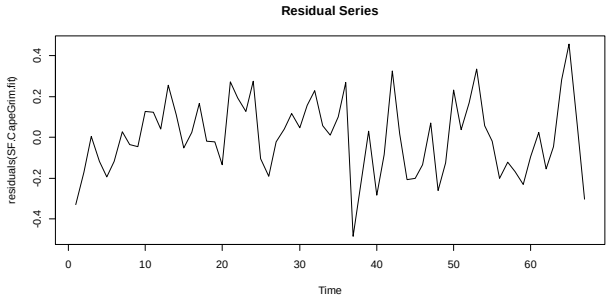
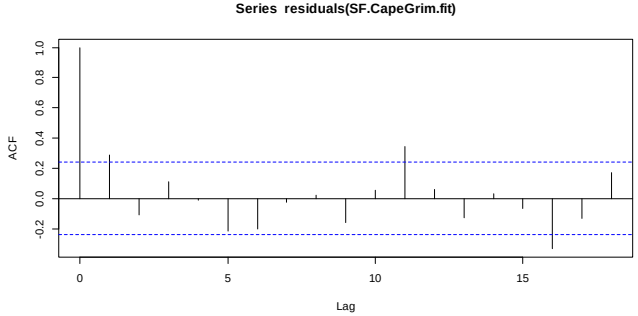
STATS 326
Applied Time Series
ASSIGNMENT THREE
R & MARKING GUIDE

Question One: (20 marks)

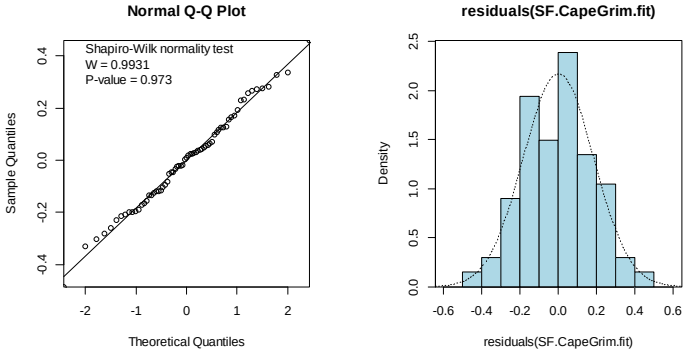
```
> Quarter = factor(rep(1:4,17))
> SF.CapeGrim.fit = lm(red.CO2.ts[-1]~Time[-1]+Time.break[-1]+
   Quarter[-1]+red.CO2.ts[-68])
> plot.ts(residuals(SF.CapeGrim.fit),main="Residual Series")
```




```
> acf(residuals(SF.CapeGrim.fit))
```




```
> normcheck(residuals(SF.CapeGrim.fit),shapiro.wilk=T)
```

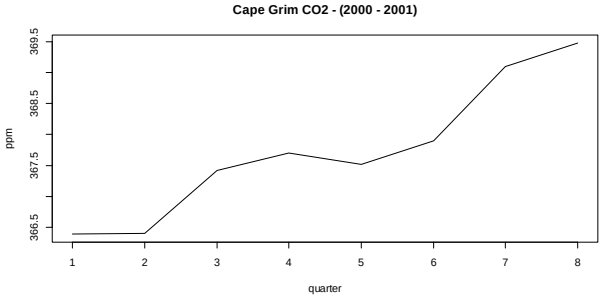



```
> summary(SF.CapeGrim.fit)

Call:
lm(formula = red.CO2.ts[-1] ~ Time[-1] + Time.break[-1] + Quarter[-1] +
    red.CO2.ts[-68])

Residuals:
     Min       1Q   Median       3Q      Max
-0.48589 -0.12979  0.01026  0.12082  0.45898

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     105.26875   30.24513   3.481 0.000939 ***
Time[-1]          0.14021    0.03972   3.530 0.000804 ***
Time.break[-1]    0.04703    0.01317   3.572 0.000707 ***
Quarter[-1]2      0.44507    0.08017   5.552 6.79e-07 ***
Quarter[-1]3      1.15836    0.07875  14.709  < 2e-16 ***
Quarter[-1]4      0.39766    0.07010   5.673 4.30e-07 ***
red.CO2.ts[-68]   0.71163    0.08275   8.600 4.68e-12 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1925 on 60 degrees of freedom
Multiple R-squared:  0.9997,    Adjusted R-squared:  0.9996
F-statistic: 2.927e+04 on 6 and 60 DF,  p-value: < 2.2e-16
```

