ARIMA

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```
library(fpp)
```

```
## Warning: package 'fpp' was built under R version 4.1.3
```

```
## Loading required package: forecast
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
## Loading required package: fma
```

```
## Warning: package 'fma' was built under R version 4.1.3
```

```
## Loading required package: expsmooth
```

```
## Warning: package 'expsmooth' was built under R version 4.1.3
```

```
## Loading required package: lmtest
```

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

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

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

```
## Loading required package: tseries
```

```
library(fpp2)
```

```
## Warning: package 'fpp2' was built under R version 4.1.3
```

```
## -- Attaching packages --------------------------------------------- fpp2 2.4 --
```

```
## v ggplot2 3.3.6
```

```
## Warning: package 'ggplot2' was built under R version 4.1.3
```

```
##
```

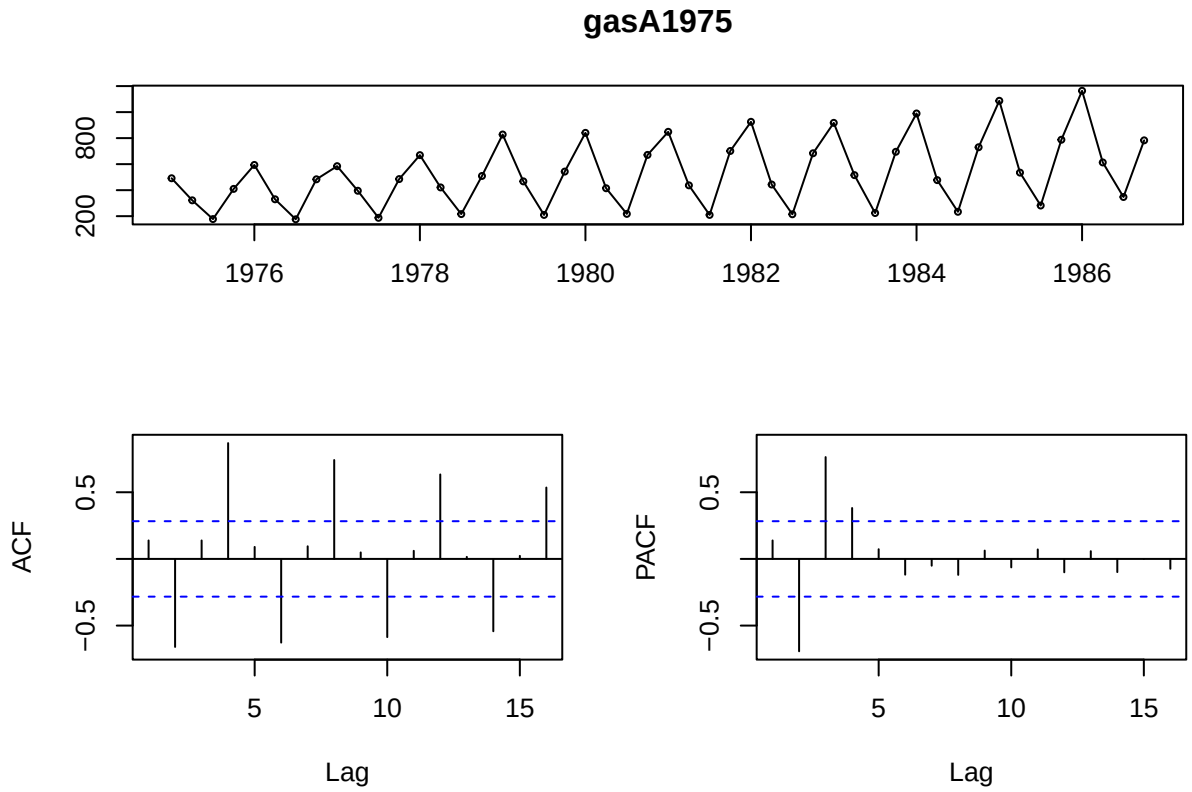
```
##
## Attaching package: 'fpp2'
```

