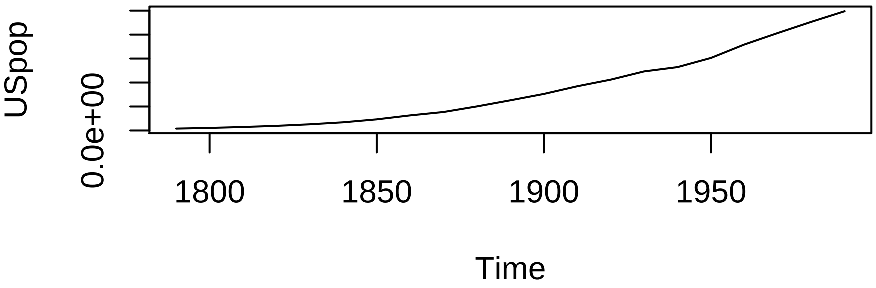
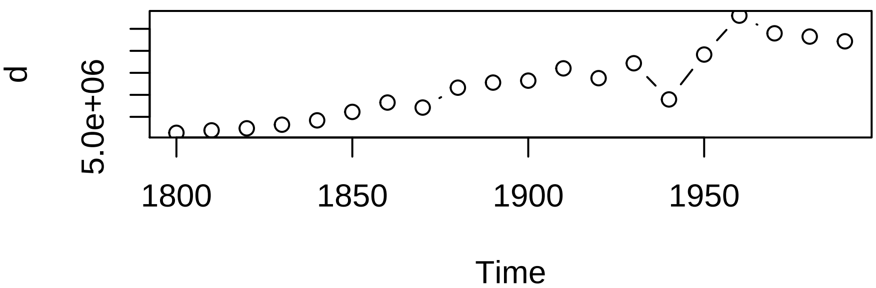
```r
# 1.1

library("quantmod")

r <- read.table("http://gamma.mini.pw.edu.pl/~szymanowskih/lab1/USPOP.DATA")
head(r,3)

##        V1
## 1 3929214
## 2 5308483
## 3 7239881

# a)

USpop <- ts(data=r, start=1790, end=1990, frequency=0.1)

# b)

ts.plot(USpop)
```




```r
d <- diff(USpop)
ts.plot(d,type="b")
```



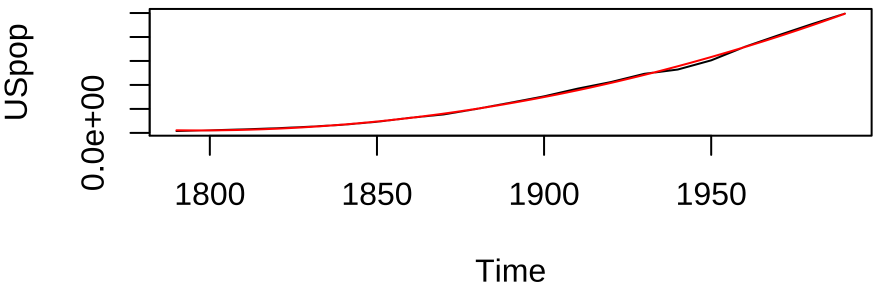

```r
which.min(d)    # najmniejszy wzrost w latach 1790-1800

## [1] 1

# c)

czas <- seq(start(USpop), end(USpop), by=1/frequency(USpop))
```

```r
m1.lm <- lm(USpop ~ czas + I(czas^2))
summary(m1.lm)
```

