R Notebook: Time Series Analysis

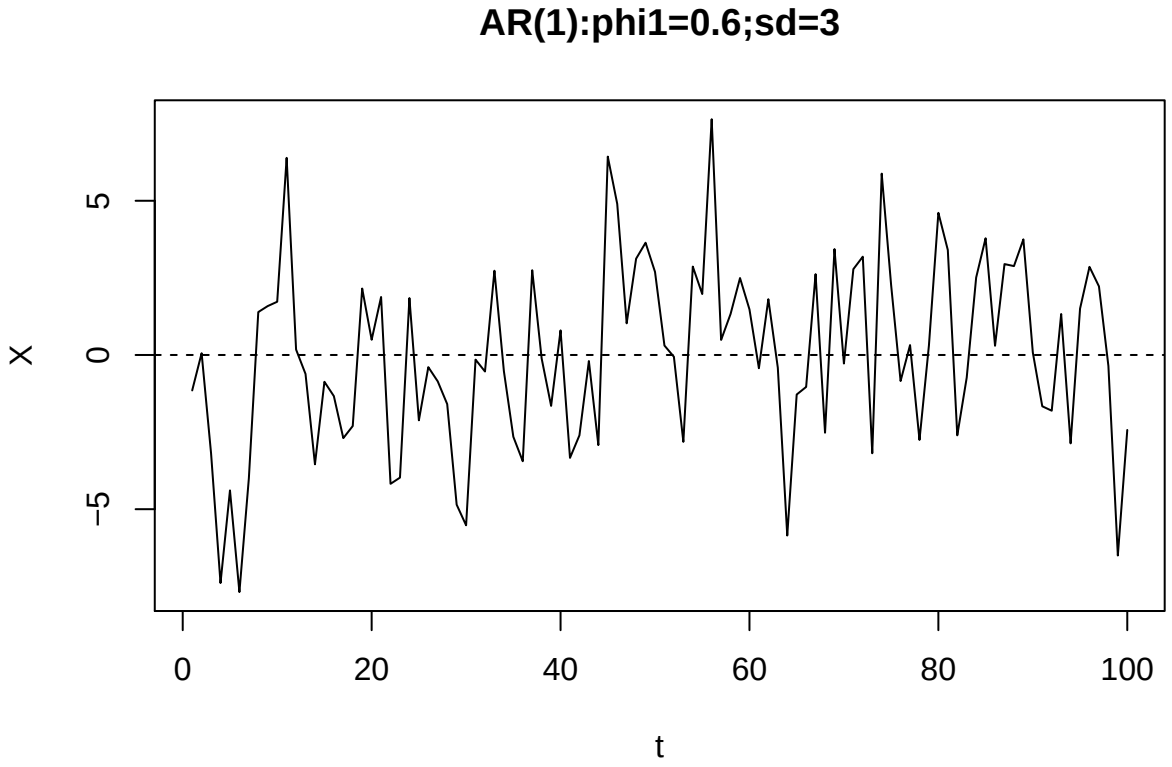
```
library(stats)
```

PART 1

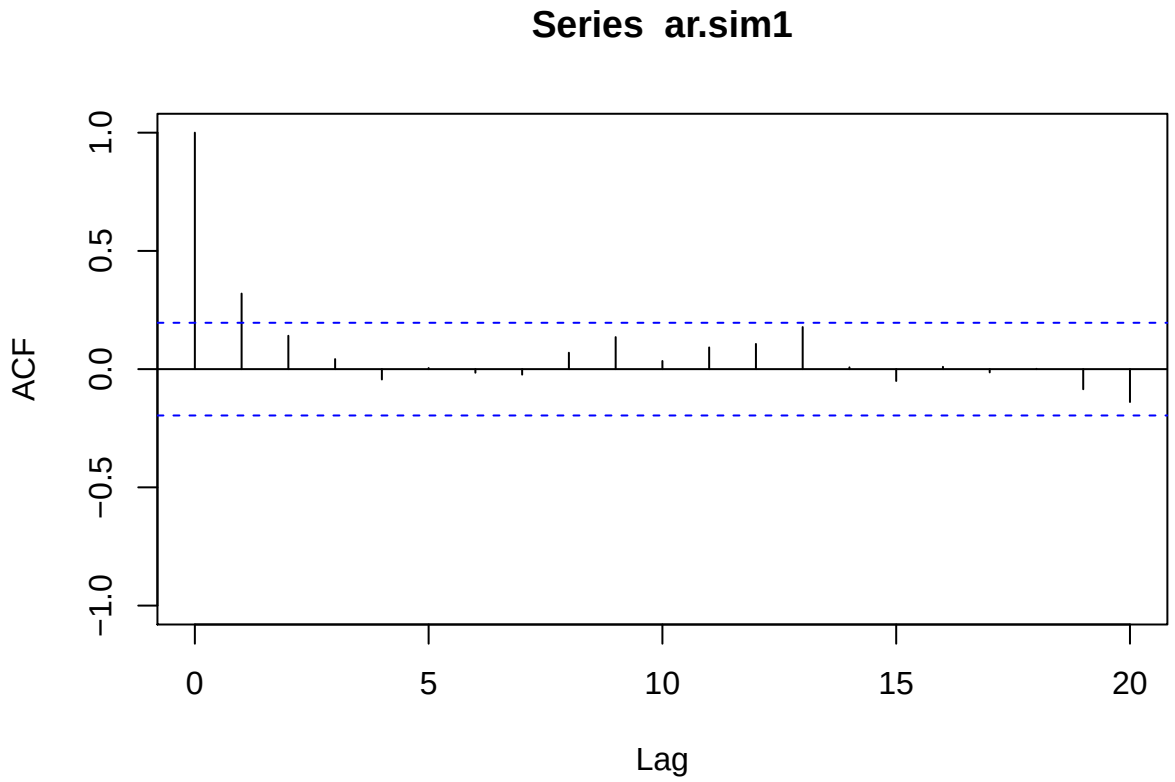
AR(1):