```
## The following objects are masked from 'package:fpp':
##
##     ausair, ausbeer, austa, austourists, debitcards, departures,
##     elecequip, euretail, guinearice, oil, sunspotarea, usmelec
```

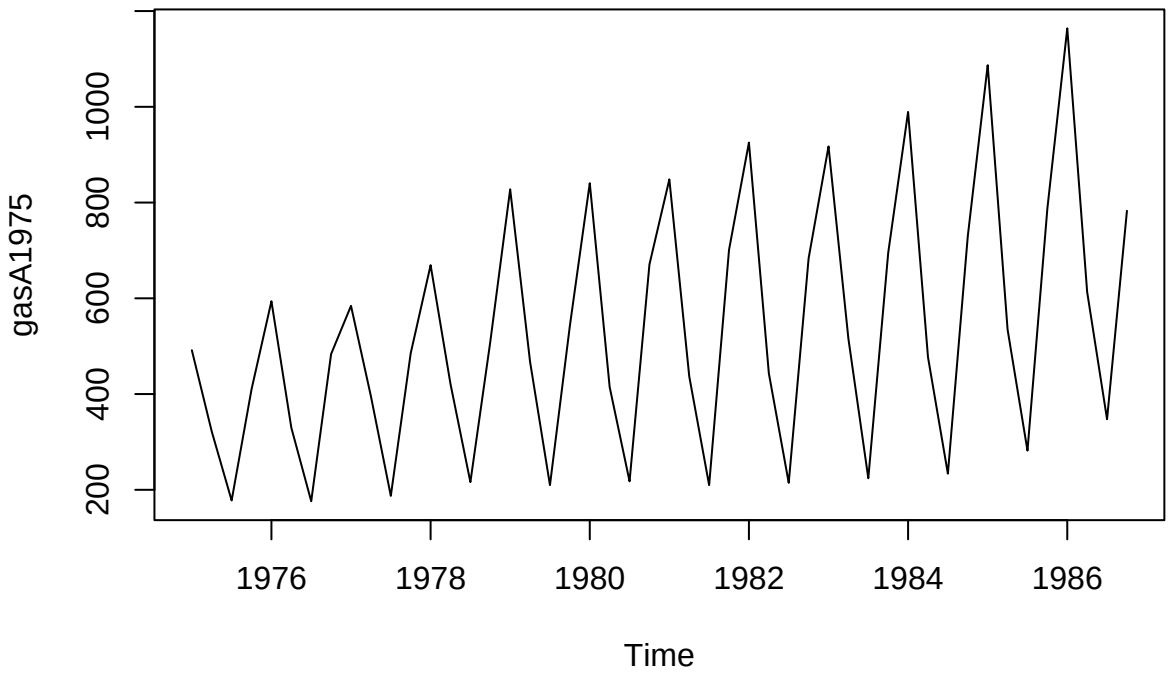
```
library(forecast)

gasA1975 <- window(UKgas, start=c(1975, 1), end=c(1986, 4))


ndiffs(gasA1975)
```

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

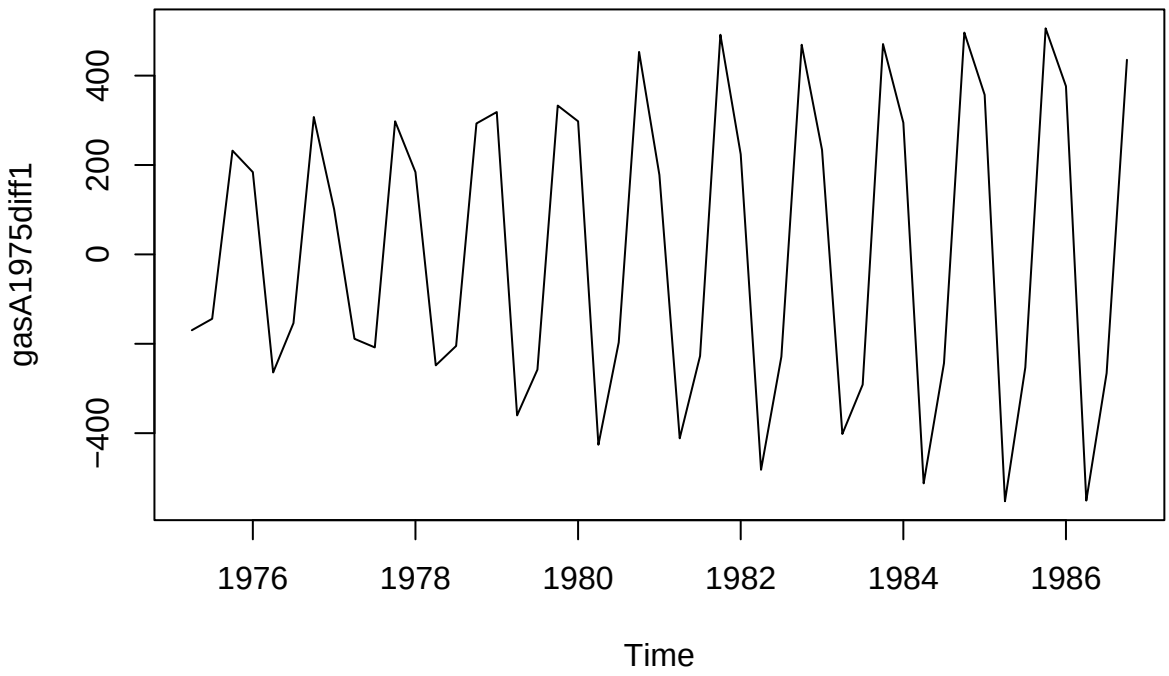
```
tsdisplay(gasA1975)
```



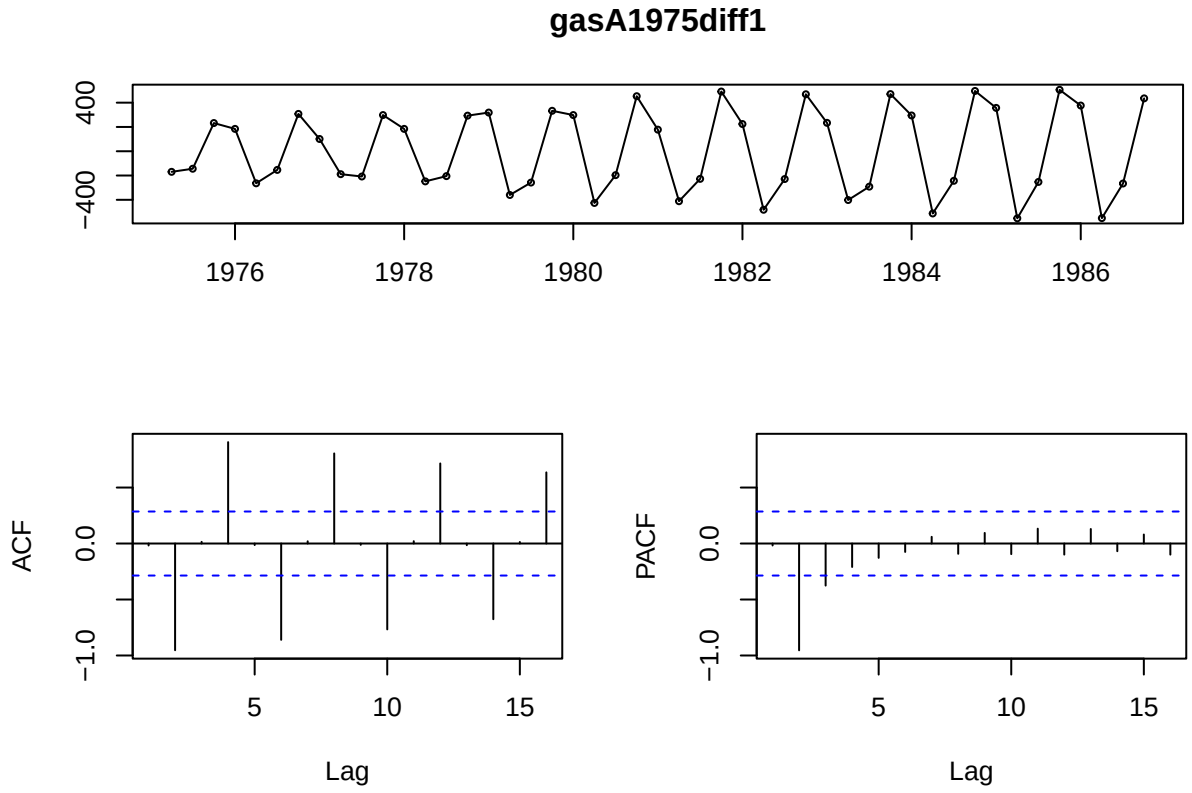

