150 150   Jun-13            161            58.6        3.1           3.25
## 151 151   Sep-13            185            58.7        4.0           3.25
## 152 152   Dec-13            186            58.7       -0.9           3.25
## 153 153   Mar-14            187            58.9        4.6           3.25
## 154 154   Jun-14            197            59.0        5.2           3.25
## 155 155   Sep-14            213            59.1        2.0           3.25
## 156 156   Dec-14            212            59.3        3.2           3.25
## 157 157   Mar-15            202            59.3        2.7           3.25
## 158 158   Jun-15            216            59.4        1.6           3.25
## 159 159   Sep-15            227            59.2        0.5           3.25
## 160 160   Dec-15            235            59.6        0.6           3.37
## 161 161   Mar-16            240            59.8        2.2           3.50
## 162 162   Jun-16            243            59.7        2.8           3.50
## 163 163   Sep-16            248            59.7        1.8           3.50
## 164 164   Dec-16            257            59.8        1.2           3.64
##       SP500
## 1    102.77
## 2    104.28
## 3    105.24
## 4    107.46
## 5     98.42
## 6    100.48
## 7     96.53
## 8     95.10
## 9     89.21
## 10    95.53
## 11   102.54
## 12    96.11
## 13   101.59
## 14   102.91
## 15   109.32
## 16   107.94
## 17   102.09
## 18   114.24
## 19   125.46
## 20   135.76
## 21   136.00
## 22   131.21
## 23   116.18
## 24   122.55
## 25   111.96
## 26   109.61
## 27   120.42
## 28   140.64
## 29   152.96
```

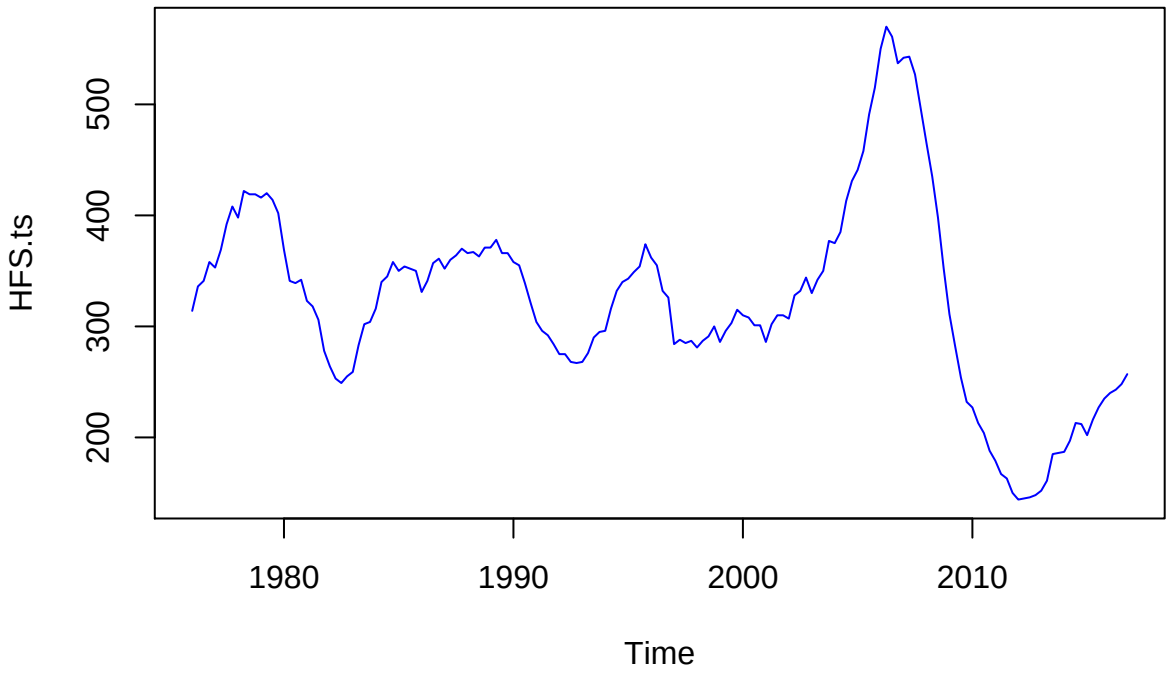
```
## 30   167.64
## 31   166.07
## 32   164.93
## 33   159.18
## 34   153.18
## 35   166.10
## 36   167.24
## 37   180.66
## 38   191.85
## 39   182.08
## 40   211.28
## 41   238.90
## 42   250.84
## 43   231.32
## 44   242.17
## 45   291.70
## 46   304.00
## 47   321.83
## 48   247.08
## 49   258.89
## 50   273.50
## 51   271.91
## 52   277.72
## 53   294.87
## 54   317.98
## 55   349.15
## 56   353.40
## 57   339.94
## 58   358.02
## 59   306.05
## 60   330.22
## 61   375.22
## 62   371.16
## 63   387.86
## 64   417.09
## 65   403.69
## 66   408.14
## 67   417.80
## 68   435.71
## 69   451.67
## 70   450.53
## 71   458.93
## 72   466.45
## 73   445.77
## 74   444.27
## 75   462.71
## 76   459.27
## 77   500.71
## 78   544.75
## 79   584.41
## 80   615.93
## 81   645.50
## 82   670.63
## 83   687.33
```

