Chapter 10(Edition 8): 10.7, 10.8, 10.10

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```r
# loading libraries
library(car)
```

10.7

The brake horsepower developed by an automobile engine on a dynamometer is thought to be a function of the engine speed in revolutions per minute (rpm), the road octane number of the fuel, and the engine compression. An experiment is run in the laboratory and the data that follow are collected:

```r
# creating data table
Brake.HP = c(225,212,229,222,219,278,246,237,233,224,223,230)
RPM = c(2000,1800,2400,1900,1600,2500,3000,3200,2800,3400,1800,2500)
RON = c(90,94,88,91,86,96,94,90,88,86,90,89)
Compression = c(100,95,110,96,100,110,98,100,105,97,100,104)
automob = data.frame(Brake.HP,RPM,RON,Compression)
```

(a) Fit a multiple regression model to these data.

```r
# linear regression
brake.lm <- lm(formula = Brake.HP ~ RPM + RON + Compression,
               data = automob)
```

(b) Test for significance of regression. What conclusions can you draw?

```r
# summary output
summary(brake.lm)
```

```
##
## Call:
## lm(formula = Brake.HP ~ RPM + RON + Compression, data = automob)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -13.3282  -3.1701   0.8026   2.9400  11.5558
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.660e+02  9.267e+01  -2.871  0.02081 *