```
gasA1975diff1 <- diff(gasA1975, differences=1)
plot(gasA1975)
```




```
plot(gasA1975diff1)
```




```
tsdisplay(gasA1975diff1)
```




```
auto_fit <- auto.arima(gasA1975, trace=TRUE, stepwise = FALSE)
```

```
##
##  ARIMA(0,0,0)(0,1,0)[4]                    : 479.8505
##  ARIMA(0,0,0)(0,1,0)[4] with drift         : 460.6335
##  ARIMA(0,0,0)(0,1,1)[4]                    : 478.0197
##  ARIMA(0,0,0)(0,1,1)[4] with drift         : 462.9371
##  ARIMA(0,0,0)(0,1,2)[4]                    : 479.6319
##  ARIMA(0,0,0)(0,1,2)[4] with drift         : 465.2268
##  ARIMA(0,0,0)(1,1,0)[4]                    : 476.6048
##  ARIMA(0,0,0)(1,1,0)[4] with drift         : 462.9376
##  ARIMA(0,0,0)(1,1,1)[4]                    : Inf
##  ARIMA(0,0,0)(1,1,1)[4] with drift         : 465.3455
##  ARIMA(0,0,0)(1,1,2)[4]                    : Inf
##  ARIMA(0,0,0)(1,1,2)[4] with drift         : 467.7253
##  ARIMA(0,0,0)(2,1,0)[4]                    : 477.3841
##  ARIMA(0,0,0)(2,1,0)[4] with drift         : 465.1752
##  ARIMA(0,0,0)(2,1,1)[4]                    : Inf
##  ARIMA(0,0,0)(2,1,1)[4] with drift         : 467.6452
##  ARIMA(0,0,0)(2,1,2)[4]                    : Inf
##  ARIMA(0,0,0)(2,1,2)[4] with drift         : Inf
##  ARIMA(0,0,1)(0,1,0)[4]                    : 477.0405
##  ARIMA(0,0,1)(0,1,0)[4] with drift         : 462.8594
##  ARIMA(0,0,1)(0,1,1)[4]                    : 477.995
##  ARIMA(0,0,1)(0,1,1)[4] with drift         : 465.2846
##  ARIMA(0,0,1)(0,1,2)[4]                    : 480.1253
```

