

Stat3032_Homework7

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Answer for 10.2

```
Highway$sigs1 = (Highway$sigs * Highway$len + 1) / Highway$len
m102b <- lm(log(rate) ~ log(len), data = Highway)
m102t <- lm(log(rate) ~ log(len) + slim + acpt + shld + log(sigs1)
           + htype + log(trks) + log(adt) + lane + itg + lwid, data = Highway)
```

Answer for 10.2.1

Forward Selection

```
step(m102b, scope = list(upper = ~ log(len) + slim + acpt + shld
                        + log(sigs1) + htype + log(trks) + log(adt)
                        + lane + itg + lwid), direction = "forward")
```

```
## Start:  AIC=-72.51
## log(rate) ~ log(len)
##
##           Df Sum of Sq  RSS    AIC
## + slim      1  2.54718 2.9366 -94.866
## + acpt      1  2.10148 3.3823 -89.355
## + shld      1  1.70693 3.7769 -85.052
## + log(sigs1) 1  0.96128 4.5225 -78.025
## + htype     3  1.33997 4.1438 -77.436
## + log(trks) 1  0.72812 4.7557 -76.065
## + log(adtt) 1  0.42857 5.0552 -73.682
## <none>                5.4838 -72.509
## + lane      1  0.26267 5.2211 -72.423
## + itg       1  0.21704 5.2667 -72.084
## + lwid      1  0.18502 5.2988 -71.847
##
## Step:  AIC=-94.87
## log(rate) ~ log(len) + slim
##
##           Df Sum of Sq  RSS    AIC
## + acpt      1  0.28844 2.6482 -96.898
## + log(trks) 1  0.26317 2.6734 -96.528
## <none>                2.9366 -94.866
## + log(sigs1) 1  0.14671 2.7899 -94.865
## + htype     3  0.33646 2.6002 -93.612
## + shld      1  0.03265 2.9040 -93.302
## + log(adtt) 1  0.02563 2.9110 -93.208
## + lwid      1  0.01664 2.9200 -93.088
## + lane      1  0.00343 2.9332 -92.912
## + itg       1  0.00265 2.9340 -92.901
##
## Step:  AIC=-96.9
## log(rate) ~ log(len) + slim + acpt
##
##           Df Sum of Sq  RSS    AIC
## + log(trks) 1  0.172940 2.4752 -97.532
## <none>                2.6482 -96.898
## + log(sigs1) 1  0.120061 2.5281 -96.708
## + shld      1  0.034595 2.6136 -95.411
## + log(adtt) 1  0.015190 2.6330 -95.122
## + lane      1  0.014872 2.6333 -95.118
## + itg       1  0.013501 2.6347 -95.097
## + lwid      1  0.012646 2.6355 -95.085
## + htype     3  0.217478 2.4307 -94.240
##
## Step:  AIC=-97.53
```

```
## log(rate) ~ log(len) + slim + acpt + log(trks)
##
##           Df Sum of Sq    RSS    AIC
## <none>                2.4752 -97.532
## + shld             1  0.065299 2.4099 -96.575
## + log(sigs1)       1  0.050568 2.4247 -96.337
## + log(adtt)        1  0.031220 2.4440 -96.027
## + htype           3  0.259505 2.2157 -95.851
## + lwid             1  0.019009 2.4562 -95.833
## + itg             1  0.010964 2.4643 -95.705
## + lane            1  0.003299 2.4719 -95.584
```

```
##
## Call:
## lm(formula = log(rate) ~ log(len) + slim + acpt + log(trks),
##     data = Highway)
##
## Coefficients:
## (Intercept)      log(len)          slim          acpt      log(trks)
##      4.16654      -0.23573      -0.03185       0.01100      -0.32904
```

