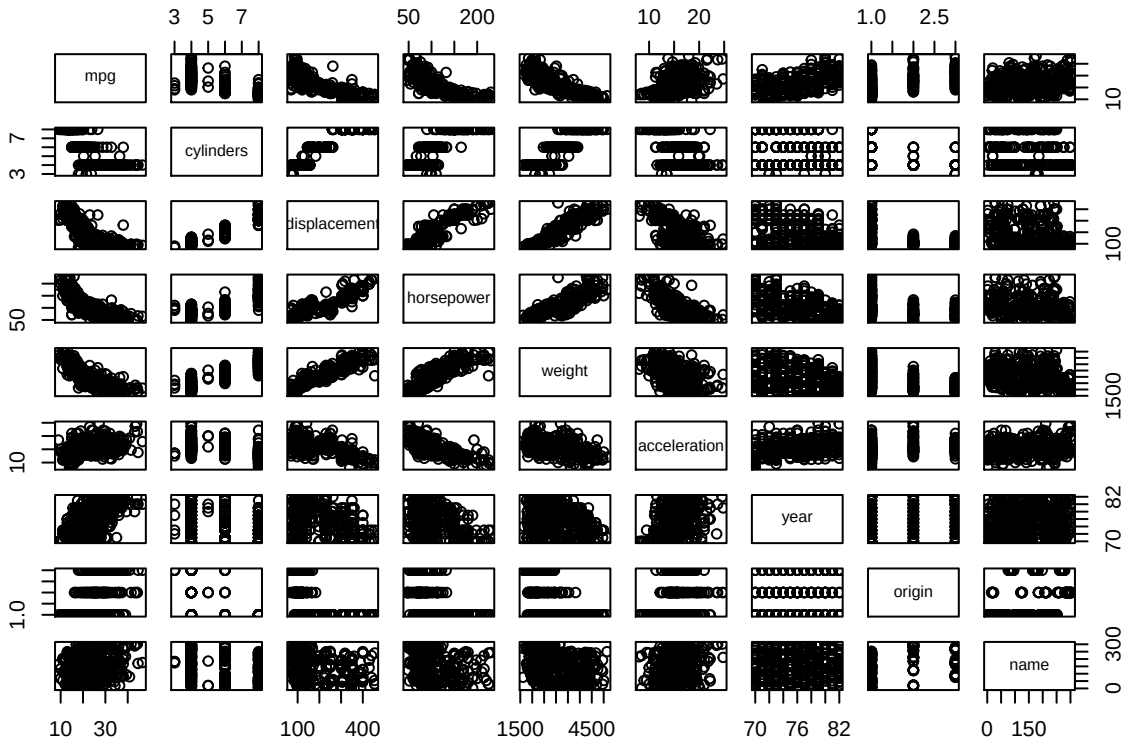
Chapter 3 Problem 9

Andira Putri

This question involves using multiple linear regression on the `Auto` data set.

a. Produce a scatterplot matrix which includes all the variables in the data set.

```
library(ISLR)
df=Auto
pairs(df)
```



b. Compute the matrix of correlations between the variables

```
auto=subset(df, select = -c(name) ) #exclude name
cor(auto)
```

```
##                     mpg  cylinders displacement horsepower     weight
## mpg           1.0000000 -0.7776175   -0.8051269 -0.7784268 -0.8322442
## cylinders    -0.7776175  1.0000000    0.9508233  0.8429834  0.8975273
## displacement -0.8051269  0.9508233    1.0000000  0.8972570  0.9329944
## horsepower   -0.7784268  0.8429834    0.8972570  1.0000000  0.8645377
## weight       -0.8322442  0.8975273    0.9329944  0.8645377  1.0000000
## acceleration  0.4233285 -0.5046834   -0.5438005 -0.6891955 -0.4168392
## year          0.5805410 -0.3456474   -0.3698552 -0.4163615 -0.3091199
## origin        0.5652088 -0.5689316   -0.6145351 -0.4551715 -0.5850054
```

```
##              acceleration       year     origin
## mpg             0.4233285  0.5805410  0.5652088
## cylinders      -0.5046834 -0.3456474 -0.5689316
## displacement   -0.5438005 -0.3698552 -0.6145351
## horsepower     -0.6891955 -0.4163615 -0.4551715
## weight         -0.4168392 -0.3091199 -0.5850054
## acceleration    1.0000000  0.2903161  0.2127458
## year            0.2903161  1.0000000  0.1815277
## origin          0.2127458  0.1815277  1.0000000
```