```
##  ARIMA(0,0,1)(0,1,2)[4] with drift         : 467.6957
##  ARIMA(0,0,1)(1,1,0)[4]                    : 477.5728
##  ARIMA(0,0,1)(1,1,0)[4] with drift         : 465.2846
##  ARIMA(0,0,1)(1,1,1)[4]                    : Inf
##  ARIMA(0,0,1)(1,1,1)[4] with drift         : 467.8009
##  ARIMA(0,0,1)(1,1,2)[4]                    : Inf
##  ARIMA(0,0,1)(1,1,2)[4] with drift         : 470.3235
##  ARIMA(0,0,1)(2,1,0)[4]                    : 479.1351
##  ARIMA(0,0,1)(2,1,0)[4] with drift         : 467.6526
##  ARIMA(0,0,1)(2,1,1)[4]                    : Inf
##  ARIMA(0,0,1)(2,1,1)[4] with drift         : 470.2445
##  ARIMA(0,0,1)(2,1,2)[4]                    : Inf
##  ARIMA(0,0,1)(2,1,2)[4] with drift         : Inf
##  ARIMA(0,0,2)(0,1,0)[4]                    : 479.1711
##  ARIMA(0,0,2)(0,1,0)[4] with drift         : 463.7003
##  ARIMA(0,0,2)(0,1,1)[4]                    : 480.2718
##  ARIMA(0,0,2)(0,1,1)[4] with drift         : 466.2188
##  ARIMA(0,0,2)(0,1,2)[4]                    : 482.5657
##  ARIMA(0,0,2)(0,1,2)[4] with drift         : 468.5602
##  ARIMA(0,0,2)(1,1,0)[4]                    : 479.8589
##  ARIMA(0,0,2)(1,1,0)[4] with drift         : 466.226
##  ARIMA(0,0,2)(1,1,1)[4]                    : Inf
##  ARIMA(0,0,2)(1,1,1)[4] with drift         : 468.9393
##  ARIMA(0,0,2)(1,1,2)[4]                    : Inf
##  ARIMA(0,0,2)(1,1,2)[4] with drift         : 471.3928
##  ARIMA(0,0,2)(2,1,0)[4]                    : 481.6415
##  ARIMA(0,0,2)(2,1,0)[4] with drift         : 468.4557
##  ARIMA(0,0,2)(2,1,1)[4]                    : Inf
##  ARIMA(0,0,2)(2,1,1)[4] with drift         : 471.2838
##  ARIMA(0,0,3)(0,1,0)[4]                    : 477.6975
##  ARIMA(0,0,3)(0,1,0)[4] with drift         : 465.6149
##  ARIMA(0,0,3)(0,1,1)[4]                    : 478.2569
##  ARIMA(0,0,3)(0,1,1)[4] with drift         : 468.2679
##  ARIMA(0,0,3)(0,1,2)[4]                    : 480.9477
##  ARIMA(0,0,3)(0,1,2)[4] with drift         : 470.7164
##  ARIMA(0,0,3)(1,1,0)[4]                    : 478.2446
##  ARIMA(0,0,3)(1,1,0)[4] with drift         : 468.2764
##  ARIMA(0,0,3)(1,1,1)[4]                    : 480.9466
##  ARIMA(0,0,3)(1,1,1)[4] with drift         : 471.1302
##  ARIMA(0,0,3)(2,1,0)[4]                    : 480.905
##  ARIMA(0,0,3)(2,1,0)[4] with drift         : 470.6022
##  ARIMA(1,0,0)(0,1,0)[4]                    : 475.9723
##  ARIMA(1,0,0)(0,1,0)[4] with drift         : 462.8895
##  ARIMA(1,0,0)(0,1,1)[4]                    : 477.4106
##  ARIMA(1,0,0)(0,1,1)[4] with drift         : 465.3139
##  ARIMA(1,0,0)(0,1,2)[4]                    : 479.6762
##  ARIMA(1,0,0)(0,1,2)[4] with drift         : 467.7284
##  ARIMA(1,0,0)(1,1,0)[4]                    : 477.1871
##  ARIMA(1,0,0)(1,1,0)[4] with drift         : 465.3141
##  ARIMA(1,0,0)(1,1,1)[4]                    : Inf
##  ARIMA(1,0,0)(1,1,1)[4] with drift         : 467.8366
##  ARIMA(1,0,0)(1,1,2)[4]                    : Inf
##  ARIMA(1,0,0)(1,1,2)[4] with drift         : 470.3593
##  ARIMA(1,0,0)(2,1,0)[4]                    : 479.003
```