Backward Elimination

```
step(m102t, scope = list(lower = ~ log(len) + shld), direction = "backward")
```

```

## Start:  AIC=-94.2
## log(rate) ~ log(len) + slim + acpt + shld + log(sigs1) + htype +
##      log(trks) + log(adt) + lane + itg + lwid
##
##           Df Sum of Sq   RSS   AIC
## - itg      1   0.00147 1.7008 -96.166
## - lane      1   0.00259 1.7019 -96.140
## - lwid      1   0.00644 1.7058 -96.052
## - acpt      1   0.03790 1.7372 -95.339
## - log(trks) 1   0.04613 1.7455 -95.155
## <none>                1.6993 -94.199
## - htype     3   0.30045 1.9998 -93.850
## - log(adt)   1   0.12981 1.8292 -93.329
## - slim      1   0.17897 1.8783 -92.294
## - log(sigs1) 1   0.44263 2.1420 -87.172
##
## Step:  AIC=-96.17
## log(rate) ~ log(len) + slim + acpt + shld + log(sigs1) + htype +
##      log(trks) + log(adt) + lane + lwid
##
##           Df Sum of Sq   RSS   AIC
## - lane      1   0.00234 1.7031 -98.112
## - lwid      1   0.00581 1.7066 -98.033
## - acpt      1   0.03689 1.7377 -97.329
## - log(trks) 1   0.04784 1.7487 -97.084
## <none>                1.7008 -96.166
## - log(adt)   1   0.14725 1.8481 -94.927
## - slim      1   0.18564 1.8864 -94.126
## - htype     3   0.48260 2.1834 -92.424
## - log(sigs1) 1   0.44308 2.1439 -89.137
##
## Step:  AIC=-98.11
## log(rate) ~ log(len) + slim + acpt + shld + log(sigs1) + htype +
##      log(trks) + log(adt) + lwid
##
##           Df Sum of Sq   RSS   AIC
## - lwid      1   0.00703 1.7102 -99.952
## - acpt      1   0.03748 1.7406 -99.263
## - log(trks) 1   0.04592 1.7491 -99.075
## <none>                1.7031 -98.112
## - log(adt)   1   0.17501 1.8782 -96.297
## - slim      1   0.19095 1.8941 -95.968
## - htype     3   0.52730 2.2304 -93.593
## - log(sigs1) 1   0.44654 2.1497 -91.031
##
## Step:  AIC=-99.95

```

```
## log(rate) ~ log(len) + slim + acpt + shld + log(sigs1) + htype +
##   log(trks) + log(adt)
##
##           Df Sum of Sq   RSS   AIC
## - acpt      1   0.05113 1.7613 -100.803
## - log(trks)  1   0.06324 1.7734 -100.535
## <none>                        1.7102 -99.952
## - log(adt)   1   0.16966 1.8798 -98.263
## - slim      1   0.20178 1.9120 -97.602
## - htype     3   0.55760 2.2678 -94.946
## - log(sigs1) 1   0.48450 2.1947 -92.224
##
## Step:  AIC=-100.8
## log(rate) ~ log(len) + slim + shld + log(sigs1) + htype + log(trks) +
##   log(adt)
##
##           Df Sum of Sq   RSS   AIC
## - log(trks)  1   0.06417 1.8255 -101.407
## <none>                        1.7613 -100.803
## - log(adt)   1   0.14794 1.9093 -99.657
## - slim      1   0.37682 2.1381 -95.242
## - htype     3   0.67509 2.4364 -94.149
## - log(sigs1) 1   0.55708 2.3184 -92.085
##
## Step:  AIC=-101.41
## log(rate) ~ log(len) + slim + shld + log(sigs1) + htype + log(adt)
##
##           Df Sum of Sq   RSS   AIC
## <none>                        1.8255 -101.407
## - log(adt)   1   0.14334 1.9688 -100.459
## - slim      1   0.39979 2.2253 -95.684
## - htype     3   0.77683 2.6023 -93.579
## - log(sigs1) 1   0.75144 2.5769 -89.962
```

```
##
## Call:
## lm(formula = log(rate) ~ log(len) + slim + shld + log(sigs1) +
##   htype + log(adt), data = Highway)
##
## Coefficients:
## (Intercept)    log(len)        slim        shld    log(sigs1)
##      4.42937     -0.25768     -0.03190      0.00681      0.20838
## htypefai    htypepa    htypema    log(adt)
##      0.11833     -0.38224     -0.14106     -0.13099
```