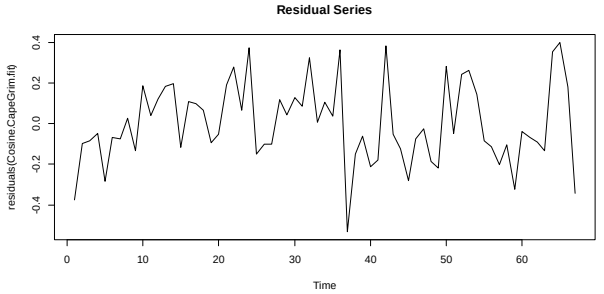
```
> t69.sf.pred = SF.CapeGrim.fit$coef[1]+SF.CapeGrim.fit$coef[2]*69+
   SF.CapeGrim.fit$coef[3]*19+SF.CapeGrim.fit$coef[7]*red.CO2.ts[68]
> t69.sf.pred
(Intercept)
    401.487

> t70.sf.pred = SF.CapeGrim.fit$coef[1]+SF.CapeGrim.fit$coef[2]*70+
   SF.CapeGrim.fit$coef[3]*20+SF.CapeGrim.fit$coef[4]+
   SF.CapeGrim.fit$coef[7]*t69sf.pred
> t70.sf.pred
(Intercept)
   402.1811

> t71.sf.pred = SF.CapeGrim.fit$coef[1]+SF.CapeGrim.fit$coef[2]*71+
   SF.CapeGrim.fit$coef[3]*21+SF.CapeGrim.fit$coef[5]+
   SF.CapeGrim.fit$coef[7]*t70sf.pred
> t71.sf.pred
(Intercept)
   403.5757

> t72.sf.pred = SF.CapeGrim.fit$coef[1]+SF.CapeGrim.fit$coef[2]*72+
   SF.CapeGrim.fit$coef[3]*22+SF.CapeGrim.fit$coef[6]+
   SF.CapeGrim.fit$coef[7]*t71sf.pred
> t72.sf.pred
(Intercept)
   403.9947

> SF.pred = c(t69.sf.pred,t70.sf.pred,t71.sf.pred,t72.sf.pred)
> names(SF.pred) = c("2017.1","2017.2","2017.3","2017.4")
> SF.pred
  2017.1   2017.2   2017.3   2017.4
401.4870 402.1811 403.5757 403.9947

> RMSEP.SF.CapeGrim = sqrt(1/4*sum((actual.2017-SF.pred)^2))
> RMSEP.SF.CapeGrim
[1] 0.3644395
```

<u>Question Two</u>: (25 marks)

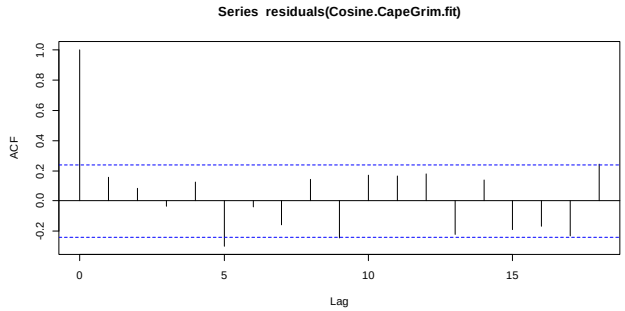
```
> plot.ts(red.CO2.ts[1:8],main="Cape Grim CO2 - (2000 -
   2001)",xlab="quarter",ylab="ppm")
```