```
##  ARIMA(1,0,0)(2,1,0)[4] with drift         : 467.6827
##  ARIMA(1,0,0)(2,1,1)[4]                    : Inf
##  ARIMA(1,0,0)(2,1,1)[4] with drift         : Inf
##  ARIMA(1,0,0)(2,1,2)[4]                    : Inf
##  ARIMA(1,0,0)(2,1,2)[4] with drift         : Inf
##  ARIMA(1,0,1)(0,1,0)[4]                    : Inf
##  ARIMA(1,0,1)(0,1,0)[4] with drift         : Inf
##  ARIMA(1,0,1)(0,1,1)[4]                    : Inf
##  ARIMA(1,0,1)(0,1,1)[4] with drift         : Inf
##  ARIMA(1,0,1)(0,1,2)[4]                    : Inf
##  ARIMA(1,0,1)(0,1,2)[4] with drift         : 468.402
##  ARIMA(1,0,1)(1,1,0)[4]                    : 476.1056
##  ARIMA(1,0,1)(1,1,0)[4] with drift         : 465.8273
##  ARIMA(1,0,1)(1,1,1)[4]                    : Inf
##  ARIMA(1,0,1)(1,1,1)[4] with drift         : 468.4575
##  ARIMA(1,0,1)(1,1,2)[4]                    : Inf
##  ARIMA(1,0,1)(1,1,2)[4] with drift         : 471.2257
##  ARIMA(1,0,1)(2,1,0)[4]                    : Inf
##  ARIMA(1,0,1)(2,1,0)[4] with drift         : 468.3843
##  ARIMA(1,0,1)(2,1,1)[4]                    : Inf
##  ARIMA(1,0,1)(2,1,1)[4] with drift         : 471.1831
##  ARIMA(1,0,2)(0,1,0)[4]                    : Inf
##  ARIMA(1,0,2)(0,1,0)[4] with drift         : 464.6516
##  ARIMA(1,0,2)(0,1,1)[4]                    : Inf
##  ARIMA(1,0,2)(0,1,1)[4] with drift         : 467.2088
##  ARIMA(1,0,2)(0,1,2)[4]                    : Inf
##  ARIMA(1,0,2)(0,1,2)[4] with drift         : 469.8688
##  ARIMA(1,0,2)(1,1,0)[4]                    : 478.6569
##  ARIMA(1,0,2)(1,1,0)[4] with drift         : 467.2294
##  ARIMA(1,0,2)(1,1,1)[4]                    : Inf
##  ARIMA(1,0,2)(1,1,1)[4] with drift         : 469.9434
##  ARIMA(1,0,2)(2,1,0)[4]                    : Inf
##  ARIMA(1,0,2)(2,1,0)[4] with drift         : 469.8591
##  ARIMA(1,0,3)(0,1,0)[4]                    : Inf
##  ARIMA(1,0,3)(0,1,0)[4] with drift         : 467.2929
##  ARIMA(1,0,3)(0,1,1)[4]                    : 479.4377
##  ARIMA(1,0,3)(0,1,1)[4] with drift         : 470.0283
##  ARIMA(1,0,3)(1,1,0)[4]                    : 478.7733
##  ARIMA(1,0,3)(1,1,0)[4] with drift         : 470.0456
##  ARIMA(2,0,0)(0,1,0)[4]                    : 477.3828
##  ARIMA(2,0,0)(0,1,0)[4] with drift         : 463.7953
##  ARIMA(2,0,0)(0,1,1)[4]                    : 479.0447
##  ARIMA(2,0,0)(0,1,1)[4] with drift         : 466.1856
##  ARIMA(2,0,0)(0,1,2)[4]                    : 481.5418
##  ARIMA(2,0,0)(0,1,2)[4] with drift         : 468.5617
##  ARIMA(2,0,0)(1,1,0)[4]                    : 478.9267
##  ARIMA(2,0,0)(1,1,0)[4] with drift         : 466.2211
##  ARIMA(2,0,0)(1,1,1)[4]                    : Inf
##  ARIMA(2,0,0)(1,1,1)[4] with drift         : 468.7711
##  ARIMA(2,0,0)(1,1,2)[4]                    : Inf
##  ARIMA(2,0,0)(1,1,2)[4] with drift         : 471.3825
##  ARIMA(2,0,0)(2,1,0)[4]                    : 481.1654
##  ARIMA(2,0,0)(2,1,0)[4] with drift         : 468.4353
##  ARIMA(2,0,0)(2,1,1)[4]                    : Inf
```

```
##  ARIMA(2,0,0)(2,1,1)[4] with drift         : 471.2644
##  ARIMA(2,0,1)(0,1,0)[4]                    : Inf
##  ARIMA(2,0,1)(0,1,0)[4] with drift         : 464.8322
##  ARIMA(2,0,1)(0,1,1)[4]                    : Inf
##  ARIMA(2,0,1)(0,1,1)[4] with drift         : 467.3269
##  ARIMA(2,0,1)(0,1,2)[4]                    : Inf
##  ARIMA(2,0,1)(0,1,2)[4] with drift         : 470
##  ARIMA(2,0,1)(1,1,0)[4]                    : Inf
##  ARIMA(2,0,1)(1,1,0)[4] with drift         : 467.357
##  ARIMA(2,0,1)(1,1,1)[4]                    : Inf
##  ARIMA(2,0,1)(1,1,1)[4] with drift         : 470.0541
##  ARIMA(2,0,1)(2,1,0)[4]                    : Inf
##  ARIMA(2,0,1)(2,1,0)[4] with drift         : 470.0117
##  ARIMA(2,0,2)(0,1,0)[4]                    : Inf
##  ARIMA(2,0,2)(0,1,0)[4] with drift         : 467.3005
##  ARIMA(2,0,2)(0,1,1)[4]                    : Inf
##  ARIMA(2,0,2)(0,1,1)[4] with drift         : 470.0152
##  ARIMA(2,0,2)(1,1,0)[4]                    : Inf
##  ARIMA(2,0,2)(1,1,0)[4] with drift         : 470.0353
##  ARIMA(2,0,3)(0,1,0)[4]                    : Inf
##  ARIMA(2,0,3)(0,1,0)[4] with drift         : Inf
##  ARIMA(3,0,0)(0,1,0)[4]                    : 474.9551
##  ARIMA(3,0,0)(0,1,0)[4] with drift         : 466.1771
##  ARIMA(3,0,0)(0,1,1)[4]                    : 477.4847
##  ARIMA(3,0,0)(0,1,1)[4] with drift         : 468.6746
##  ARIMA(3,0,0)(0,1,2)[4]                    : 480.1674
##  ARIMA(3,0,0)(0,1,2)[4] with drift         : 471.2193
##  ARIMA(3,0,0)(1,1,0)[4]                    : 477.4853
##  ARIMA(3,0,0)(1,1,0)[4] with drift         : 468.7171
##  ARIMA(3,0,0)(1,1,1)[4]                    : Inf
##  ARIMA(3,0,0)(1,1,1)[4] with drift         : 471.4241
##  ARIMA(3,0,0)(2,1,0)[4]                    : 480.1758
##  ARIMA(3,0,0)(2,1,0)[4] with drift         : 471.061
##  ARIMA(3,0,1)(0,1,0)[4]                    : Inf
##  ARIMA(3,0,1)(0,1,0)[4] with drift         : 467.3054
##  ARIMA(3,0,1)(0,1,1)[4]                    : Inf
##  ARIMA(3,0,1)(0,1,1)[4] with drift         : 470.0884
##  ARIMA(3,0,1)(1,1,0)[4]                    : Inf
##  ARIMA(3,0,1)(1,1,0)[4] with drift         : 471.4833
##  ARIMA(3,0,2)(0,1,0)[4]                    : Inf
##  ARIMA(3,0,2)(0,1,0)[4] with drift         : Inf
##
##
##
##  Best model: ARIMA(0,0,0)(0,1,0)[4] with drift
```