```
## 84   740.74
## 85   757.12
## 86   885.14
## 87   947.28
## 88   970.43
## 89  1101.75
## 90  1133.84
## 91  1017.01
## 92  1229.23
## 93  1286.37
## 94  1372.71
## 95  1282.71
## 96  1469.25
## 97  1498.58
## 98  1454.60
## 99  1436.51
## 100 1320.28
## 101 1160.33
## 102 1224.38
## 103 1040.94
## 104 1148.08
## 105 1147.39
## 106  989.82
## 107  815.28
## 108  879.82
## 109  848.18
## 110  974.50
## 111  995.97
## 112 1111.92
## 113 1126.21
## 114 1140.84
## 115 1114.58
## 116 1211.92
## 117 1180.59
## 118 1191.33
## 119 1228.81
## 120 1248.29
## 121 1294.87
## 122 1270.20
## 123 1335.85
## 124 1418.30
## 125 1420.86
## 126 1503.35
## 127 1526.75
## 128 1468.36
## 129 1322.70
## 130 1280.00
## 131 1166.36
## 132  903.25
## 133  797.87
## 134  919.32
## 135 1057.08
## 136 1115.10
## 137 1169.43
```

```
## 138 1030.71
## 139 1141.20
## 140 1257.64
## 141 1325.83
## 142 1320.64
## 143 1131.42
## 144 1257.60
## 145 1408.47
## 146 1362.16
## 147 1440.67
## 148 1426.19
## 149 1569.19
## 150 1606.28
## 151 1681.55
## 152 1848.36
## 153 1872.34
## 154 1960.23
## 155 1972.29
## 156 2058.90
## 157 2067.89
## 158 2063.11
## 159 1920.03
## 160 2043.94
## 161 2059.74
## 162 2098.86
## 163 2168.27
## 164 2238.83
```

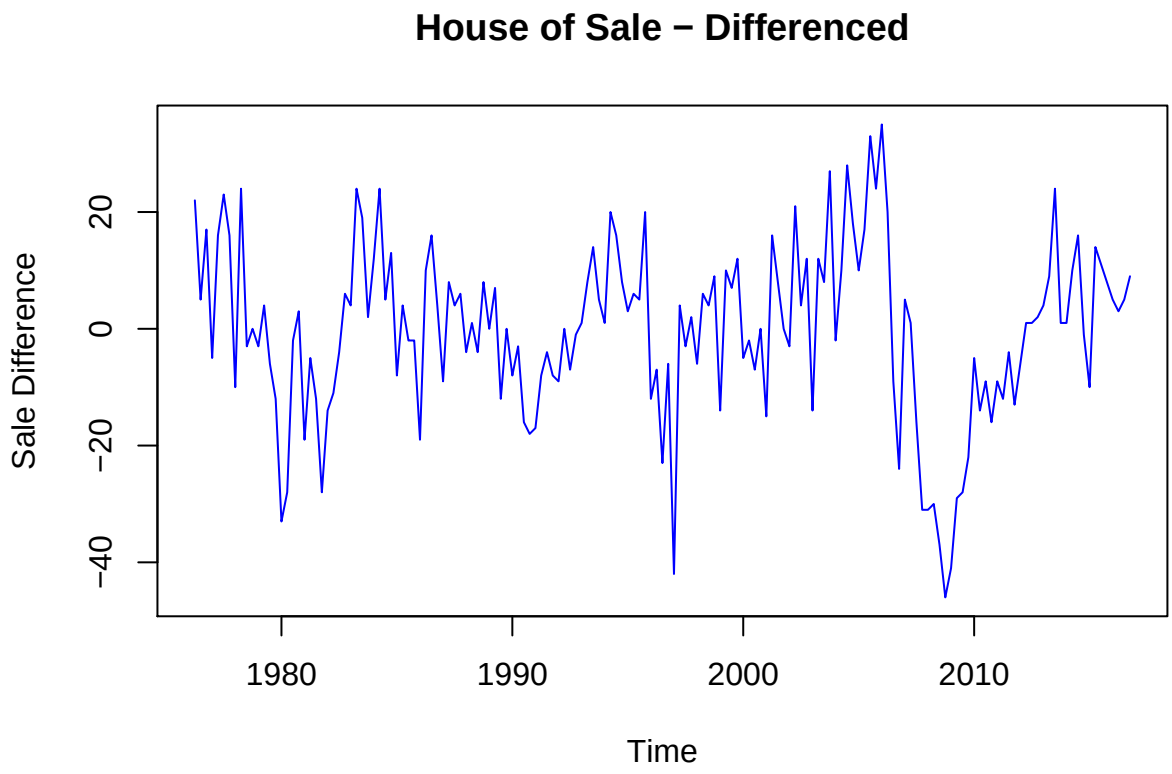
Question 1. Provide the time series plot of the 'Houses for Sale' data. Which assumptions of stationarity, if any, seem to be violated. Provide the time series plot of the 1st order difference of the Houses for Sale data.

```
HFS = data.train$Houses_for_Sale
HFS.ts = ts(data=HFS, start=1976, frequency = 4)
ts.plot(HFS.ts, col='blue')