c. Use the lm() function to perform a multiple linear regression with mpg as the response and all other variables except name as predictors.

```
lm.fit=lm(mpg~.,data=auto)
summary(lm.fit)
```

```
##
## Call:
## lm(formula = mpg ~ ., data = auto)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.5903 -2.1565 -0.1169  1.8690 13.0604
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -17.218435   4.644294  -3.707  0.00024 ***
## cylinders     -0.493376   0.323282  -1.526  0.12780
## displacement   0.019896   0.007515   2.647  0.00844 **
## horsepower    -0.016951   0.013787  -1.230  0.21963
## weight        -0.006474   0.000652  -9.929  < 2e-16 ***
## acceleration   0.080576   0.098845   0.815  0.41548
## year           0.750773   0.050973  14.729  < 2e-16 ***
## origin         1.426141   0.278136   5.127 4.67e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.328 on 384 degrees of freedom
## Multiple R-squared:  0.8215, Adjusted R-squared:  0.8182
## F-statistic: 252.4 on 7 and 384 DF,  p-value: < 2.2e-16
```

- Is there a relationship between the predictors and the response?

Yes! Some predictors are more significant than others...

- Which predictors appear to have a statistically significant relationship to the response?

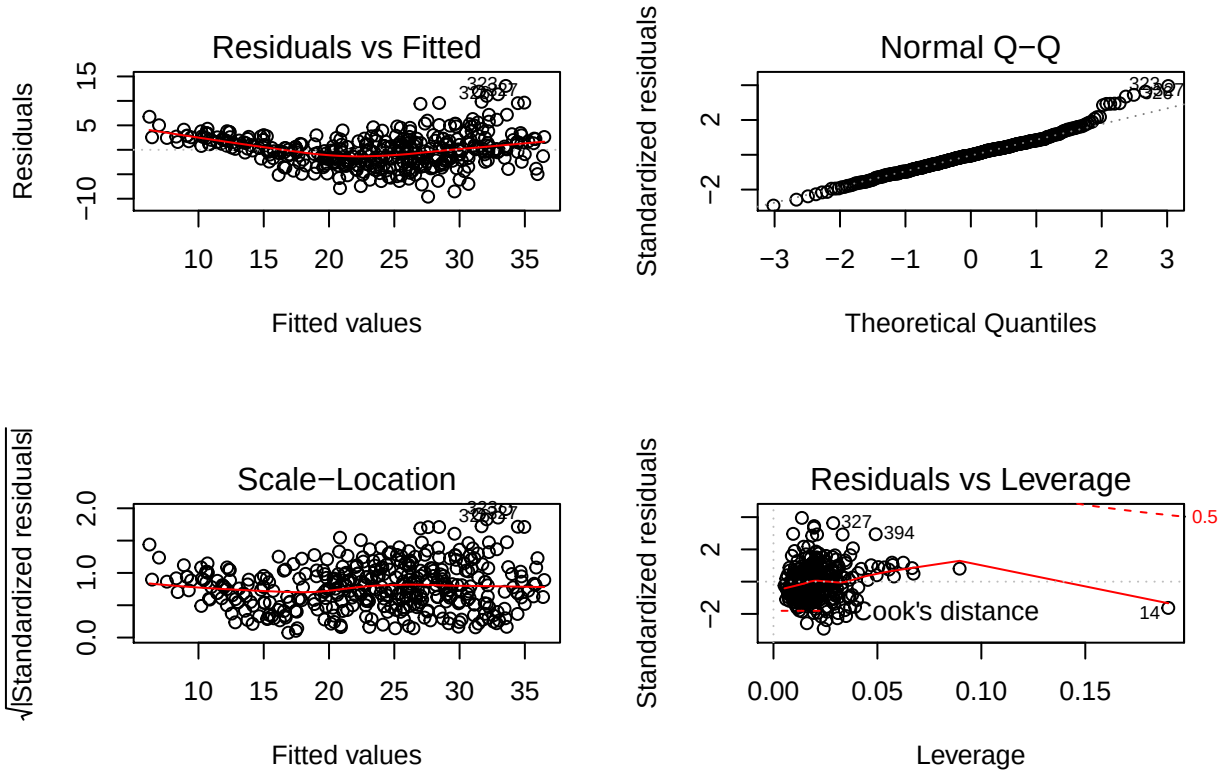
Displacement, weight, year, origin (low p-values)