```
auto_fit
```

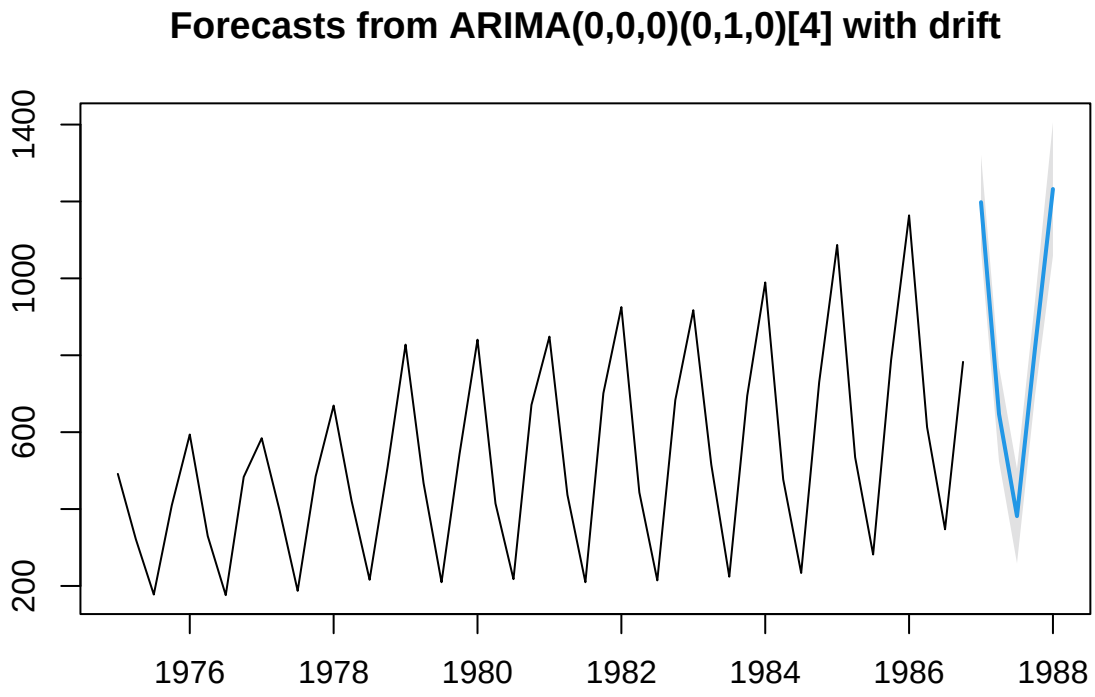
```
## Series: gasA1975
## ARIMA(0,0,0)(0,1,0)[4] with drift
##
## Coefficients:
##        drift
##       8.5591
## s.e.  1.6296
```

```
##
## sigma^2 estimated as 1913:  log likelihood=-228.17
## AIC=460.34   AICc=460.63   BIC=463.91
```

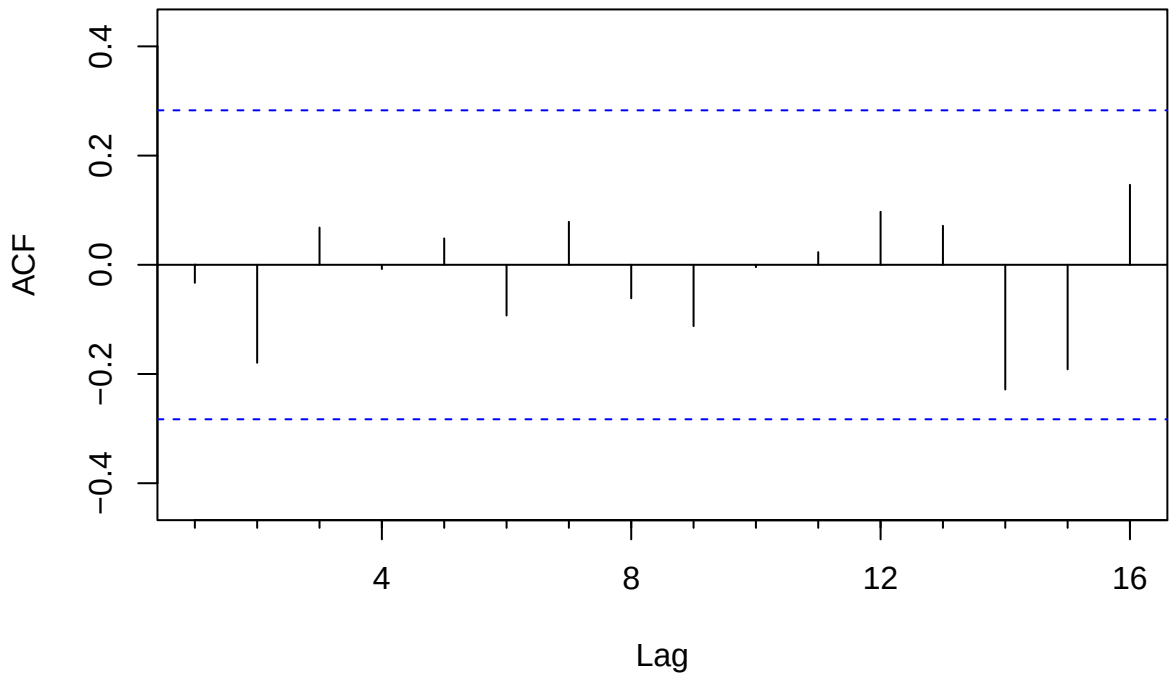
```
attributes(auto_fit)
```