$X\_t = 0.6X\_(t-1) + e\_t$; $Var(X\_t) = 9$

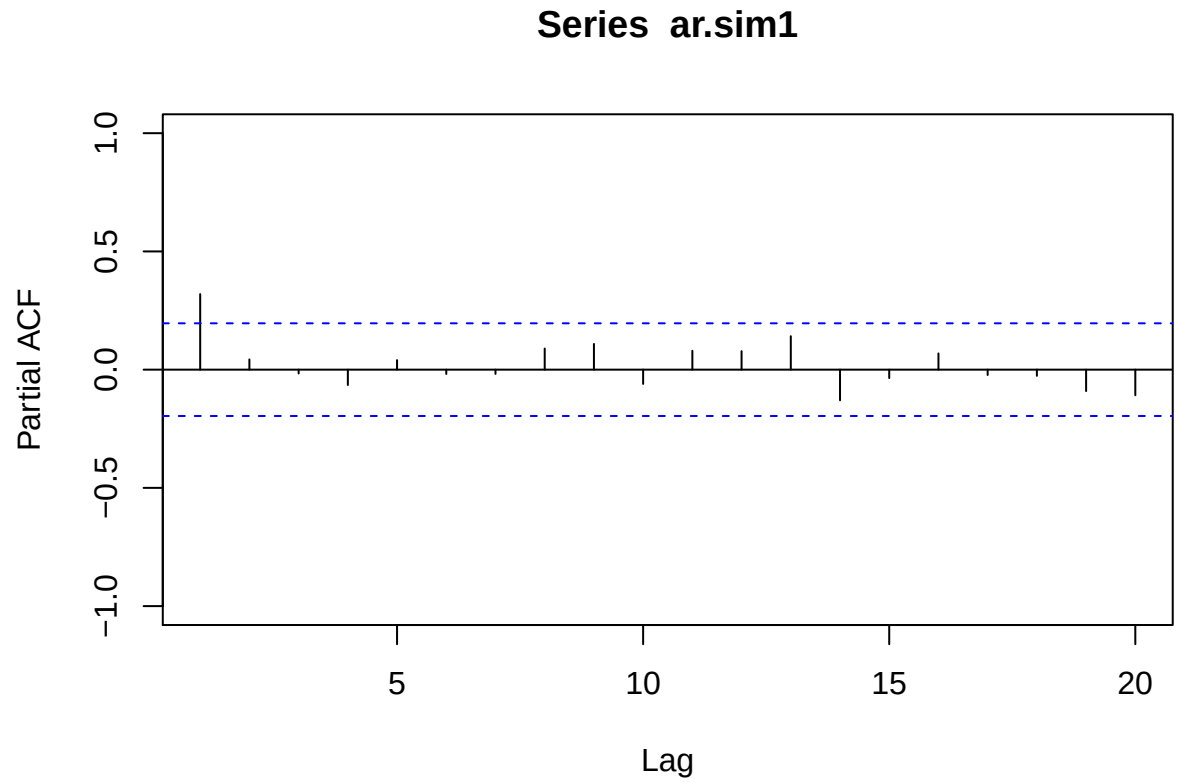
```
set.seed(2018)
ar.sim1=arima.sim(n=100,list(ar=0.6),sd=3)
plot(ar.sim1,xlab="t",ylab="X",main="AR(1):phi1=0.6;sd=3")
abline(h=0,lty=2)
```




```
plot(acf(ar.sim1,lag.max=20,plot=FALSE),ylim=c(-1,1))
```



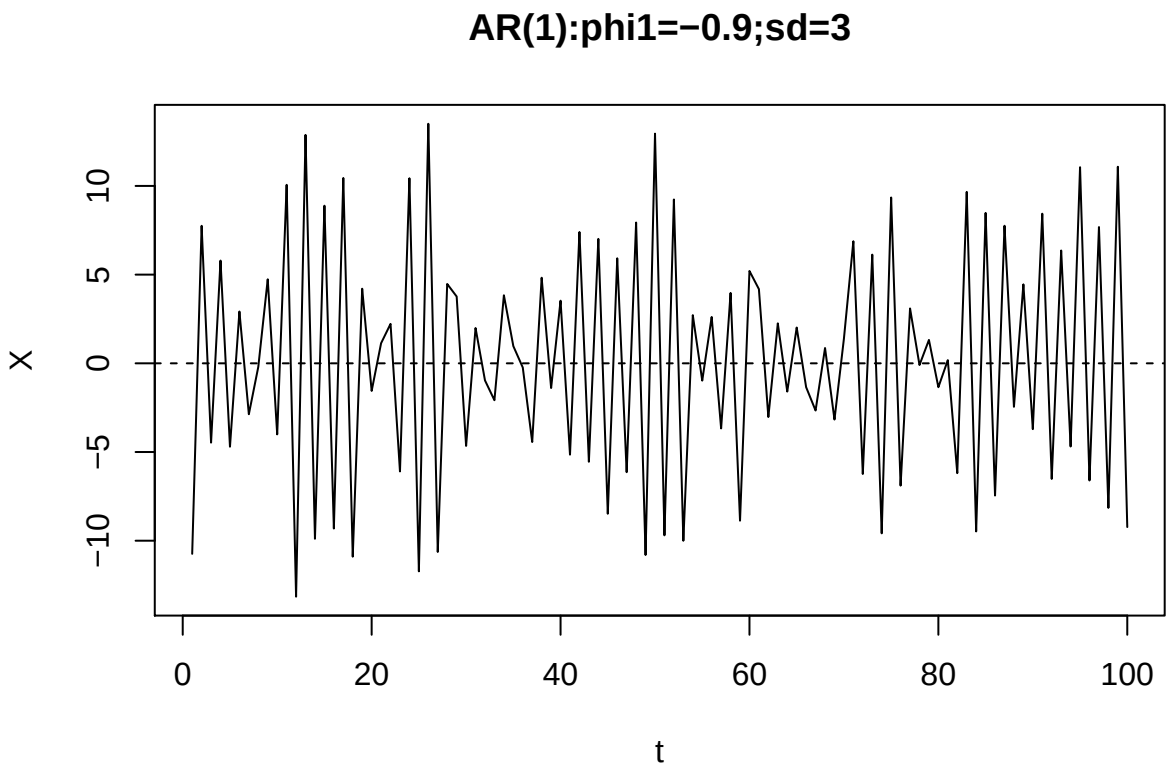

```
plot(pacf(ar.sim1,lag.max=20,plot=FALSE),ylim=c(-1,1))
```



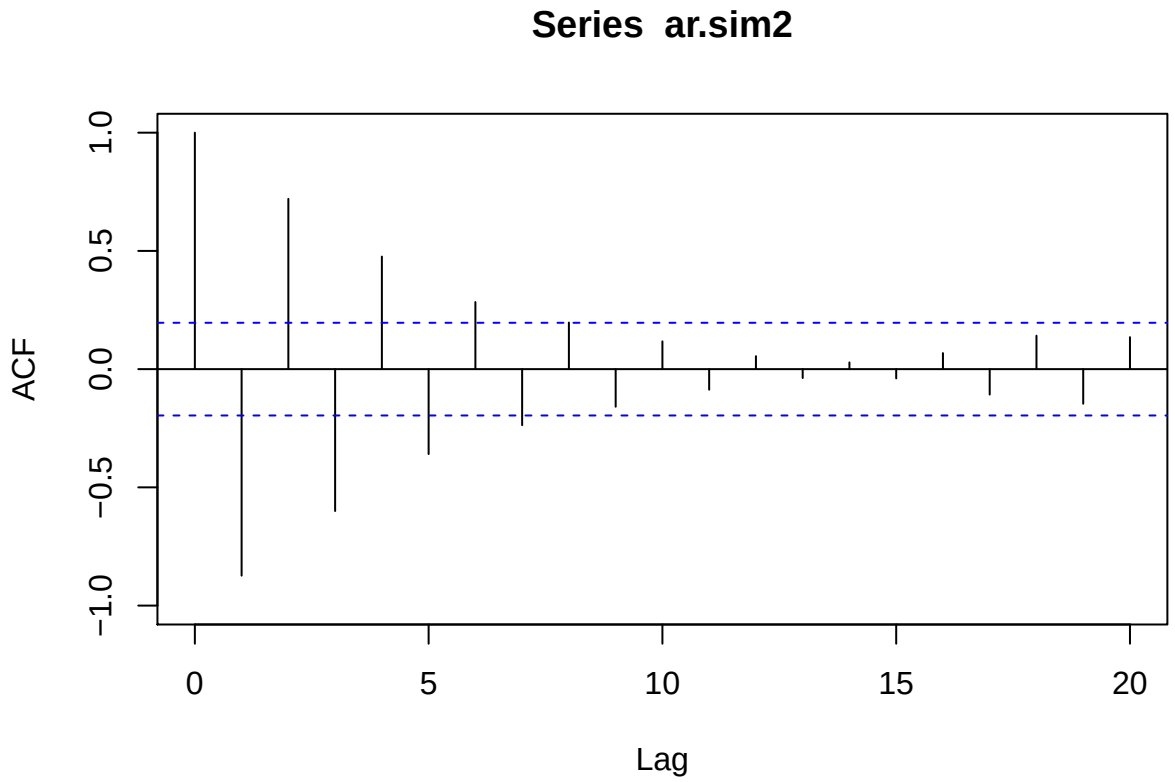
AR(1)