Answer for 10.2.2

```
m1022b <- lm(log(rate * len) ~ 1, data = Highway)
m1022t <- lm(log(rate * len) ~ slim + acpt + shld + log(sigs1)
             + htype + log(trks) + log(adt) + lane + itg + lwid, data = Highway)
```

Forward

```
step(m1022b, scope = list(upper = ~ slim + acpt + shld
                          + log(sigs1) + htype + log(trks) + log(adt) + lane
                          + itg + lwid), direction = "forward")
```

```
## Start: AIC=-51.71
## log(rate * len) ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + shld      1  2.23119  7.6078 -59.741
## + log(adtl)  1  2.13123  7.7078 -59.232
## + htype     3  2.24274  7.5963 -55.800
## + lane      1  1.05230  8.7867 -54.122
## + lwid      1  1.03754  8.8015 -54.057
## + slim      1  0.97712  8.8619 -53.790
## + itg       1  0.87822  8.9608 -53.357
## + acpt      1  0.51519  9.3238 -51.808
## <none>                        9.8390 -51.711
## + log(sigs1) 1  0.12032  9.7187 -50.191
## + log(trks)  1  0.09532  9.7437 -50.091
##
## Step: AIC=-59.74
## log(rate * len) ~ shld
##
##           Df Sum of Sq    RSS    AIC
## + lwid      1  1.17434  6.4335 -64.280
## + log(adtl)  1  0.65583  6.9520 -61.257
## <none>                        7.6078 -59.741
## + itg       1  0.16535  7.4425 -58.598
## + log(sigs1) 1  0.14934  7.4585 -58.514
## + lane      1  0.12209  7.4858 -58.372
## + log(trks)  1  0.10113  7.5067 -58.263
## + acpt      1  0.00841  7.5994 -57.784
## + slim      1  0.00315  7.6047 -57.757
## + htype     3  0.50543  7.1024 -56.422
##
## Step: AIC=-64.28
## log(rate * len) ~ shld + lwid
##
##           Df Sum of Sq    RSS    AIC
## <none>                        6.4335 -64.280
## + log(adtl)  1  0.256905  6.1766 -63.869
## + log(sigs1) 1  0.105865  6.3276 -62.927
## + itg       1  0.072722  6.3608 -62.723
## + slim      1  0.063538  6.3700 -62.667
## + lane      1  0.042924  6.3906 -62.541
## + log(trks)  1  0.023656  6.4098 -62.423
## + acpt      1  0.000383  6.4331 -62.282
## + htype     3  0.224798  6.2087 -59.667
```

```
##
## Call:
## lm(formula = log(rate * len) ~ shld + lwid, data = Highway)
##
## Coefficients:
## (Intercept)      shld      lwid
##      8.82649     -0.08229     -0.38597
```

```
final.model.fs = lm(log(rate) + log(len) ~ lwid + shld, data = Highway)
summary(final.model.fs)
```

```
##
## Call:
## lm(formula = log(rate) + log(len) ~ lwid + shld, data = Highway)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.93871 -0.25541  0.02587  0.20973  0.79116
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  8.82649     1.81366   4.867 2.26e-05 ***
## lwid        -0.38597     0.15057  -2.563 0.014686 *
## shld        -0.08229     0.02261  -3.640 0.000849 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4227 on 36 degrees of freedom
## Multiple R-squared:  0.3461, Adjusted R-squared:  0.3098
## F-statistic: 9.528 on 2 and 36 DF, p-value: 0.0004774
```