```



Constant mean/constant variance

```
HFS.dif = diff(HFS.ts)
ts.plot(HFS.dif,main='House of Sale - Differenced',ylab='Sale Difference',col='blue')
```



Question 2.

Identify the best ARIMA model to fit the Houses for Sale data according to the AIC criterion. Use regular 1st order differencing and consider up to order 5 for AR and MA terms. Report the AIC and estimated

coefficients of your selected model. Which coefficients are significant at the 5% significance level?

Provide plots of the ACF and PACF of the residuals from your ARIMA model and perform the Ljung-Box test. Do the residuals appear uncorrelated?

```
n = length(HFS.ts)
test_modelA <- function(p,d,q){
mod = arima(HFS.ts, order=c(p,d,q), method="ML")
current.aic = AIC(mod)
df = data.frame(p,d,q,current.aic)
names(df) <- c("p","d","q","AIC")
print(paste(p,d,q,current.aic,sep=" "))
return(df)
}
orders = data.frame(Inf,Inf,Inf,Inf)
names(orders) <- c("p","d","q","AIC")

for (p in 0:5){
  for (d in 0:1){
    for (q in 0:5) {
      possibleError <- tryCatch(
        orders<-rbind(orders,test_modelA(p,d,q)),
        error=function(e) e
      )
      if(inherits(possibleError, "error")) next

    }
  }
}
```

```
## [1] "0 0 0 1936.28822900367"
## [1] "0 0 1 1750.12086560537"
## [1] "0 0 2 1564.52151886075"
## [1] "0 0 3 1502.77987432438"
## [1] "0 0 4 1414.04420380128"
## [1] "0 0 5 1398.82179493849"
## [1] "0 1 0 1345.99676335138"
## [1] "0 1 1 1313.44753993353"
## [1] "0 1 2 1289.66768637719"
## [1] "0 1 3 1291.61382559805"
## [1] "0 1 4 1264.51999484175"
## [1] "0 1 5 1265.6773305181"
## [1] "1 0 0 1359.72019871953"
```