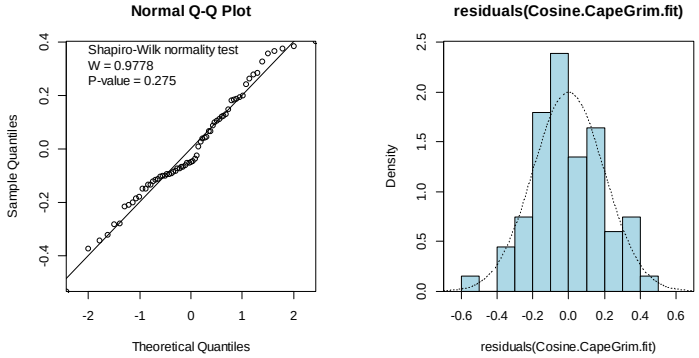

```
> Seasonal = cos((2*pi*(Time-3))/4)
> Cosine.CapeGrim.fit = lm(red.CO2.ts[-1]~Time[-1]+Time.break[-1]+
   Seasonal[-1]+red.CO2.ts[-68])
> plot.ts(residuals(Cosine.CapeGrim.fit),main="Residual Series")
```




```
> acf(residuals(Cosine.CapeGrim.fit))
```



```
> normcheck(residuals(Cosine.CapeGrim.fit),shapiro.wilk=T)
```

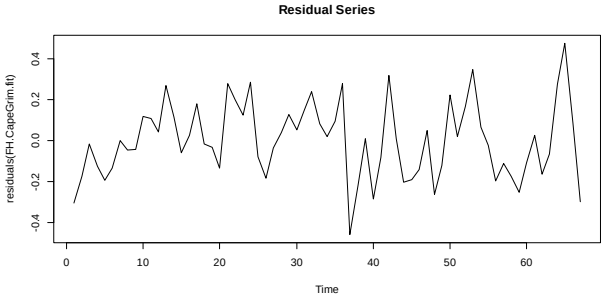



```
> summary(Cosine.CapeGrim.fit)

Call:
lm(formula = red.CO2.ts[-1] ~ Time[-1] + Time.break[-1] + Seasonal[-1] +
    red.CO2.ts[-68])

Residuals:
     Min       1Q   Median       3Q      Max
-0.53253 -0.11442 -0.04936  0.12633  0.40090

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     125.89258   23.02993   5.466 8.68e-07 ***
Time[-1]          0.16675    0.03030   5.504 7.53e-07 ***
Time.break[-1]    0.05389    0.01136   4.743 1.28e-05 ***
Seasonal[-1]      0.56793    0.03921  14.486  < 2e-16 ***
red.CO2.ts[-68]   0.65654    0.06304  10.414 3.04e-15 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2059 on 62 degrees of freedom
Multiple R-squared:  0.9996,    Adjusted R-squared:  0.9996
F-statistic: 3.84e+04 on 4 and 62 DF,  p-value: < 2.2e-16
```