This summary indicates that $\log(\text{rate}) + \log(\text{len}) \sim \text{lwid} + \text{shld}$ is a good model ##### Backward

```
step(m1022t, scope = list(lower = ~ lwid), direction = "backward")
```



```
## Start: AIC=-47.69
## log(rate * len) ~ slim + acpt + shld + log(sigs1) + htype + log(trks) +
##     log(adtt) + lane + itg + lwid
##
##           Df Sum of Sq    RSS    AIC
## - htype      3   0.18628 6.0812 -52.476
## - log(trks)   1   0.00007 5.8950 -49.689
## - slim        1   0.00200 5.8969 -49.676
## - lane        1   0.00242 5.8973 -49.673
## - log(sigs1)  1   0.00521 5.9001 -49.655
## - itg         1   0.04647 5.9414 -49.383
## - acpt        1   0.04806 5.9430 -49.373
## - log(adtt)   1   0.08268 5.9776 -49.146
## <none>                5.8949 -47.689
## - shld        1   0.35127 6.2462 -47.432
##
## Step: AIC=-52.48
## log(rate * len) ~ slim + acpt + shld + log(sigs1) + log(trks) +
##     log(adtt) + lane + itg + lwid
##
##           Df Sum of Sq    RSS    AIC
## - log(sigs1)  1   0.00066 6.0818 -54.472
## - itg         1   0.00112 6.0823 -54.469
## - log(trks)   1   0.00377 6.0850 -54.452
## - slim        1   0.00860 6.0898 -54.421
## - lane        1   0.03960 6.1208 -54.223
## - acpt        1   0.05202 6.1332 -54.144
## - log(adtt)   1   0.12314 6.2043 -53.694
## <none>                6.0812 -52.476
## - shld        1   0.46029 6.5415 -51.631
##
## Step: AIC=-54.47
## log(rate * len) ~ slim + acpt + shld + log(trks) + log(adtt) +
##     lane + itg + lwid
##
##           Df Sum of Sq    RSS    AIC
## - itg         1   0.00278 6.0846 -56.454
## - log(trks)   1   0.00575 6.0876 -56.435
## - slim        1   0.01142 6.0933 -56.399
## - lane        1   0.03905 6.1209 -56.222
## - acpt        1   0.05149 6.1333 -56.143
## - log(adtt)   1   0.18006 6.2619 -55.334
## <none>                6.0818 -54.472
## - shld        1   0.45999 6.5418 -53.628
##
## Step: AIC=-56.45
```

```
## log(rate * len) ~ slim + acpt + shld + log(trks) + log(adt) +
##   lane + lwid
##
##           Df Sum of Sq   RSS   AIC
## - log(trks)  1   0.00622 6.0908 -58.414
## - slim      1   0.01385 6.0985 -58.365
## - lane      1   0.04755 6.1322 -58.151
## - acpt      1   0.05046 6.1351 -58.132
## - log(adt)  1   0.21226 6.2969 -57.117
## <none>                        6.0846 -56.454
## - shld      1   0.50076 6.5854 -55.370
##
## Step:  AIC=-58.41
## log(rate * len) ~ slim + acpt + shld + log(adt) + lane + lwid
##
##           Df Sum of Sq   RSS   AIC
## - slim      1   0.02034 6.1112 -60.284
## - lane      1   0.04412 6.1350 -60.133
## - acpt      1   0.04472 6.1356 -60.129
## - log(adt)  1   0.21095 6.3018 -59.086
## <none>                        6.0908 -58.414
## - shld      1   0.55605 6.6469 -57.007
##
## Step:  AIC=-60.28
## log(rate * len) ~ acpt + shld + log(adt) + lane + lwid
##
##           Df Sum of Sq   RSS   AIC
## - acpt      1   0.02530 6.1365 -62.123
## - lane      1   0.05111 6.1623 -61.959
## - log(adt)  1   0.27897 6.3902 -60.543
## <none>                        6.1112 -60.284
## - shld      1   0.75088 6.8621 -57.765
##
## Step:  AIC=-62.12
## log(rate * len) ~ shld + log(adt) + lane + lwid
##
##           Df Sum of Sq   RSS   AIC
## - lane      1   0.04011 6.1766 -63.869
## - log(adt)  1   0.25409 6.3906 -62.541
## <none>                        6.1365 -62.123
## - shld      1   1.08816 7.2246 -57.756
##
## Step:  AIC=-63.87
## log(rate * len) ~ shld + log(adt) + lwid
##
##           Df Sum of Sq   RSS   AIC
```

```
## - log(adtl) 1 0.25691 6.4335 -64.280
## <none> 6.1766 -63.869
## - shld 1 1.05141 7.2280 -59.738
##
## Step: AIC=-64.28
## log(rate * len) ~ shld + lwid
##
##          Df Sum of Sq    RSS    AIC
## <none>          6.4335 -64.280
## - shld 1      2.368 8.8015 -54.057
```

```
##
## Call:
## lm(formula = log(rate * len) ~ shld + lwid, data = Highway)
##
## Coefficients:
## (Intercept)      shld      lwid
##      8.82649     -0.08229     -0.38597
```

```
final.model.be = lm(log(rate) + log(len) ~ shld + lwid, data = Highway)
summary(final.model.be)
```

```
##
## Call:
## lm(formula = log(rate) + log(len) ~ shld + lwid, data = Highway)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.93871 -0.25541  0.02587  0.20973  0.79116
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  8.82649     1.81366   4.867 2.26e-05 ***
## shld        -0.08229     0.02261  -3.640 0.000849 ***
## lwid        -0.38597     0.15057  -2.563 0.014686 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4227 on 36 degrees of freedom
## Multiple R-squared:  0.3461, Adjusted R-squared:  0.3098
## F-statistic: 9.528 on 2 and 36 DF, p-value: 0.0004774
```