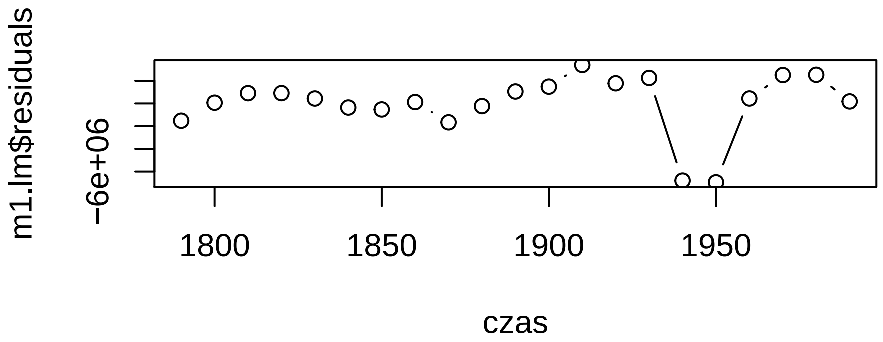
```
##
## Call:
## lm(formula = USpop ~ czas + I(czas^2))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -6947521  -358167   436285  1481410  3391761
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.10e+10   6.59e+08    31.9   <2e-16 ***
## czas        -2.34e+07   6.98e+05   -33.5   <2e-16 ***
## I(czas^2)    6.51e+03   1.85e+02    35.2   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2770000 on 18 degrees of freedom
## Multiple R-squared:  0.999,Adjusted R-squared:  0.999
## F-statistic: 8.05e+03 on 2 and 18 DF,  p-value: <2e-16
```

```r
wsp <- summary(m1.lm)$coefficients[,1]
```

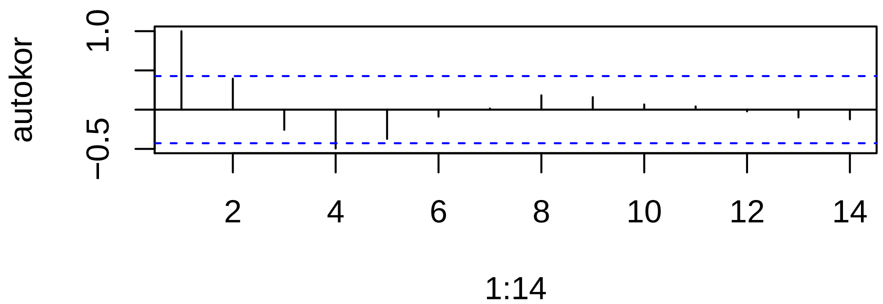
```r
ts.plot(USpop)
curve(wsp[1]+wsp[2]*x+wsp[3]*x^2,from=1790, to=1990,add=TRUE,col="red")
```



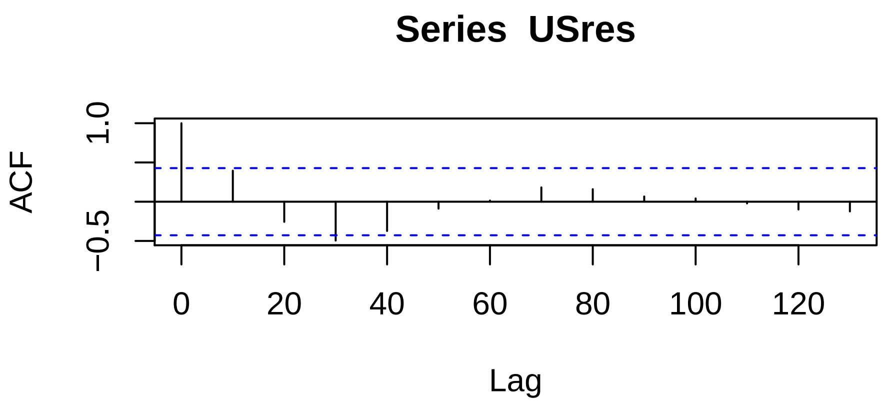

```r
# wykres reziduow od czasu:

plot(czas, m1.lm$residuals, type="b")
```




```
# d)

res <- m1.lm$residuals
USres <- ts(res, start=1790, end=1990, frequency=0.1)

n <- length(USres)
sr <- mean(res)
autokor <- numeric(14)
gamma0 <- (sum((res-sr)^2))/n
autokor[1] <- 1

for(i in 1:13){
   gammah <- (sum((res[1:(21-i)]-sr)*(res[(i+1):21]-sr)))/n
   autokor[i+1] <- gammah/gamma0
}

plot(1:14,autokor,type="h")
kw <- qnorm(0.975)/sqrt(n)
abline(b=0,a=kw,lty=2,col="blue")
abline(b=0,a=-kw,lty=2,col="blue")
abline(b=0,a=0)
```