X_t = -0.9X_(t-1) + e_t ; Var(X_t) = 9

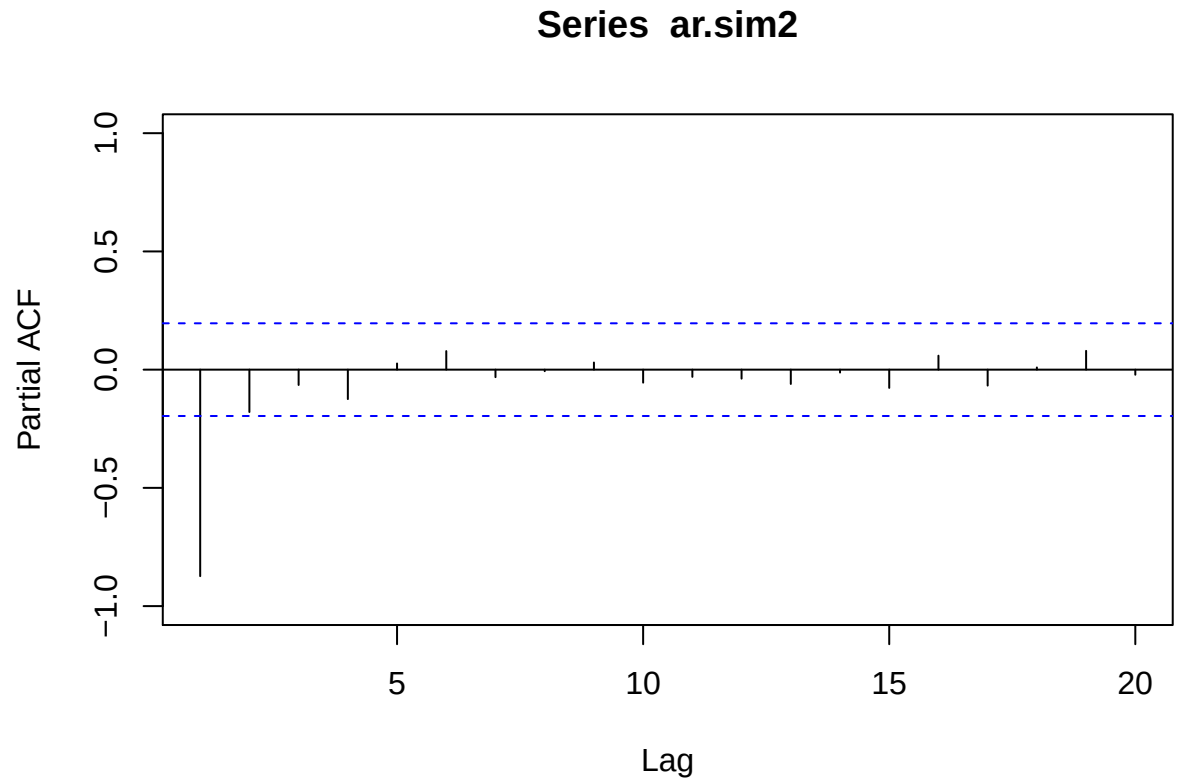
```
set.seed(2018)
ar.sim2=arima.sim(n=100,list(ar=-0.9),sd=3)
plot(ar.sim2,xlab="t",ylab="X",main="AR(1):phi1=-0.9;sd=3")
abline(h=0,lty=2)
```




```
plot(acf(ar.sim2,lag.max=20,plot=FALSE),ylim=c(-1,1))
```



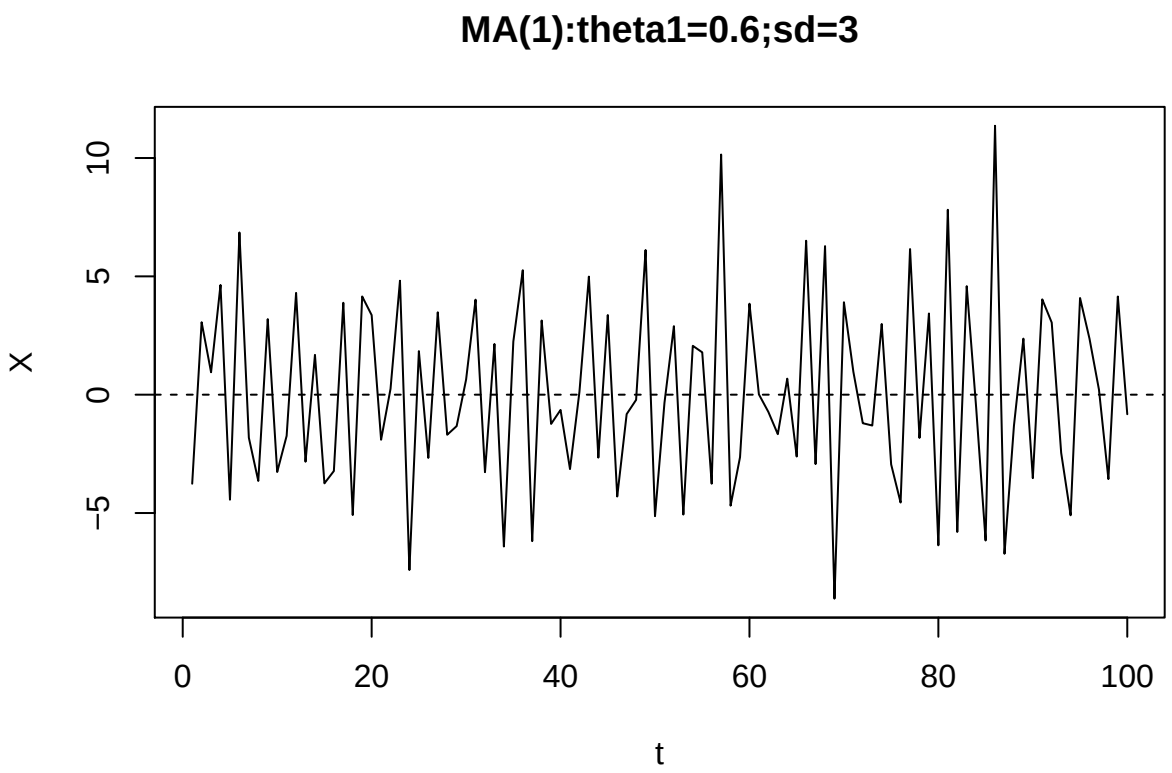

```
plot(pacf(ar.sim2,lag.max=20,plot=FALSE),ylim=c(-1,1))
```