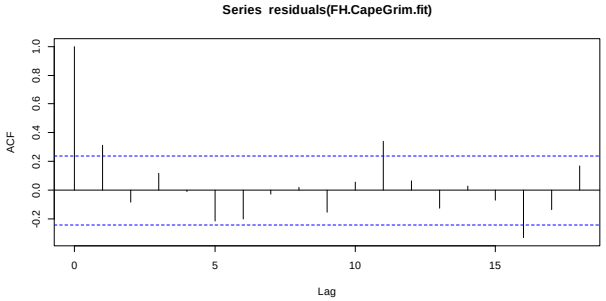
```
> t69.cos.pred = Cosine.CapeGrim.fit$coef[1]+
   Cosine.CapeGrim.fit$coef[2]*69+Cosine.CapeGrim.fit$coef[3]*19+
   Cosine.CapeGrim.fit$coef[4]*cos((2*pi*(69-3))/4)+
   Cosine.CapeGrim.fit$coef[5]*red.CO2.ts[68]
> t69.cos.pred
(Intercept)
   401.3885

> t70.cos.pred = Cosine.CapeGrim.fit$coef[1]+
   Cosine.CapeGrim.fit$coef[2]*70+Cosine.CapeGrim.fit$coef[3]*20+
   Cosine.CapeGrim.fit$coef[4]*cos((2*pi*(70-3))/4)+
   Cosine.CapeGrim.fit$coef[5]*t69.cos.pred
> t70.cos.pred
(Intercept)
   402.1695

> t71.cos.pred = Cosine.CapeGrim.fit$coef[1]+
   Cosine.CapeGrim.fit$coef[2]*71+Cosine.CapeGrim.fit$coef[3]*21+
   Cosine.CapeGrim.fit$coef[4]*cos((2*pi*(71-3))/4)+
   Cosine.CapeGrim.fit$coef[5]*t70.cos.pred
> t71.cos.pred
(Intercept)
   403.4708

> t72.cos.pred = Cosine.CapeGrim.fit$coef[1]+
   Cosine.CapeGrim.fit$coef[2]*72+Cosine.CapeGrim.fit$coef[3]*22+
   Cosine.CapeGrim.fit$coef[4]*cos((2*pi*(72-3))/4)+
   Cosine.CapeGrim.fit$coef[5]*t71.cos.pred
> t72.cos.pred
(Intercept)
   403.9779

> Cos.pred = c(t69.cos.pred,t70.cos.pred,t71.cos.pred,t72.cos.pred)
> names(Cos.pred) = c("2017.1","2017.2","2017.3","2017.4")
> Cos.pred
  2017.1   2017.2   2017.3   2017.4
401.3885 402.1695 403.4708 403.9779

> RMSEP.Cos.CapeGrim = sqrt(1/4*sum((actual.2017-Cos.pred)^2))
> RMSEP.Cos.CapeGrim
[1] 0.3101495
```

```
> c1 = cos(2*pi*Time*(1/4))
> s1 = sin(2*pi*Time*(1/4))
> c2 = cos(2*pi*Time*(2/4))

> FH.CapeGrim.fit = lm(red.CO2.ts[-1]~Time[-1]+Time.break[-1]+c1[-1]+
   s1[-1]+c2[-1]+red.CO2.ts[-68])
> summary(FH.CapeGrim.fit)

Call:
lm(formula = red.CO2.ts[-1] ~ Time[-1] + Time.break[-1] + c1[-1] +
    s1[-1] + c2[-1] + red.CO2.ts[-68])

Residuals:
     Min       1Q   Median       3Q      Max
-0.48589 -0.12979  0.01026  0.12082  0.45898

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)     105.76902   30.22886   3.499 0.000887 ***
Time[-1]          0.14021    0.03972   3.530 0.000804 ***
Time.break[-1]    0.04703    0.01317   3.572 0.000707 ***
c1[-1]           -0.02370    0.04598  -0.515 0.608103
s1[-1]           -0.57918    0.03938 -14.709  < 2e-16 ***
c2[-1]           -0.07891    0.02394  -3.296 0.001649 **
red.CO2.ts[-68]   0.71163    0.08275   8.600 4.68e-12 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1925 on 60 degrees of freedom
Multiple R-squared:  0.9997,    Adjusted R-squared:  0.9996
F-statistic: 2.927e+04 on 6 and 60 DF,  p-value: < 2.2e-16
```