This indicates that $\log(\text{rate}) + \log(\text{len}) \sim \text{shld} + \text{lwid}$ is a good model by both forward and backward test.

Answer for 10.2.3

Forward

```
m1022boffset <- lm(log(rate) ~ 1, data = Highway, offset = -log(len))
stepAIC(m1022boffset, scope = list(upper = ~ slim + acpt + shld
                                   + log(sigs1) + htype + log(trks) + log(adt) + lane
                                   + itg + lwid,
                                   lower = ~ 1), direction = "forward")
```

```
## Start: AIC=-51.71
## log(rate) ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + shld      1  2.23119  7.6078 -59.741
## + log(adtl)  1  2.13123  7.7078 -59.232
## + htype     3  2.24274  7.5963 -55.800
## + lane      1  1.05230  8.7867 -54.122
## + lwid      1  1.03754  8.8015 -54.057
## + slim      1  0.97712  8.8619 -53.790
## + itg       1  0.87822  8.9608 -53.357
## + acpt      1  0.51519  9.3238 -51.808
## <none>                        9.8390 -51.711
## + log(sigs1) 1  0.12032  9.7187 -50.191
## + log(trks)  1  0.09532  9.7437 -50.091
##
## Step: AIC=-59.74
## log(rate) ~ shld
##
##           Df Sum of Sq    RSS    AIC
## + lwid      1  1.17434  6.4335 -64.280
## + log(adtl)  1  0.65583  6.9520 -61.257
## <none>                        7.6078 -59.741
## + itg       1  0.16535  7.4425 -58.598
## + log(sigs1) 1  0.14934  7.4585 -58.514
## + lane      1  0.12209  7.4858 -58.372
## + log(trks)  1  0.10113  7.5067 -58.263
## + acpt      1  0.00841  7.5994 -57.784
## + slim      1  0.00315  7.6047 -57.757
## + htype     3  0.50543  7.1024 -56.422
##
## Step: AIC=-64.28
## log(rate) ~ shld + lwid
##
##           Df Sum of Sq    RSS    AIC
## <none>                        6.4335 -64.280
## + log(adtl)  1  0.256905  6.1766 -63.869
## + log(sigs1) 1  0.105865  6.3276 -62.927
## + itg       1  0.072722  6.3608 -62.723
## + slim      1  0.063538  6.3700 -62.667
## + lane      1  0.042924  6.3906 -62.541
## + log(trks)  1  0.023656  6.4098 -62.423
## + acpt      1  0.000383  6.4331 -62.282
## + htype     3  0.224798  6.2087 -59.667
```

```
##
## Call:
## lm(formula = log(rate) ~ shld + lwid, data = Highway, offset = -log(len))
##
## Coefficients:
## (Intercept)      shld      lwid
##      8.82649     -0.08229     -0.38597
```

```
final.model.fs.offset = lm(log(rate) ~ lwid + shld,
                           data = Highway, offset = -log(len))
summary(final.model.fs.offset)
```

```
##
## Call:
## lm(formula = log(rate) ~ lwid + shld, data = Highway, offset = -log(len))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.93871 -0.25541  0.02587  0.20973  0.79116
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  8.82649     1.81366   4.867 2.26e-05 ***
## lwid        -0.38597     0.15057  -2.563 0.014686 *
## shld        -0.08229     0.02261  -3.640 0.000849 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4227 on 36 degrees of freedom
## Multiple R-squared:  0.6824, Adjusted R-squared:  0.6648
## F-statistic: 38.68 on 2 and 36 DF, p-value: 1.08e-09
```