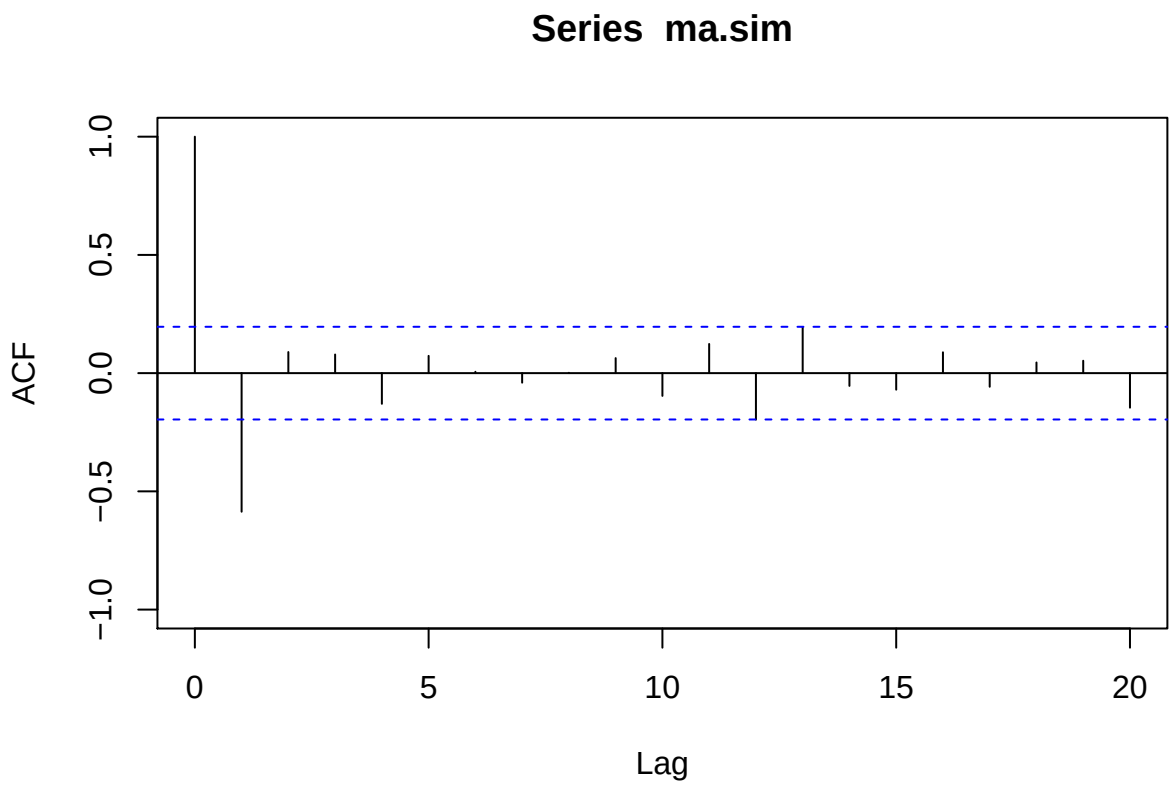
MA(1)

X_t = e_t - 0.7e_(t-1) ; Var(X_t) = 9

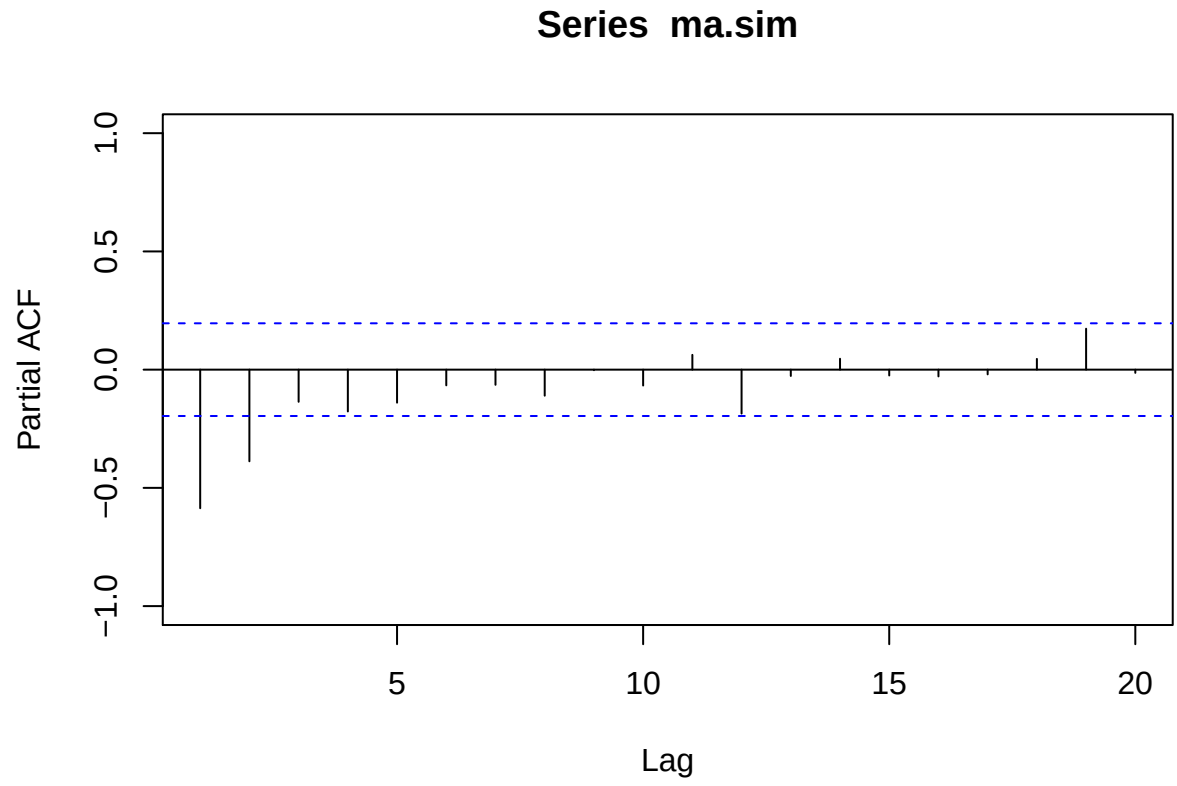
```
set.seed(2018)
ma.sim=arima.sim(n=100,list(ma=-0.7),sd=3)
plot(ma.sim,xlab="t",ylab="X",main="MA(1):theta1=0.6;sd=3")
abline(h=0,lty=2)
```




```
plot(acf(ma.sim,lag.max=20,plot=FALSE),ylim=c(-1,1))
```