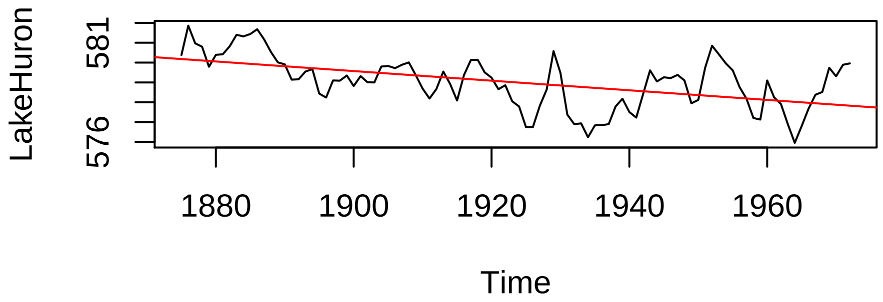



```
# funkcja wbudowana rysujaca ten sam wykres:

acf(USres)   # jest autokorelacja rzedu 3 -> testujemy formalnie, czy jest korelacja
```

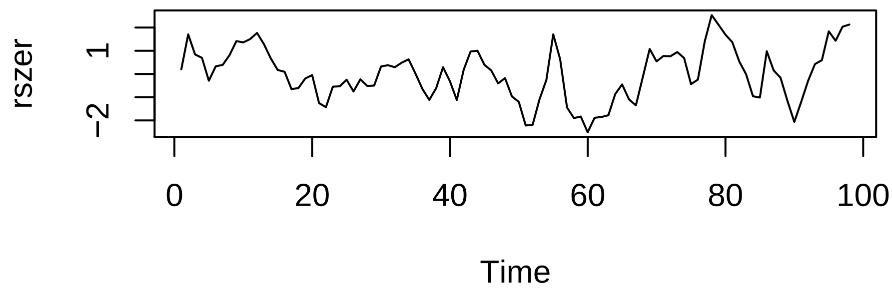



```
# e)
# H0: pierwsze 10 korelacji jest rowne zero
# lag := h

Box.test(USres, lag = 10, type="Ljung")

##
##  Box-Ljung test
##
## data:  USres
## X-squared = 18.6, df = 10, p-value = 0.04565

# czyli rezidua nie sa bialym szumem niestety

# 1.2

data(LakeHuron)
head(LakeHuron)

## [1] 580.4 581.9 581.0 580.8 579.8 580.4

is.ts(LakeHuron)

## [1] TRUE
```

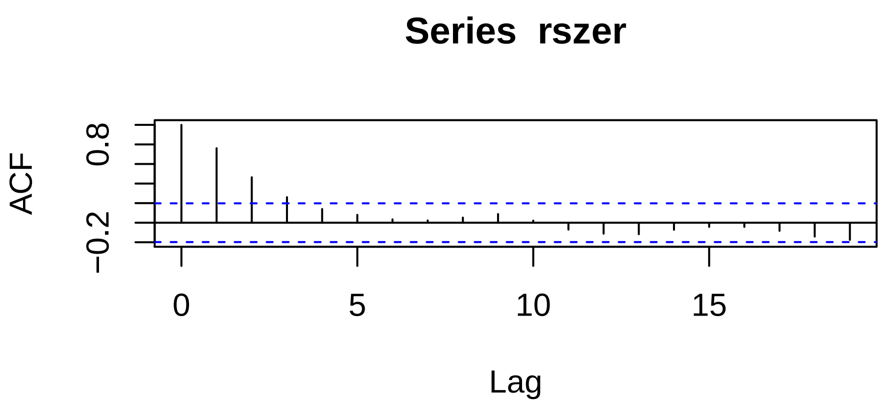
```
# a)

ts.plot(LakeHuron)    # widac tendencje malejaca

# b)

czas <- as.vector(time(LakeHuron))
lake.lm <- lm(LakeHuron ~ czas, data=LakeHuron)
abline(lake.lm, col="red")
```




```
# c)

res <- lake.lm$residuals
rszer <- ts(data=res)
ts.plot(rszer)
```




```
acf(rszer)    # pasowaloby MA(3)
```




```
Box.test(rszer, lag = 20, type="Ljung")

##
##  Box-Ljung test
##
## data:  rszer
## X-squared = 107.8, df = 20, p-value = 4.885e-14
```

```r
# to zdecydowanie nie jest biały szum!

# d)

r0 <- res
r1 <- Lag(res,k=1)
r2 <- Lag(res,k=2)

head(r0)
```

```
##       1       2       3       4       5       6
##  0.2022  1.7064  0.8406  0.6948 -0.2910  0.3332
```

```r
head(r1)
```

```
##        Lag.1
## [1,]      NA
## [2,]  0.2022
## [3,]  1.7064
## [4,]  0.8406
## [5,]  0.6948
## [6,] -0.2910
```