This indicates that even we set $\log(\text{len})$ as an offset, the we will still get the same model from compare AIC. ##### Backward

```
m1022toffset = lm(log(rate) ~ slim + acpt + shld + log(sigs1)
                  + htype + log(trks) + log(adtt) + lane + itg
                  + lwid, data = Highway, offset = - log(len))
stepAIC(m1022toffset, scope = list(lower = ~ 1), direction = "backward")
```

```

## Start:  AIC=-47.69
## log(rate) ~ slim + acpt + shld + log(sigs1) + htype + log(trks) +
##      log(adtt) + lane + itg + lwid
##
##           Df Sum of Sq    RSS      AIC
## - htype      3   0.18628 6.0812 -52.476
## - log(trks)   1   0.00007 5.8950 -49.689
## - slim        1   0.00200 5.8969 -49.676
## - lane        1   0.00242 5.8973 -49.673
## - log(sigs1)  1   0.00521 5.9001 -49.655
## - itg         1   0.04647 5.9414 -49.383
## - acpt        1   0.04806 5.9430 -49.373
## - log(adtt)   1   0.08268 5.9776 -49.146
## <none>                5.8949 -47.689
## - shld        1   0.35127 6.2462 -47.432
## - lwid        1   0.49962 6.3945 -46.517
##
## Step:  AIC=-52.48
## log(rate) ~ slim + acpt + shld + log(sigs1) + log(trks) + log(adtt) +
##      lane + itg + lwid
##
##           Df Sum of Sq    RSS      AIC
## - log(sigs1)  1   0.00066 6.0818 -54.472
## - itg         1   0.00112 6.0823 -54.469
## - log(trks)   1   0.00377 6.0850 -54.452
## - slim        1   0.00860 6.0898 -54.421
## - lane        1   0.03960 6.1208 -54.223
## - acpt        1   0.05202 6.1332 -54.144
## - log(adtt)   1   0.12314 6.2043 -53.694
## <none>                6.0812 -52.476
## - shld        1   0.46029 6.5415 -51.631
## - lwid        1   0.59251 6.6737 -50.850
##
## Step:  AIC=-54.47
## log(rate) ~ slim + acpt + shld + log(trks) + log(adtt) + lane +
##      itg + lwid
##
##           Df Sum of Sq    RSS      AIC
## - itg         1   0.00278 6.0846 -56.454
## - log(trks)   1   0.00575 6.0876 -56.435
## - slim        1   0.01142 6.0933 -56.399
## - lane        1   0.03905 6.1209 -56.222
## - acpt        1   0.05149 6.1333 -56.143
## - log(adtt)   1   0.18006 6.2619 -55.334
## <none>                6.0818 -54.472
## - shld        1   0.45999 6.5418 -53.628