```
## $names
##  [1] "coef"      "sigma2"    "var.coef"  "mask"      "loglik"    "aic"
##  [7] "arma"      "residuals" "call"      "series"    "code"      "n.cond"
## [13] "nobs"      "model"     "xreg"      "bic"       "aicc"      "x"
## [19] "fitted"
##
## $class
## [1] "forecast_ARIMA" "ARIMA"          "Arima"
```

```
plot(forecast(auto_fit,h=5,level=c(99.5)))
```




```
#Residual Analysis
Acf(auto_fit$residuals)
```



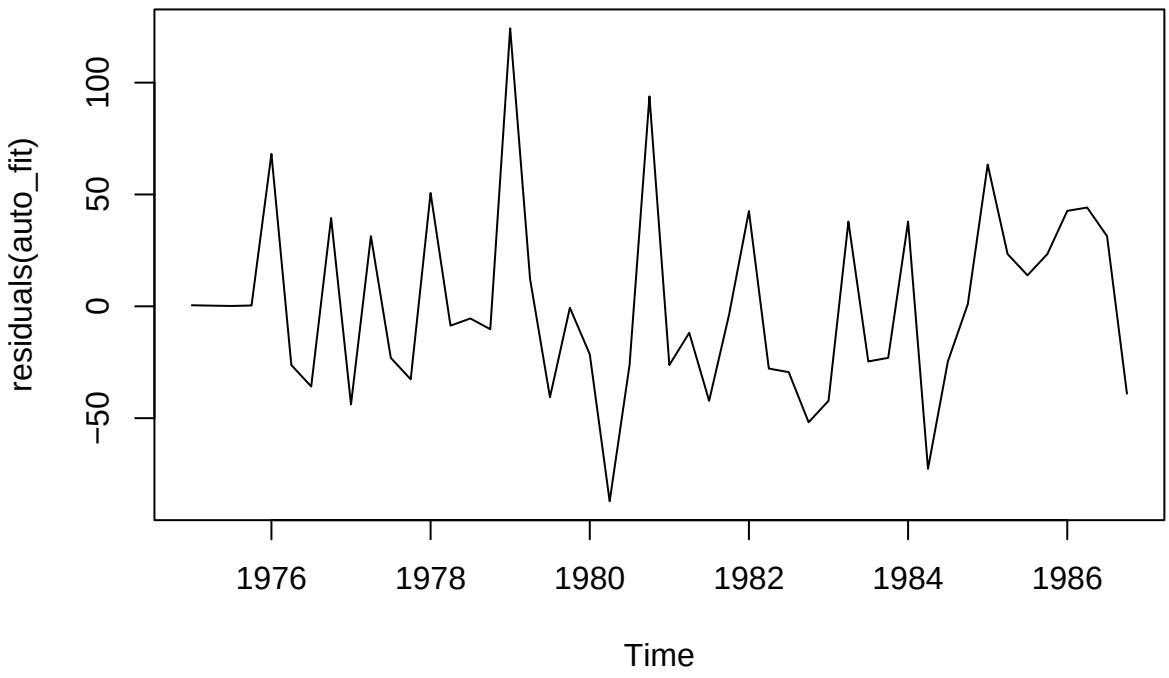