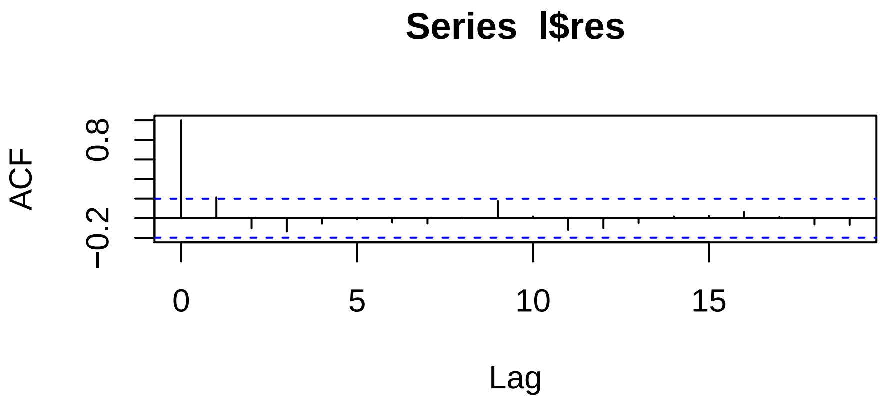
```r
head(r2)
```

```
##       Lag.2
## [1,]     NA
## [2,]     NA
## [3,] 0.2022
## [4,] 1.7064
## [5,] 0.8406
## [6,] 0.6948
```

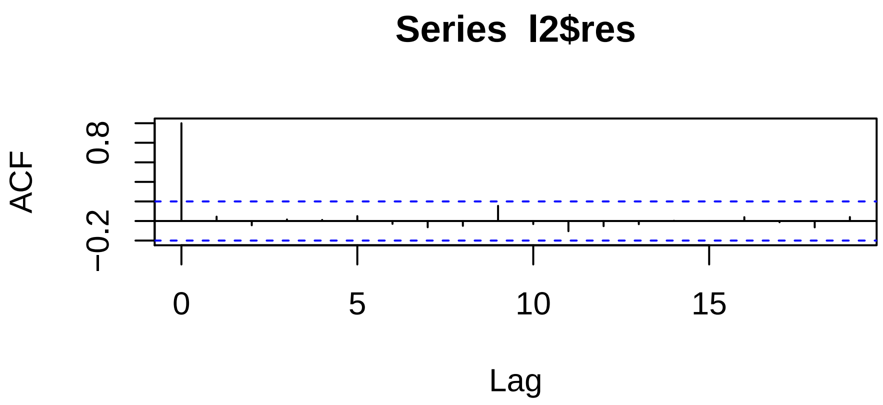
```r
# e)

l <- lm(r0~r1)
summary(l)
```

```
##
## Call:
## lm(formula = r0 ~ r1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.9588 -0.4993  0.0017  0.4178  1.8956
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.0153     0.0727    0.21     0.83
## r1            0.7911     0.0659   12.00   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.716 on 95 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.603,Adjusted R-squared:  0.599
## F-statistic:  144 on 1 and 95 DF,  p-value: <2e-16
```

```r
mean(l$residuals^2)     # MSE

## [1] 0.5022

acf(l$res)
```