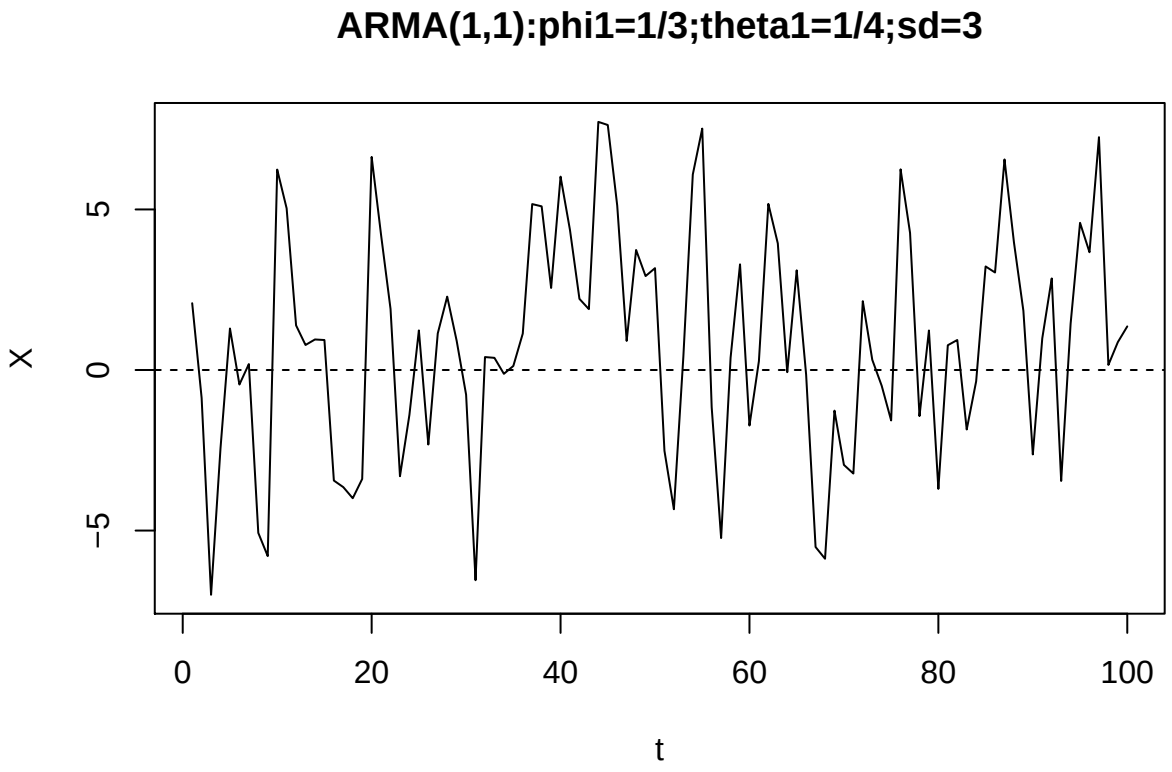

```
plot(pacf(ma.sim,lag.max=20,plot=FALSE),ylim=c(-1,1))
```



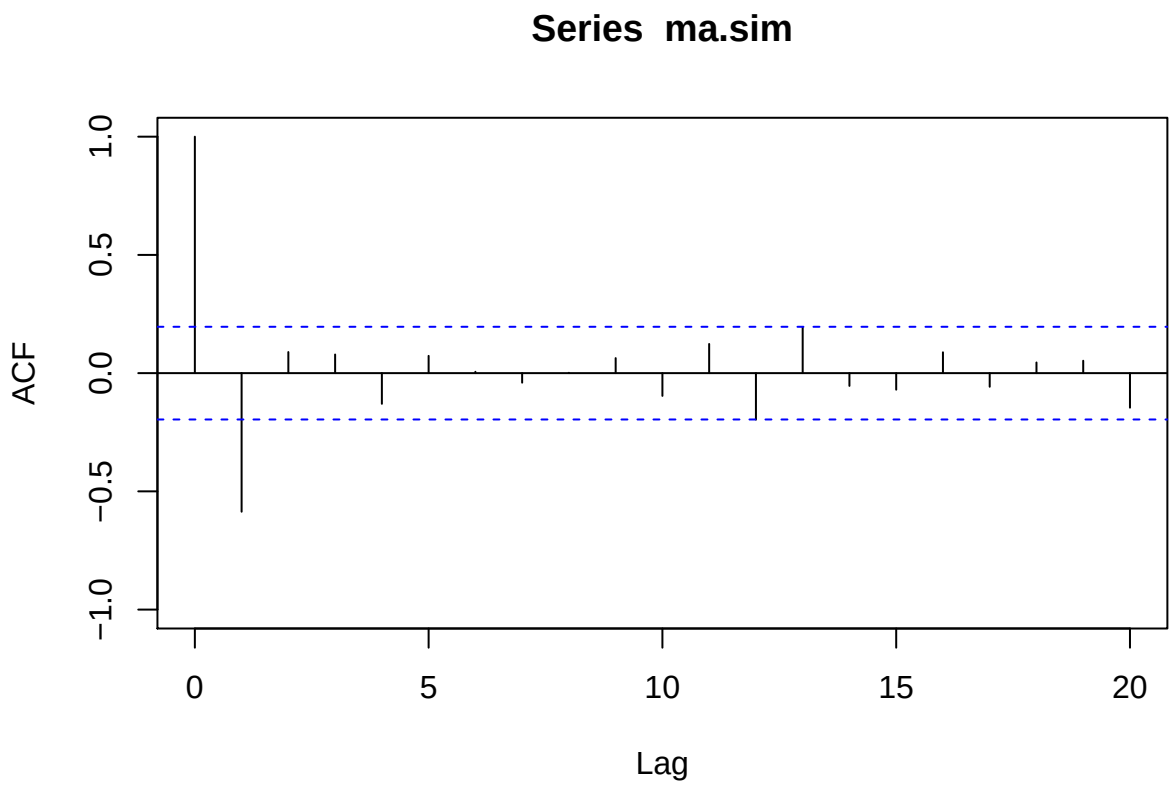
ARMA(1,1)

X_t = 1/3 X_(t-1) + e_t + 1/4 e_(t-1) ; Var(X_t) = 9

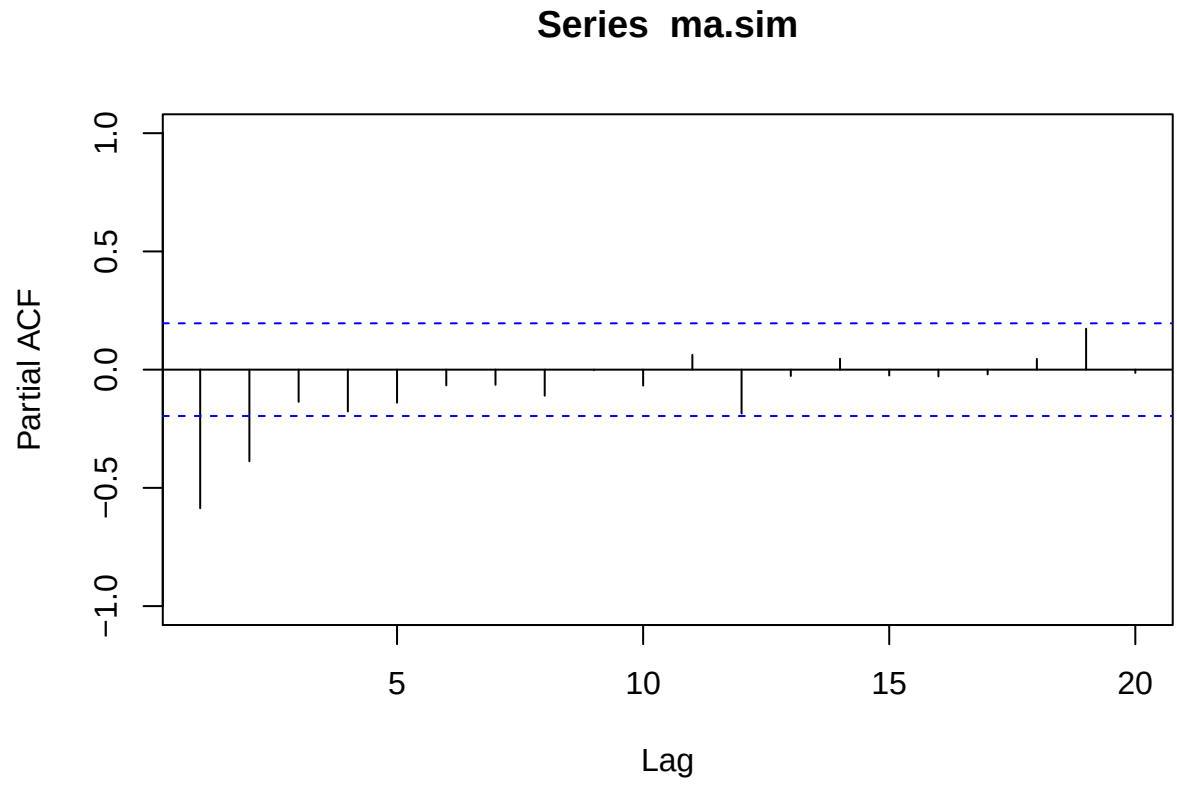
```
arma.sim=arima.sim(n=100,list(ar=1/3,ma=1/4),sd=3)
plot(arma.sim,xlab="t",ylab="X",main="ARMA(1,1):phi1=1/3;theta1=1/4;sd=3")
abline(h=0,lty=2)
```




```
plot(acf(ma.sim,lag.max=20,plot=FALSE),ylim=c(-1,1))
```