```
#no lag showing high correlation
Box.test(residuals(auto_fit), lag=20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  residuals(auto_fit)
## X-squared = 13.823, df = 20, p-value = 0.8394
```

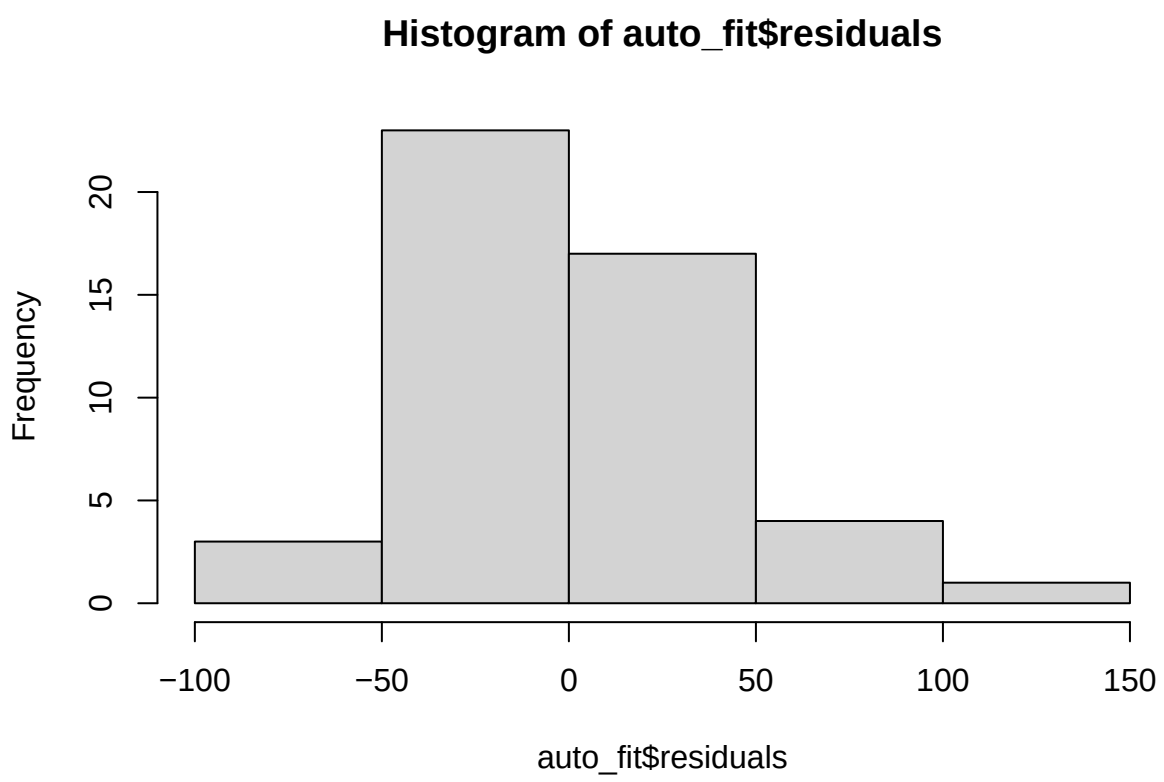
```
#The test statistic of the test the p-value of the test is 0.8394, which is much larger than 0.05. Thus
Box.test(residuals(auto_fit), lag=10, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  residuals(auto_fit)
## X-squared = 3.9763, df = 10, p-value = 0.9484
```

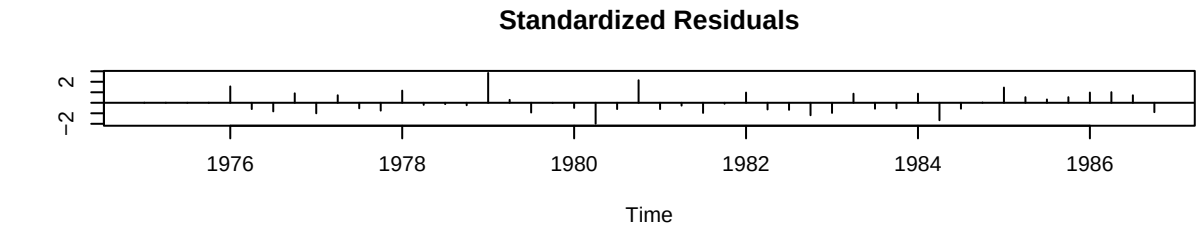
```
plot.ts(residuals(auto_fit))
```

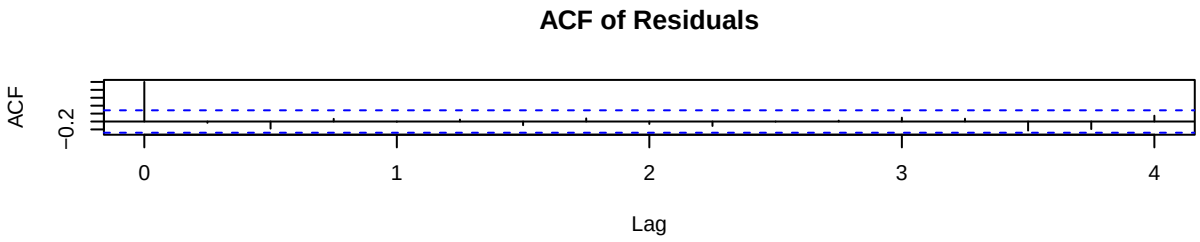


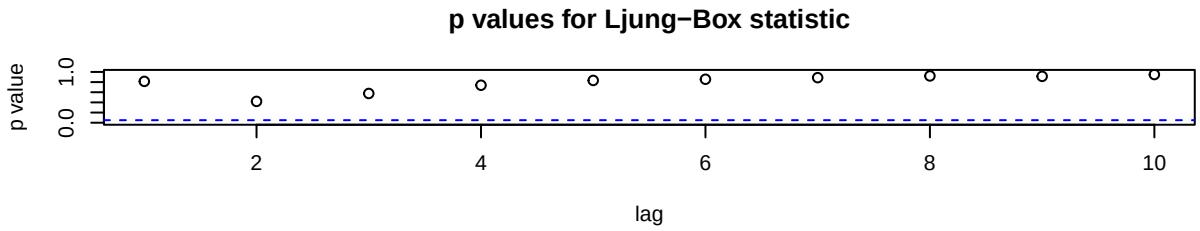

```
#plot is likely normal distribution and random but the histagram shows a right skewed distribution.
hist(auto_fit$residuals)
```




```
tsdiag(auto_fit)
```


Standardized Residuals
2
−2
1976
1978
1980
1982
1984
1986
Time


ACF of Residuals
ACF
−0.2
0
1
2
3
4
Lag


p values for Ljung−Box statistic
p value
0.0
1.0
2
4
6
8
10
lag