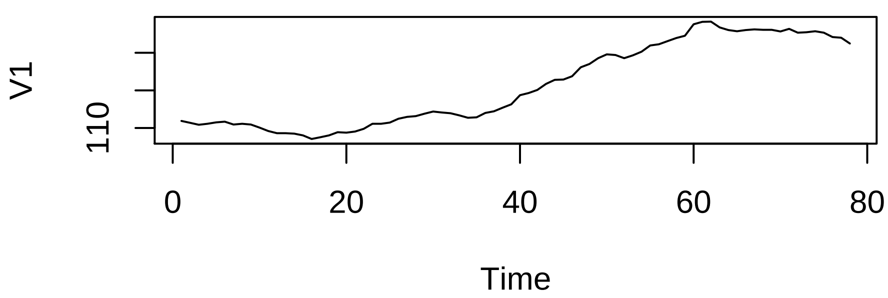



```r
Box.test(l$res,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  l$res
## X-squared = 19.71, df = 20, p-value = 0.4765

# f)

l2 <- lm(r0~r1+r2)
summary(l2)

##
## Call:
## lm(formula = r0 ~ r1 + r2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.5843 -0.4525 -0.0162  0.4030  1.7320
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.00785    0.06912   -0.11   0.9098
## r1           1.00214    0.09722   10.31   <2e-16 ***
## r2          -0.28380    0.09900   -2.87   0.0051 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.677 on 93 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.644,Adjusted R-squared:  0.636
## F-statistic: 84.2 on 2 and 93 DF,  p-value: <2e-16

mean(l2$residuals^2)

## [1] 0.4435

acf(l2$res)
```

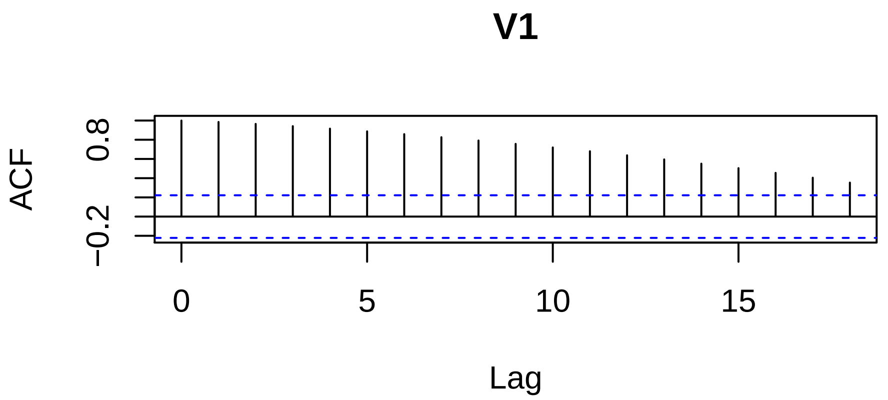



```
Box.test(l2$res,lag=20,type="Ljung")  # lepiej dopasowany niz l

##
##  Box-Ljung test
##
## data:  l2$res
## X-squared = 9.033, df = 20, p-value = 0.9825

# g)

model_ar1 <- arima(r0,c(1,0,0))
model_ar2 <- arima(r0,c(2,0,0))

Box.test(model_ar1$residuals,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  model_ar1$residuals
## X-squared = 19.92, df = 20, p-value = 0.4631

Box.test(model_ar2$residuals,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  model_ar2$residuals
## X-squared = 8.466, df = 20, p-value = 0.9883

# h)

model_ar1

##
## Call:
## arima(x = r0, order = c(1, 0, 0))
##
## Coefficients:
##          ar1  intercept
##        0.783      0.080
## s.e.  0.063      0.318
##
## sigma^2 estimated as 0.497:  log likelihood = -105.3,  aic = 216.6
```

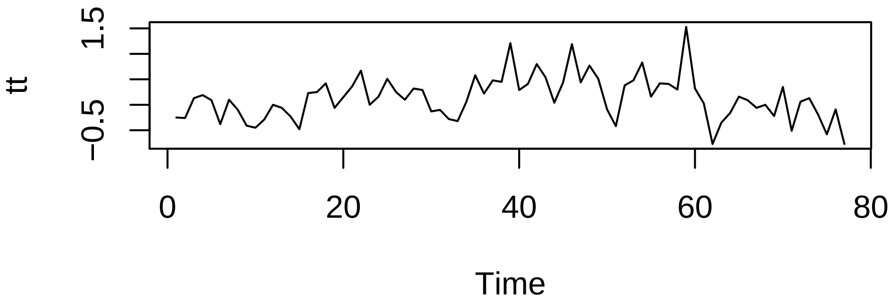
```
l$coefficients    # ok, w miare podobne

## (Intercept)          r1
##     0.01529     0.79112

# 1.3

d <- read.table("C:\\Users\\Marta\\Desktop\\Marta\\studia\\rok4\\Szeregi czasowe\\DOWJ.DAT")
head(d)

##      V1
## 1 110.9
## 2 110.7
## 3 110.4
## 4 110.6
## 5 110.8
## 6 110.8

# a)

t <- ts(data=d)

# b)

plot(t)    # widoczny jest trend!!!
```