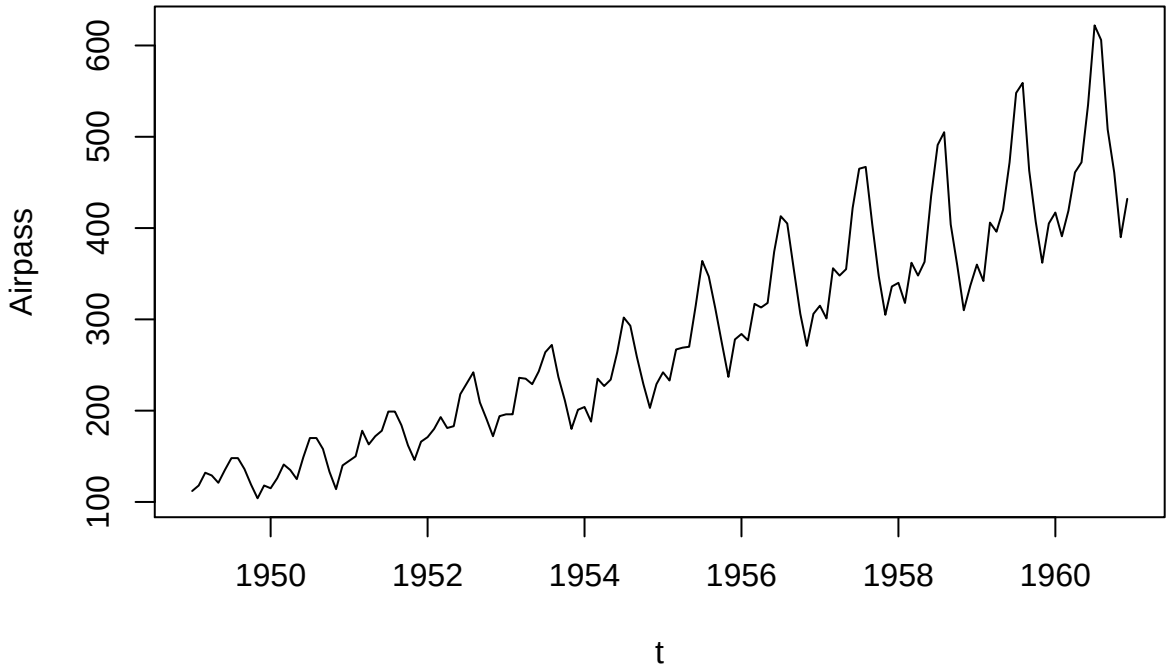



```
plot(pacf(ma.sim,lag.max=20,plot=FALSE),ylim=c(-1,1))
```

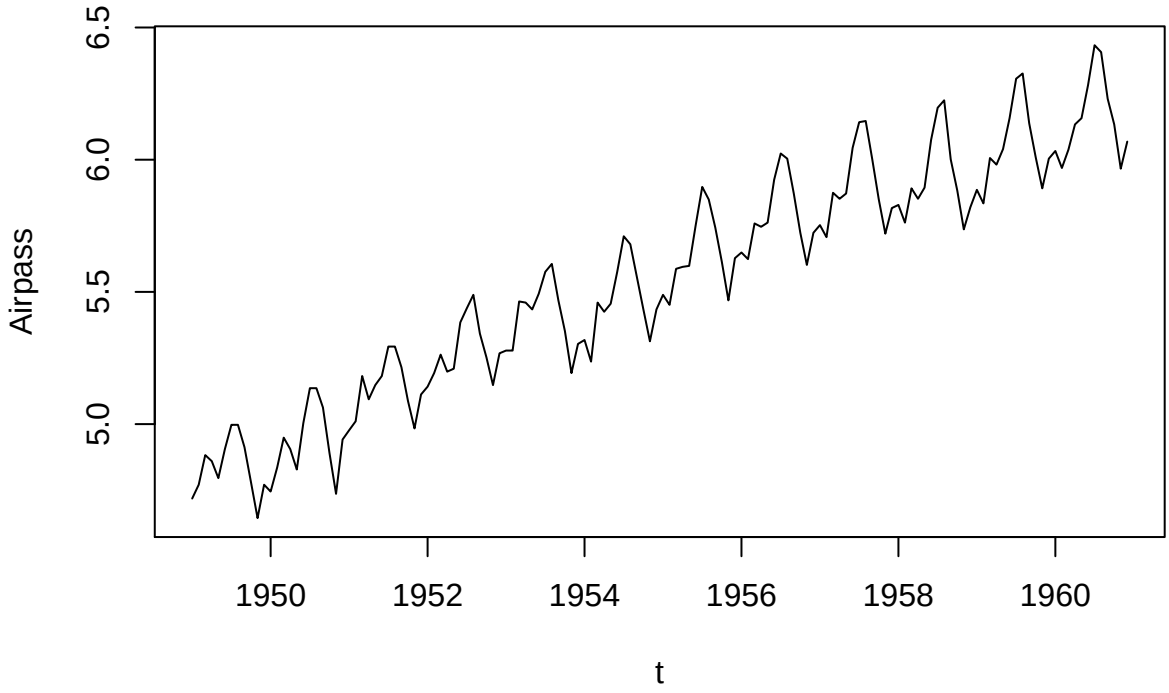


Modeling

```
x=AirPassengers
y=log(x)
plot(x,xlab="t",ylab="Airpass")
```




```
plot(y,xlab="t",ylab="Airpass")
```



Example

```
a=c(1:10); a
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```
b=cumsum(a); b
```

```
##  [1]  1  3  6 10 15 21 28 36 45 55
```

```
c=cumsum(b); c
```

```
##  [1]   1   4  10  20  35  56  84 120 165 220
```

```
diff(c, lag=1, differences = 1)
```

```
## [1]  3  6 10 15 21 28 36 45 55
```

```
diff(c, lag=1, differences = 2)
```

```
## [1]  3  4  5  6  7  8  9 10
```

```
diff(c, lag=2, differences = 1)
```