- What does the coefficient for the year variable suggest?

Since the coefficient is positive, newer cars have higher mpg

d. Produce diagnostic plots of the linear regression fit. Comment on any problems you see with the fit. Do the residual plots suggest any unusually large outliers? Does the leverage plot identify any observations with unusually high leverage?

```
par(mfrow=c(2,2))
plot(lm.fit)
```



There is a strong pattern in the Residuals vs. Fitted plot, which suggests non-linearity in the model. There are outliers, like point 323, but it's not too strong. Point 14 has very high leverage.

e. Use the * and : symbols to fit linear regression models with interaction effects. Do any interactions appear to be statistically significant?

```
lm.fit1=lm(mpg~weight*horsepower,data=auto)
lm.fit2=lm(mpg~weight*acceleration,data=auto)
lm.fit3=lm(mpg~horsepower*acceleration,data=auto)
summary(lm.fit1) #Weight and horsepower
```

```
##
## Call:
## lm(formula = mpg ~ weight * horsepower, data = auto)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.7725  -2.2074  -0.2708   1.9973  14.7314
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        6.356e+01  2.343e+00  27.127  < 2e-16 ***
## weight            -1.077e-02  7.738e-04 -13.921  < 2e-16 ***
## horsepower        -2.508e-01  2.728e-02  -9.195  < 2e-16 ***
```

```
## weight:horsepower  5.355e-05  6.649e-06   8.054 9.93e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.93 on 388 degrees of freedom
## Multiple R-squared:  0.7484, Adjusted R-squared:  0.7465
## F-statistic: 384.8 on 3 and 388 DF,  p-value: < 2.2e-16
```

```
summary(lm.fit2) #Weight and acceleration
```

```
##
## Call:
## lm(formula = mpg ~ weight * acceleration, data = auto)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.5823  -2.6411  -0.3517   2.2611  15.6704
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          2.814e+01  4.872e+00   5.776 1.57e-08 ***
## weight              -3.168e-03  1.461e-03  -2.168  0.03076 *
## acceleration         1.117e+00  3.097e-01   3.608  0.00035 ***
## weight:acceleration -2.787e-04  9.694e-05  -2.875  0.00426 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.249 on 388 degrees of freedom
## Multiple R-squared:  0.706,  Adjusted R-squared:  0.7037
## F-statistic: 310.5 on 3 and 388 DF,  p-value: < 2.2e-16
```

```
summary(lm.fit3) #Horsepower and acceleration
```

```
##
## Call:
## lm(formula = mpg ~ horsepower * acceleration, data = auto)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -13.3442  -2.7324  -0.4049   2.4210  15.8840
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)             33.512440   3.420187   9.798  < 2e-16 ***
## horsepower               0.017590   0.027425   0.641 0.521664
## acceleration             0.800296   0.211899   3.777 0.000184 ***
## horsepower:acceleration -0.015698   0.002003  -7.838 4.45e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.426 on 388 degrees of freedom
## Multiple R-squared:  0.6809, Adjusted R-squared:  0.6784
## F-statistic: 275.9 on 3 and 388 DF,  p-value: < 2.2e-16
```

All models have statistically significant interaction terms.