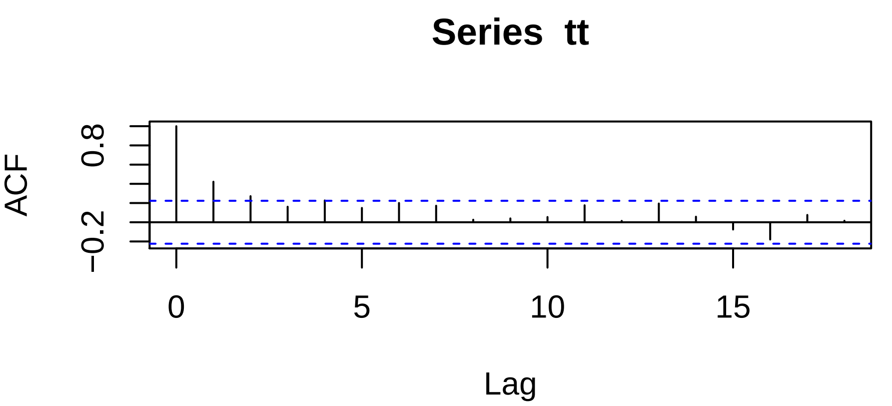

```
# c)

acf(t)     # szereg niestacjonarny -> zeby sie pozbyc trendu roznicujemy
```



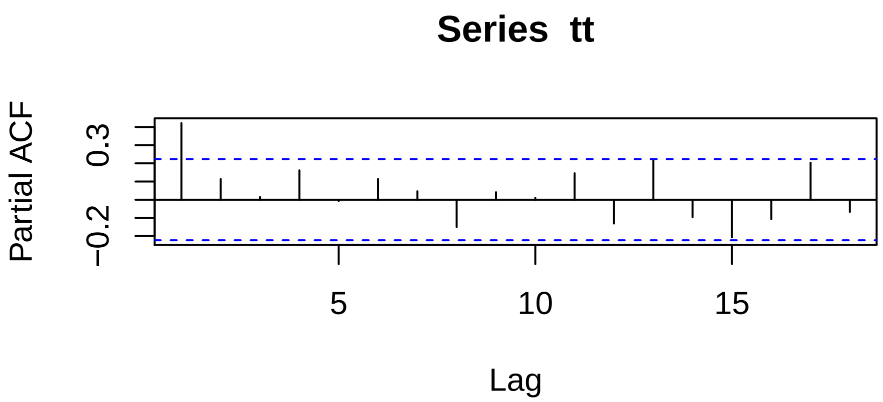
```r
# d)

dd <- diff(as.numeric(as.matrix(d)))
tt <- ts(data=dd)

# e)

ts.plot(tt)
```




```r
Box.test(tt,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  tt
## X-squared = 46.43, df = 20, p-value = 0.0007039

# f)

acf(tt)   # sugeruje model MA(2)
```




```r
pacf(tt)  # sugeruje model AR(1)
```




```
ma2 <- arima(dd,c(0,0,2))
ar1 <- arima(dd,c(1,0,0))
arma12 <- arima(dd,c(1,0,2))

Box.test(ma2$res,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  ma2$res
## X-squared = 31.4, df = 20, p-value = 0.05011

Box.test(ar1$res,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  ar1$res
## X-squared = 32.55, df = 20, p-value = 0.03774

Box.test(arma12$res,lag=20,type="Ljung")

##
##  Box-Ljung test
##
## data:  arma12$res
## X-squared = 27.95, df = 20, p-value = 0.1105

acf(arma12$residuals)
```