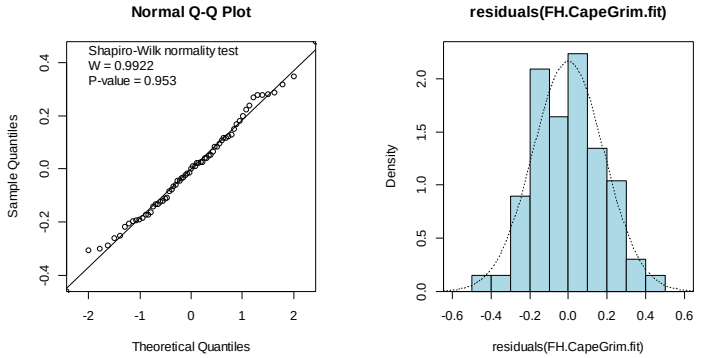
```
> RH.CapeGrim.fit = lm(red.CO2.ts[-1]~Time[-1]+Time.break[-1]+s1[-1]+
   c2[-1]+red.CO2.ts[-68])
> plot.ts(residuals(RH.CapeGrim.fit),main="Residual Series")
```




```
> acf(residuals(RH.CapeGrim.fit))
```




```
> normcheck(residuals(RH.CapeGrim.fit),shapiro.wilk=T)
```



```
> summary(RH.CapeGrim.fit)

Call:
lm(formula = red.CO2.ts[-1] ~ Time[-1] + Time.break[-1] + s1[-1] +
    c2[-1] + red.CO2.ts[-68])

Residuals:
     Min       1Q   Median       3Q      Max
-0.45882 -0.13281  0.00092  0.11672  0.47718

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     116.60269   21.59681   5.399 1.16e-06 ***
Time[-1]          0.15443    0.02841   5.435 1.02e-06 ***
Time.break[-1]    0.05101    0.01060   4.813 1.02e-05 ***
s1[-1]           -0.57181    0.03647 -15.680  < 2e-16 ***
c2[-1]           -0.07734    0.02360  -3.277  0.00173 **
red.CO2.ts[-68]   0.68198    0.05912  11.535  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1914 on 61 degrees of freedom
Multiple R-squared:  0.9997,    Adjusted R-squared:  0.9996
F-statistic: 3.555e+04 on 5 and 61 DF,  p-value: < 2.2e-16
```

```
> t69.rh.pred = RH.CapeGrim.fit$coef[1]+RH.CapeGrim.fit$coef[2]*69+
  RH.CapeGrim.fit$coef[3]*19+RH.CapeGrim.fit$coef[4]*sin(2*pi*69*(1/4))+
  RH.CapeGrim.fit$coef[5]*cos(2*pi*69*(2/4))+
  RH.CapeGrim.fit$coef[6]*red.CO2.ts[68]
> t69.rh.pred
(Intercept)
   401.4792

> t70.rh.pred = RH.CapeGrim.fit$coef[1]+RH.CapeGrim.fit$coef[2]*70+
  RH.CapeGrim.fit$coef[3]*20+RH.CapeGrim.fit$coef[4]*sin(2*pi*70*(1/4))+
  RH.CapeGrim.fit$coef[5]*cos(2*pi*70*(2/4))+
  RH.CapeGrim.fit$coef[6]*t69.rh.pred
> t70.rh.pred
(Intercept)
   402.1558

> t71.rh.pred = RH.CapeGrim.fit$coef[1]+RH.CapeGrim.fit$coef[2]*71+
  RH.CapeGrim.fit$coef[3]*21+RH.CapeGrim.fit$coef[4]*sin(2*pi*71*(1/4))+
  RH.CapeGrim.fit$coef[5]*cos(2*pi*71*(2/4))+
  RH.CapeGrim.fit$coef[6]*t70.rh.pred
> t71.rh.pred
(Intercept)
   403.5492

> t72.rh.pred = RH.CapeGrim.fit$coef[1]+RH.CapeGrim.fit$coef[2]*72+
  RH.CapeGrim.fit$coef[3]*22+RH.CapeGrim.fit$coef[4]*sin(2*pi*72*(1/4))+
  RH.CapeGrim.fit$coef[5]*cos(2*pi*72*(2/4))+
  RH.CapeGrim.fit$coef[6]*t71.rh.pred
> t72.rh.pred
(Intercept)
   403.9784

> RH.pred = c(t69.rh.pred,t70.rh.pred,t71.rh.pred,t72.rh.pred)
> names(RH.pred) = c("2017.1","2017.2","2017.3","2017.4")
> RH.pred
  2017.1   2017.2   2017.3   2017.4
401.4792 402.1558 403.5492 403.9784

> RMSEP.RH.CapeGrim = sqrt(1/4*sum((actual.2017-RH.pred)^2))
> RMSEP.RH.CapeGrim
[1] 0.3446073
```