```
## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1
```

```
## [1] "1 0 2 1301.89757172154"
## [1] "1 0 3 1309.08454336027"
```

```
## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1
```

```
## [1] "1 0 4 1306.04260365583"
## [1] "1 0 5 1291.06419082058"
## [1] "1 1 0 1285.35526692511"
## [1] "1 1 1 1272.37486246077"

## Warning in log(s2): NaNs produced

## Warning in log(s2): NaNs produced

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "1 1 2 1274.01272070035"
## [1] "1 1 3 1275.69626249276"
## [1] "1 1 4 1262.83351521415"
## [1] "1 1 5 1261.72500934647"
## [1] "2 0 0 1295.91390695195"
## [1] "2 0 1 1361.05370748814"
## [1] "2 0 2 1299.25825693534"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "2 0 3 1287.4978176598"
## [1] "2 0 4 1287.07562048983"
## [1] "2 0 5 1270.60099115942"
## [1] "2 1 0 1273.99529402935"
## [1] "2 1 1 1261.35419760246"
## [1] "2 1 2 1260.45811666923"
## [1] "2 1 3 1257.18925731033"
## [1] "2 1 4 1251.43150579343"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "2 1 5 1250.73144451251"
## [1] "3 0 0 1280.75552380391"
## [1] "3 0 1 1270.4341180022"
## [1] "3 0 2 1262.11058887685"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "3 0 3 1293.92063721938"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "3 0 4 1260.25426290657"
```

```
## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "3 0 5 1253.6789671528"
## [1] "3 1 0 1275.71385853575"
## [1] "3 1 1 1262.70117520159"
## [1] "3 1 2 1260.82130041566"
## [1] "3 1 3 1256.90242292559"
## [1] "3 1 4 1250.14731447623"
## [1] "3 1 5 1245.12277920984"
## [1] "4 0 0 1281.25151121983"
## [1] "4 0 1 1270.71855442803"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "4 0 2 1274.26947922504"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "4 0 3 1261.8485532801"
## [1] "4 0 4 1260.28567658561"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "4 0 5 1254.59416640471"
## [1] "4 1 0 1262.01701610238"
## [1] "4 1 1 1249.71107590406"
## [1] "4 1 2 1251.64857530809"
## [1] "4 1 3 1251.71045923905"
## [1] "4 1 4 1252.98899063494"
## [1] "4 1 5 1254.95126964376"
## [1] "5 0 0 1257.51023698568"
## [1] "5 0 1 1249.99803340576"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "5 0 2 1252.3924480544"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "5 0 3 1253.5880376859"

## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1

## [1] "5 0 4 1255.22816394422"
```

```
## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1
```

```
## [1] "5 0 5 1257.05512819809"
## [1] "5 1 0 1252.86213433597"
## [1] "5 1 1 1251.60669459247"
## [1] "5 1 2 1242.08470194206"
## [1] "5 1 3 1243.51282706088"
## [1] "5 1 4 1245.22727489838"
```

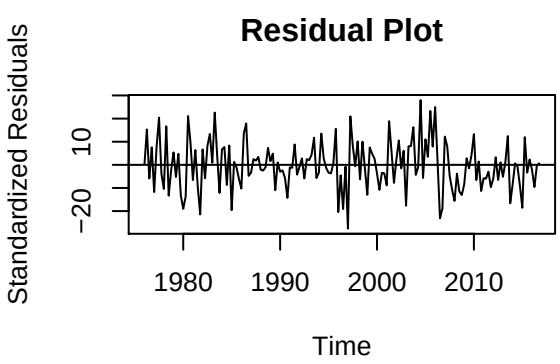
```
## Warning in arima(HFS.ts, order = c(p, d, q), method = "ML"): possible
## convergence problem: optim gave code = 1
```

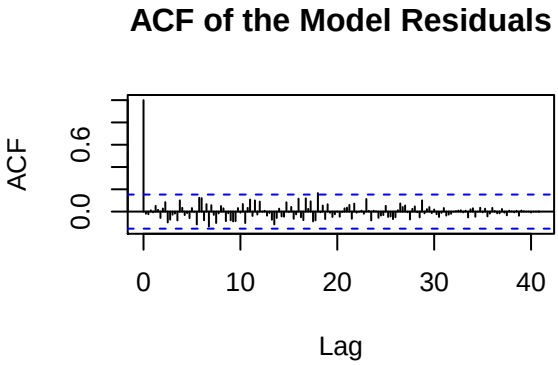
```
## [1] "5 1 5 1247.15459748106"
```

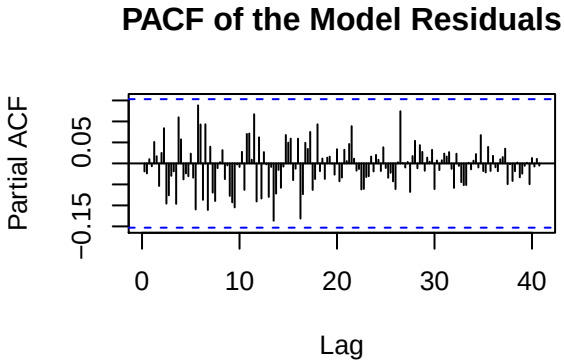
```
orders <- orders[order(-orders$AIC),]
tail(orders)
```

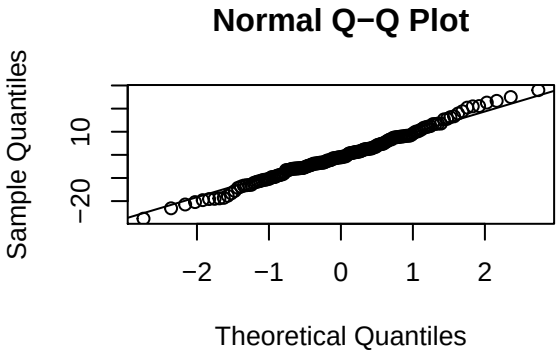
```
##    p d q      AIC
## 56 4 1 1 1249.711
## 72 5 1 5 1247.155
## 71 5 1 4 1245.227
## 48 3 1 5 1245.123
## 70 5 1 3 1243.513
## 69 5 1 2 1242.085
```

```
final_HFS = arima(HFS.ts, order = c(5,1,2), method = "ML")
resids.HFS = resid(final_HFS)
## Residual Analysis
par(mfrow=c(2,2))
plot(resids.HFS, ylab='Standardized Residuals', main="Residual Plot")
abline(h=0)
acf(resids.HFS,main= 'ACF of the Model Residuals', lag.max = 52*4)
pacf(resids.HFS,main='PACF of the Model Residuals', lag.max = 52*4)
qqnorm(resids.HFS)
qqline(resids.HFS)
```










```
## Test for Independence for final model
Box.test(resids.HFS, lag = (5+1+2), type = "Box-Pierce", fitdf = (5+2))
```

```
##
##  Box-Pierce test
##
## data:  resids.HFS
## X-squared = 1.2875, df = 1, p-value = 0.2565
```

```
Box.test(resids.HFS, lag = (5+1+2), type = "Ljung-Box", fitdf = (5+2))
```

```
##
##  Box-Ljung test
##
## data:  resids.HFS
## X-squared = 1.3504, df = 1, p-value = 0.2452
```

```
library(lmtest)
```

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

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

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

```
coeftest(final_HFS)
```

```
##
## z test of coefficients:
##
##      Estimate Std. Error z value  Pr(>|z|)
## ar1  0.781603   0.117265  6.6653 2.642e-11 ***
## ar2  0.547297   0.163586  3.3456  0.000821 ***
## ar3 -0.277578   0.098355 -2.8222  0.004769 **
## ar4  0.292068   0.112128  2.6048  0.009194 **
## ar5 -0.403426   0.075578 -5.3379 9.403e-08 ***
## ma1 -0.348029   0.124228 -2.8015  0.005086 **
## ma2 -0.651964   0.122592 -5.3182 1.048e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Question 3.

Plot the forecasts for the 2017 data using the ARIMA model fit in Question 2 alongside the actual observations. Using the precision measure, assess the prediction accuracy of the model.