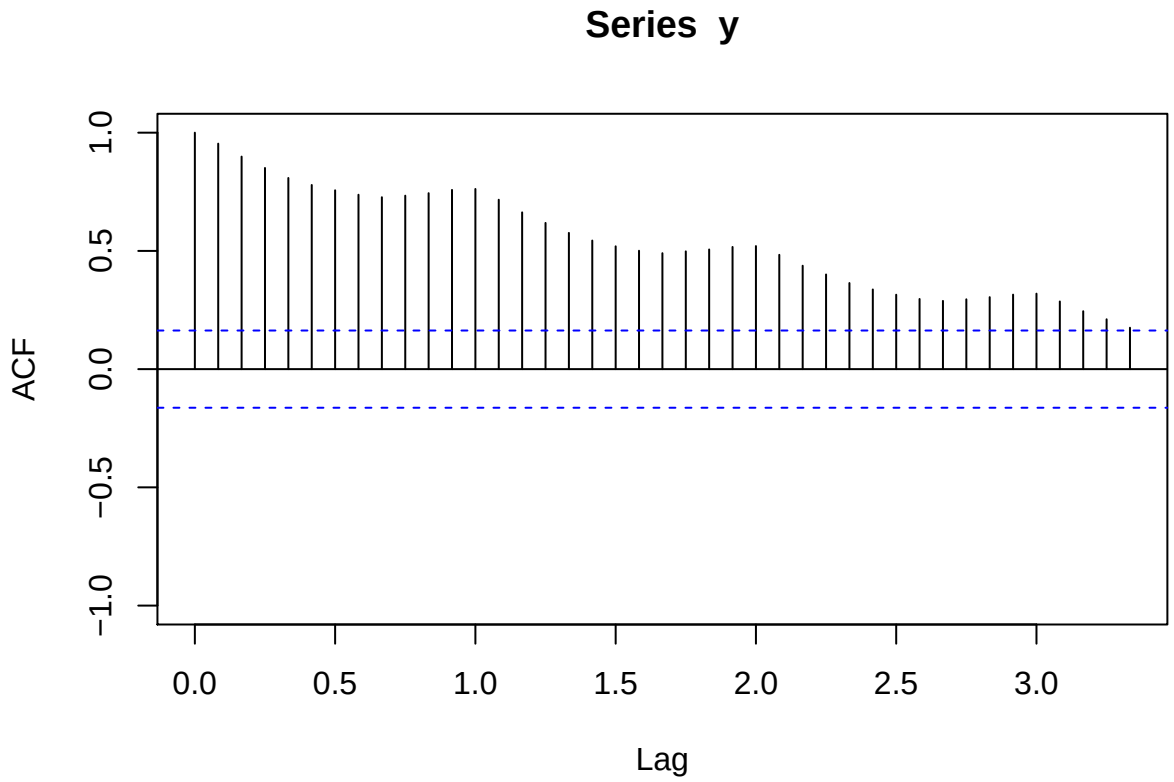
```
## [1]   9  16  25  36  49  64  81 100
```

```
diff(c, lag=2, differences = 2)
```

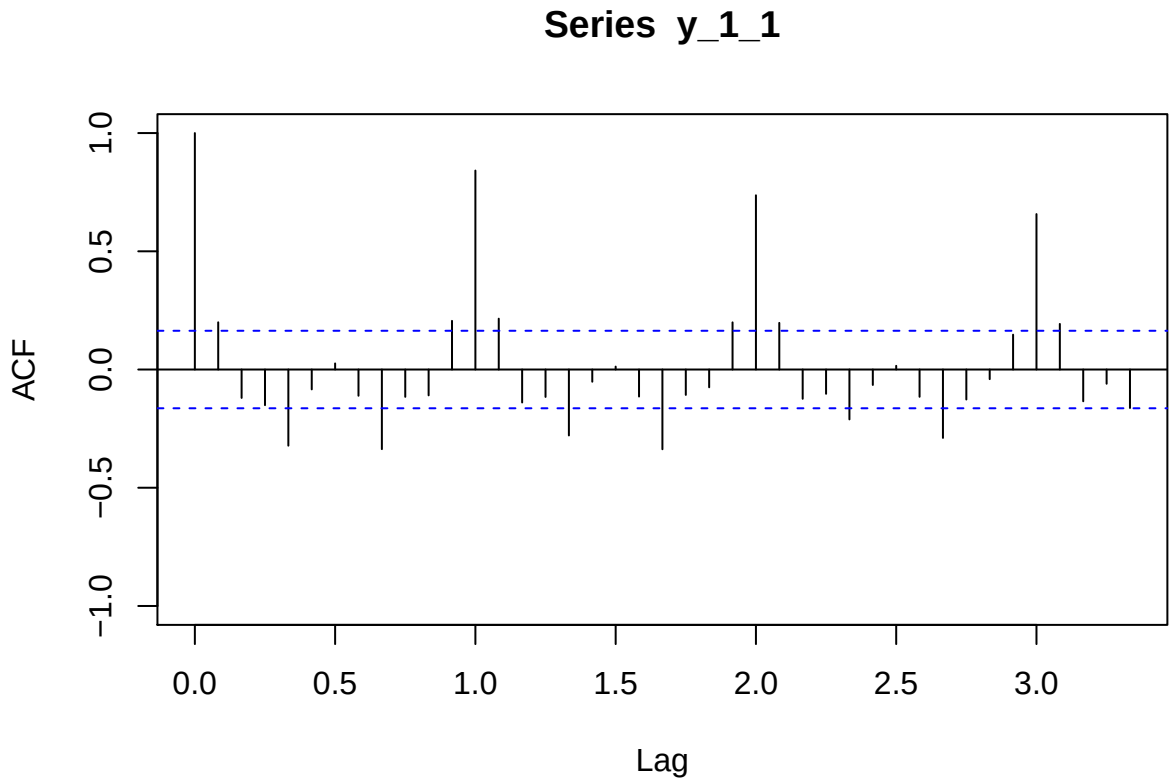
```
## [1] 16 20 24 28 32 36
```

Stationarity

```
plot(acf(y,lag.max=40,plot=FALSE),ylim=c(-1,1))
```

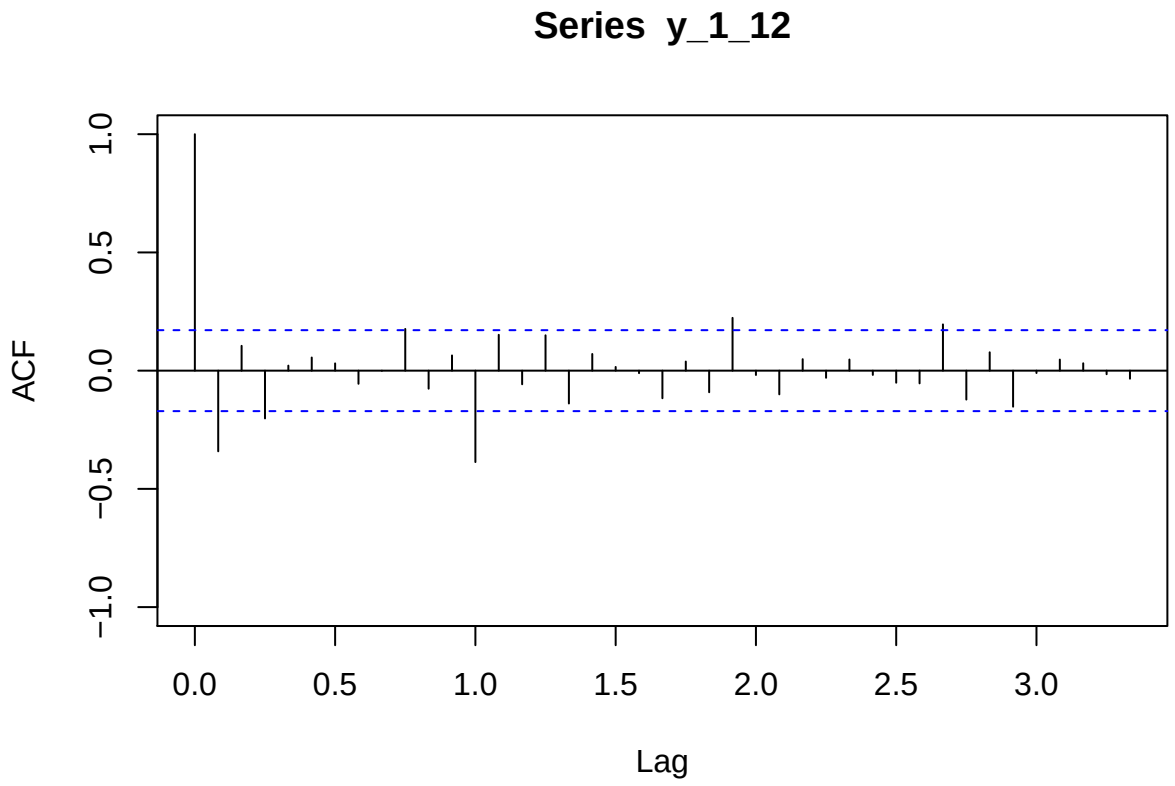



```
y_1_1=diff(y,lag=1,differences=1)
plot(acf(y_1_1,lag.max=40,plot=FALSE),ylim=c(-1,1))
```