```

```
## - lwid      1    0.59629 6.6781 -52.824
##
## Step:  AIC=-56.45
## log(rate) ~ slim + acpt + shld + log(trks) + log(adt) + lane +
##      lwid
##
##           Df Sum of Sq    RSS      AIC
## - log(trks) 1    0.00622 6.0908 -58.414
## - slim       1    0.01385 6.0985 -58.365
## - lane       1    0.04755 6.1322 -58.151
## - acpt       1    0.05046 6.1351 -58.132
## - log(adt)   1    0.21226 6.2969 -57.117
## <none>                6.0846 -56.454
## - shld       1    0.50076 6.5854 -55.370
## - lwid       1    0.62238 6.7070 -54.656
##
## Step:  AIC=-58.41
## log(rate) ~ slim + acpt + shld + log(adt) + lane + lwid
##
##           Df Sum of Sq    RSS      AIC
## - slim       1    0.02034 6.1112 -60.284
## - lane       1    0.04412 6.1350 -60.133
## - acpt       1    0.04472 6.1356 -60.129
## - log(adt)   1    0.21095 6.3018 -59.086
## <none>                6.0908 -58.414
## - shld       1    0.55605 6.6469 -57.007
## - lwid       1    0.68432 6.7752 -56.262
##
## Step:  AIC=-60.28
## log(rate) ~ acpt + shld + log(adt) + lane + lwid
##
##           Df Sum of Sq    RSS      AIC
## - acpt       1    0.02530 6.1365 -62.123
## - lane       1    0.05111 6.1623 -61.959
## - log(adt)   1    0.27897 6.3902 -60.543
## <none>                6.1112 -60.284
## - lwid       1    0.67347 6.7847 -58.207
## - shld       1    0.75088 6.8621 -57.765
##
## Step:  AIC=-62.12
## log(rate) ~ shld + log(adt) + lane + lwid
##
##           Df Sum of Sq    RSS      AIC
## - lane       1    0.04011 6.1766 -63.869
## - log(adt)   1    0.25409 6.3906 -62.541
## <none>                6.1365 -62.123
```



```
## - lwid      1    0.72705 6.8635 -59.756
## - shld      1    1.08816 7.2246 -57.756
##
## Step:  AIC=-63.87
## log(rate) ~ shld + log(adt) + lwid
##
##           Df Sum of Sq    RSS    AIC
## - log(adt)  1    0.25691 6.4335 -64.280
## <none>                        6.1766 -63.869
## - lwid      1    0.77542 6.9520 -61.257
## - shld      1    1.05141 7.2280 -59.738
##
## Step:  AIC=-64.28
## log(rate) ~ shld + lwid
##
##           Df Sum of Sq    RSS    AIC
## <none>                        6.4335 -64.280
## - lwid  1    1.1743 7.6078 -59.741
## - shld  1    2.3680 8.8015 -54.057
```

```
##
## Call:
## lm(formula = log(rate) ~ shld + lwid, data = Highway, offset = -log(len))
##
## Coefficients:
## (Intercept)          shld          lwid
##      8.82649      -0.08229      -0.38597
```

```
final.model.be.offset = lm(log(rate) ~ shld + lwid,
                           data = Highway, offset = -log(len))
summary(final.model.be.offset)
```

```
##
## Call:
## lm(formula = log(rate) ~ shld + lwid, data = Highway, offset = -log(len))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.93871 -0.25541  0.02587  0.20973  0.79116
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  8.82649     1.81366   4.867 2.26e-05 ***
## shld        -0.08229     0.02261  -3.640 0.000849 ***
## lwid        -0.38597     0.15057  -2.563 0.014686 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4227 on 36 degrees of freedom
## Multiple R-squared:  0.6824, Adjusted R-squared:  0.6648
## F-statistic: 38.68 on 2 and 36 DF,  p-value: 1.08e-09
```

This indicates that even set $\log(\text{len})$ as offset, we will still get same model

