Problem Sheet 4

1. A data set of durations until payment for 130 consecutive orders from a goods distributor are in the days object in the TSA package. Type library(TSA); data(days); print(days) in R to see the data set.

   (a) Fit an MA(2) model and write the code to estimate the parameters using the Method of Moments. Compare the results with estimates using the least squares and the maximum likelihood methods.

   ```
         # Fit MA(2) model using Least Squares
   days.ma2.fit <- arima(days,order=c(0,0,1),method='CSS') ### Use 'ML' for maximum likelihood
   days.ma2.fit
   ```

   (b) Forecast the next 10 values of the series, and list the forecasted values. Also plot the series along with the forecasted values and 95% prediction limits for the next ten values of the series.
   Use the code below

   ```
   n=length(days)
   # Obtain MMSE forecasts
   days.ma2.predict <- predict(days.ma2.fit,n.ahead=10)
   round(days.ma2.predict$pred,3)
   round(days.ma2.predict$se,3)
   # Create lower and upper prediction interval bounds
   lower.pi<-days.ma2.predict$pred-qnorm(0.975,0,1)*days.ma2.predict$se
   upper.pi<-days.ma2.predict$pred+qnorm(0.975,0,1)*days.ma2.predict$se
   # Display prediction intervals (2007-2026)
   n1=n+1
   n10=n+10
   data.frame(Year=c(n1:n10),lower.pi,upper.pi)
   # Note: Argument pch=16 produces a small black circle (for MMSE forecasts)
   plot(days.ma2.fit,n.ahead=10,col='red',type='b',pch=16,ylab="Deviations (in inch)",xlab="Time")
   # Put horizontal line at ML estimate of overall mean
   abline(h=coef(days.ma2.fit)[names(coef(days.ma2.fit))=='intercept'])
   ```

   (c) There are three clear outliers (at times 63, 106, and 129) which can be seen from the time series plot. Replace these outliers with a "typical duration" value of 35. To do this, you can use the code

   ```
   days.adj=days
   days.adj[c(63,106,129)]=35
   print(days.adj)
   ```

   Fit an MA(2) model to this adjusted series using the three methods of estimation and compare the results.

   (d) Forecast the next 10 values of the adjusted series, and list the forecasted values. Also plot the series along with the forecasted values and 95% prediction limits for the next ten values of the series.

   (e) Comment on any differences between the forecasts based on the original data and the forecasts based on the adjusted data.

2. A data set of 57 consecutive measurements from a machine tool are in the deere3 object in the TSA package. Type library(TSA); data(deere3); print(deere3) in R to see the data set.

   (a) Fit an AR(1) model and use it to forecast the next ten values of the series, and list the forecasted values. Also plot the series along with the forecasted values and 95% prediction limits for the next ten values of the series.

3. A data set of 324 measurements of an industrial robot's positions are in the robot object in the TSA package. Type library(TSA); data(robot); print(robot) in R to see the data set.

   (a) Fit an IMA(1,1) model and use it to forecast the next five values of the series, and list the forecasted values. [You can verify that for this data set, you do NOT need to include a constant (intercept) term in the IMA model.]

   (b) Plot the last ten observed values of the series along with the forecasted values and 95% prediction limits for the next five values of the series. [Hint: type help(plot.arima) and look at the n1 argument of the plot function.]

   (c) Fit an ARMA(1,1) model and use it to forecast the next five values of the series, and list the forecasted values. Also plot the last ten observed values of the series along with the forecasted values and 95% prediction limits for the next five values of the series.

   (d) Compare the results from parts (a) and (b).