Question Three: (30 marks)

Tech Notes

Question Four: (20 marks)

```
> Seasonal.F = cos((2*pi*(Time.F-3))/4)
> Cosine.CapeGrim.F.fit = lm(CO2.ts[-1]~Time.F[-1]+Time.break.F[-1]+
   Seasonal.F[-1]+CO2.ts[-72])
> summary(Cosine.CapeGrim.F.fit)

Call:
lm(formula = CO2.ts[-1] ~ Time.F[-1] + Time.break.F[-1] + Seasonal.F[-1] +
    CO2.ts[-72])

Residuals:
     Min       1Q   Median       3Q      Max
-0.54086 -0.11554 -0.03662  0.11992  0.45400

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)      123.49375   22.30337   5.537 5.74e-07 ***
Time.F[-1]         0.16397    0.02935   5.587 4.72e-07 ***
Time.break.F[-1]   0.04867    0.01017   4.787 9.93e-06 ***
Seasonal.F[-1]     0.57480    0.03778  15.214  < 2e-16 ***
CO2.ts[-72]        0.66309    0.06106  10.860 2.47e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2025 on 66 degrees of freedom
Multiple R-squared:  0.9997,    Adjusted R-squared:  0.9996
F-statistic: 4.845e+04 on 4 and 66 DF,  p-value: < 2.2e-16

> t73.cos.pred = Cosine.CapeGrim.F.fit$coef[1]+
   Cosine.CapeGrim.F.fit$coef[2]*73+Cosine.CapeGrim.F.fit$coef[3]*23+
   Cosine.CapeGrim.F.fit$coef[4]*cos((2*pi*(73-3))/4)+
   Cosine.CapeGrim.F.fit$coef[5]*CO2.ts[72]
> t73.cos.pred
(Intercept)
   403.6894

> t74.cos.pred = Cosine.CapeGrim.F.fit$coef[1]+
   Cosine.CapeGrim.F.fit$coef[2]*74+Cosine.CapeGrim.F.fit$coef[3]*24+
   Cosine.CapeGrim.F.fit$coef[4]*cos((2*pi*(74-3))/4)+
   Cosine.CapeGrim.F.fit$coef[5]*t73.cos.pred
> t74.cos.pred
(Intercept)
   404.4765

> t75.cos.pred = Cosine.CapeGrim.F.fit$coef[1]+
   Cosine.CapeGrim.F.fit$coef[2]*75+Cosine.CapeGrim.F.fit$coef[3]*25+
   Cosine.CapeGrim.F.fit$coef[4]*cos((2*pi*(75-3))/4)+
   Cosine.CapeGrim.F.fit$coef[5]*t74.cos.pred
> t75.cos.pred
(Intercept)
   405.7858

> t76.cos.pred = Cosine.CapeGrim.F.fit$coef[1]+
   Cosine.CapeGrim.F.fit$coef[2]*76+Cosine.CapeGrim.F.fit$coef[3]*26+
   Cosine.CapeGrim.F.fit$coef[4]*cos((2*pi*(76-3))/4)+
   Cosine.CapeGrim.F.fit$coef[5]*t75.cos.pred
> t76.cos.pred
(Intercept)
   406.2918
```