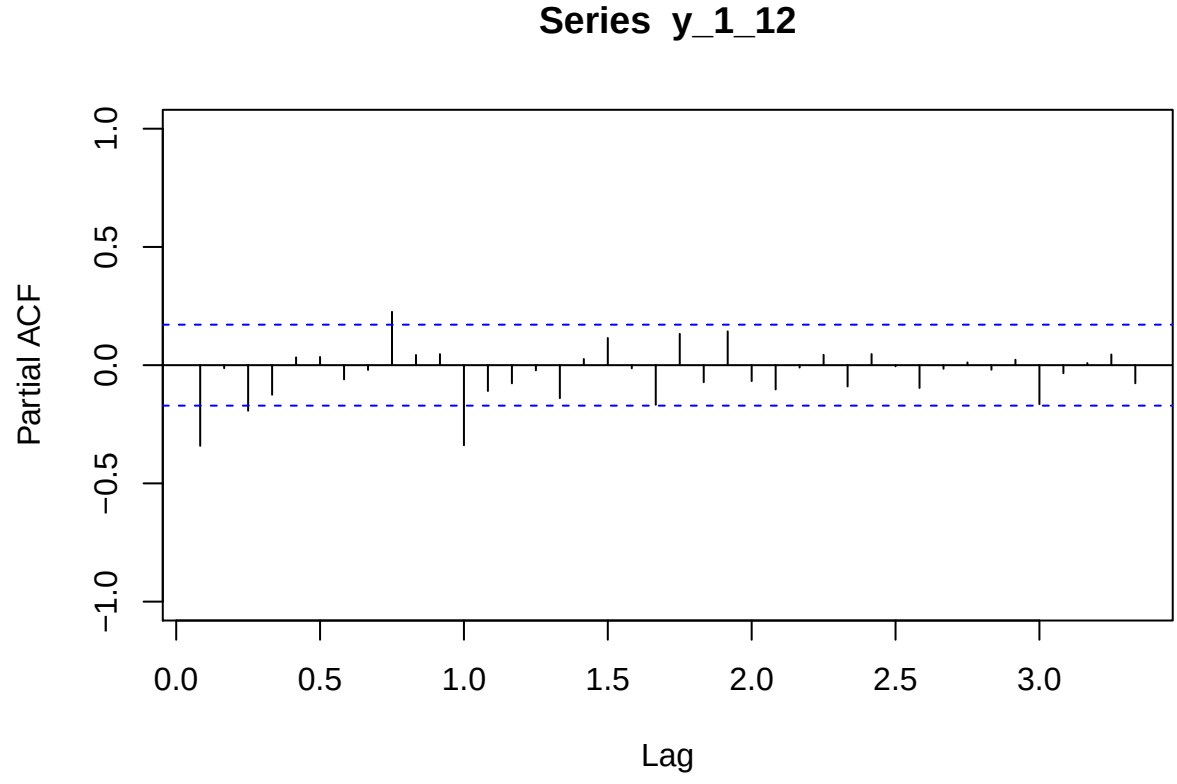



```
y_1_12=diff(y_1_1,lag=12,differences=1)
```

```
plot(acf(y_1_12,lag.max=40,plot=FALSE),ylim=c(-1,1))
```




```
plot(pacf(y_1_12,lag.max=40,plot=FALSE),ylim=c(-1,1))
```



```r
library(TSA)
```

```
## Loading required package: leaps
## Loading required package: locfit
## locfit 1.5-9.1    2013-03-22
## Loading required package: mgcv
## Loading required package: nlme
## This is mgcv 1.8-17. For overview type 'help("mgcv-package")'.
## Loading required package: tseries
## Warning: package 'tseries' was built under R version 3.4.4
##
## Attaching package: 'TSA'
## The following objects are masked from 'package:stats':
##
##     acf, arima
## The following object is masked from 'package:utils':
##
##     tar
```

```r
library(caschrono)
```

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

Model 1

```r
model1=arima(y,order=c(1,1,1),list(order=c(1,1,1),period=12),include.mean=FALSE,method="CSS-ML")
model1
```

```
##
## Call:
## arima(x = y, order = c(1, 1, 1), seasonal = list(order = c(1, 1, 1), period = 12),
##     include.mean = FALSE, method = "CSS-ML")
##
## Coefficients:
##          ar1      ma1    sar1     sma1
##       0.1666  -0.5615  -0.099  -0.4973
## s.e.  0.2459   0.2115   0.154   0.1360
##
## sigma^2 estimated as 0.001336:  log likelihood = 245.16,  aic = -482.31
```

```r
t_stat(model1)
```

```
##             ar1       ma1      sar1      sma1
## t.stat 0.677738 -2.654214 -0.642984 -3.657670
```

```
## p.val  0.497938  0.007949  0.520235  0.000255
```

Model 2

```
model2=arima(y,order=c(1,1,1),list(order=c(0,1,1),period=12),include.mean=FALSE,method="CSS-ML")
model2
```

```
##
## Call:
## arima(x = y, order = c(1, 1, 1), seasonal = list(order = c(0, 1, 1), period = 12),
##     include.mean = FALSE, method = "CSS-ML")
##
## Coefficients:
##          ar1      ma1     sma1
##       0.1960  -0.5784  -0.5643
## s.e.  0.2475   0.2132   0.0747
##
## sigma^2 estimated as 0.001341:  log likelihood = 244.95,  aic = -483.9
```

```
t_stat(model2)
```

```
##             ar1       ma1      sma1
## t.stat 0.792074 -2.712668 -7.554412
## p.val  0.428318  0.006674  0.000000
```

Model 3

```
model3=arima(y,order=c(0,1,1),list(order=c(0,1,1),period=12),include.mean=FALSE,method="CSS-ML")
model3
```

```
##
## Call:
## arima(x = y, order = c(0, 1, 1), seasonal = list(order = c(0, 1, 1), period = 12),
##     include.mean = FALSE, method = "CSS-ML")
##
## Coefficients:
##          ma1     sma1
##       -0.4018  -0.5569
## s.e.   0.0896   0.0731
##
## sigma^2 estimated as 0.001348:  log likelihood = 244.7,  aic = -485.4
```

```
t_stat(model3)
```

```
##             ma1      sma1
## t.stat -4.482494 -7.618978
## p.val   0.000007  0.000000
```

```
shapiro.test(model3$residuals)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  model3$residuals
## W = 0.98637, p-value = 0.1674
```