Answer for Part 2

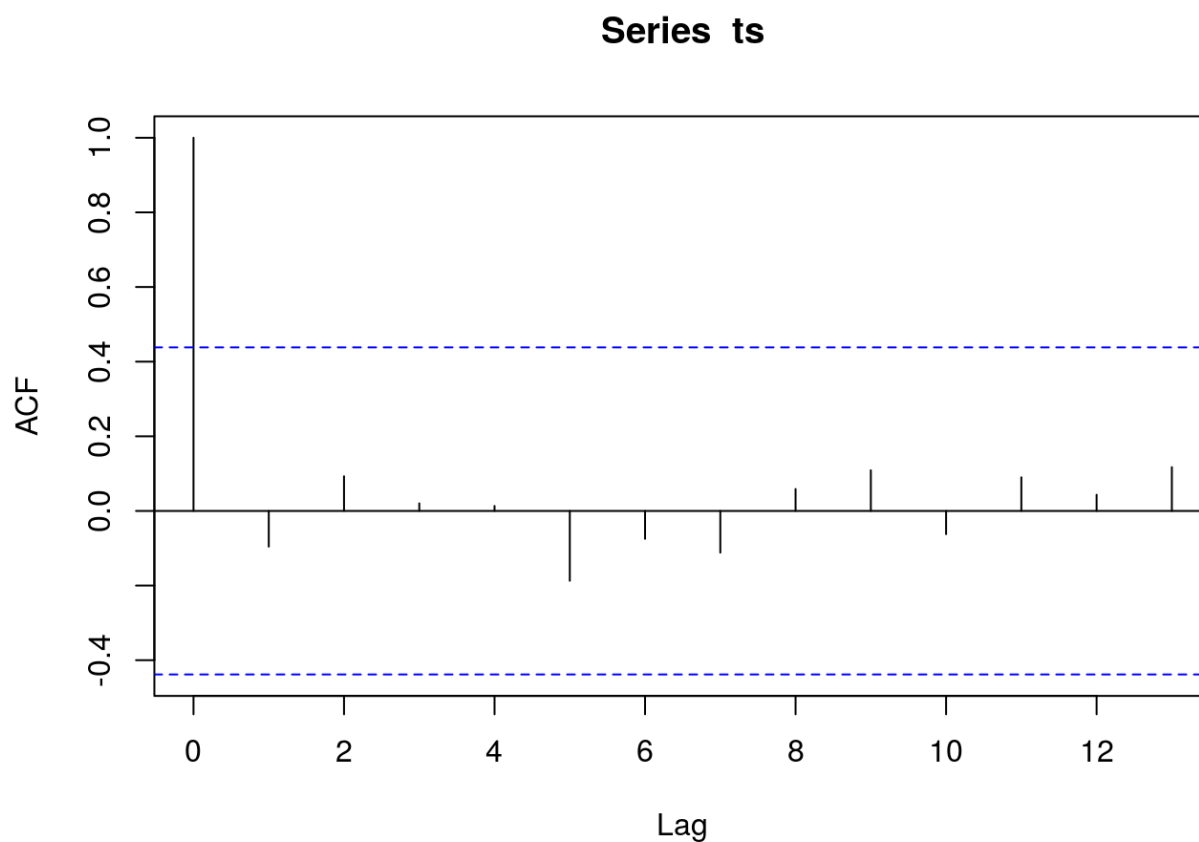
```
ts <- c( -0.7, 0.4, -1.3, -0.5, -0.6, 0.3, 0.1, -0.5, 0.1, -0.3, 0.8, -1
.2, -0.8, 0.2, -0.1, -1.9, 1.6, 0.5, 1.2, 0.7)
#Mean of this series is:
ts.mean <- mean(ts)
# autocovariance is:
acf(ts, type = "covariance", plot = FALSE)
```

```
##
## Autocovariances of series 'ts', by lag
##
##      0      1      2      3      4      5      6      7      8
## 0.7160 -0.0685 0.0665 0.0145 0.0095 -0.1340 -0.0535 -0.0800 0.0420
##      9     10     11     12     13
## 0.0780 -0.0445 0.0645 0.0310 0.0840
```

```
# ACF is :
acf(ts, type = "correlation", plot = FALSE)
```

```
##
## Autocorrelations of series 'ts', by lag
##
##      0      1      2      3      4      5      6      7      8      9
## 1.000 -0.096  0.093  0.020  0.013 -0.187 -0.075 -0.112  0.059  0.109
##     10     11     12     13
## -0.062  0.090  0.043  0.117
```

```
# ACF plot is :
acf(ts, type ="correlation", plot =TRUE)
```



sample auto-correlation at lag 0 equal to 1 is because it is calculated from $\gamma(0)/\gamma(0)$. Therefore, it must be 1.

The sample ACF values are randomly distributed and overall are less than 0.2 when the lag is greater than 0.