## RPM          1.071e-02  4.483e-03   2.390  0.04388 *
## RON          3.135e+00  8.444e-01   3.712  0.00594 **
## Compression  1.867e+00  5.345e-01   3.494  0.00816 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 8.812 on 8 degrees of freedom
## Multiple R-squared:  0.8065, Adjusted R-squared:  0.734
## F-statistic: 11.12 on 3 and 8 DF,  p-value: 0.00317
```

To check for regression significance, we test for the following:

$H_0 : \beta_1 = \cdots = \beta_p = 0$
$H_1 : \beta_i \neq 0$, where $i = i, \ldots, p$

From our summary output, we find that the p-value for our F test is .00317. Rejecting the null hypothesis at $\alpha = .05$, we find that at least one of the regressors is significant in our model.

(c) Based on t-tests, do you need all three regressor variables in the model? To determine whether or not our regressors are statistically significant to our model, we test for the following:

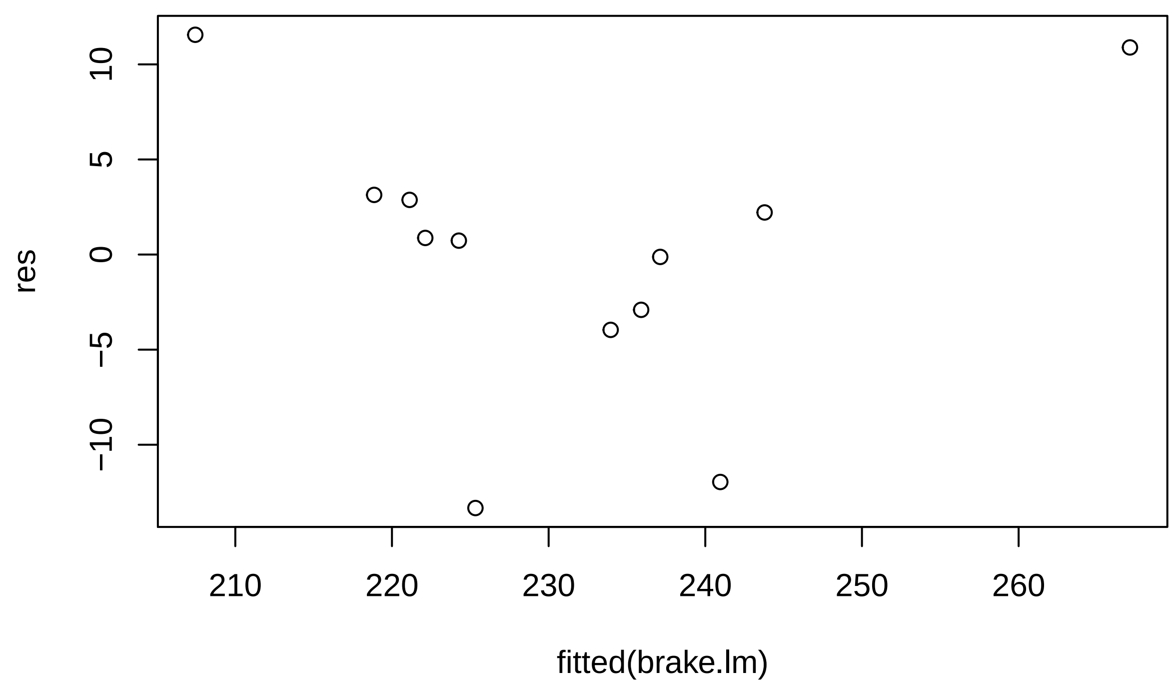
$H_0 : \beta_i = 0$
$H_1 : \beta_i \neq 0$

For each regressor, we reject the null hypothesis and conclude that we need all three regressor variables in the model.

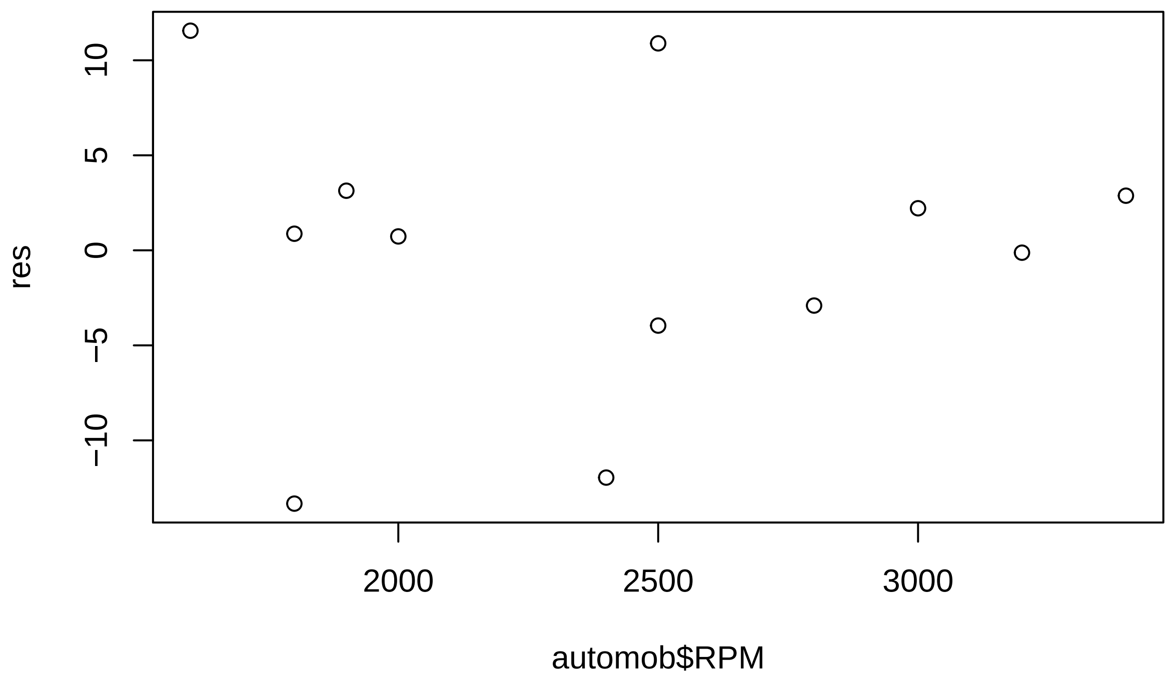
10.8

Analyze the residuals from the regression model in Problem 10.7. Comment on model adequacy.

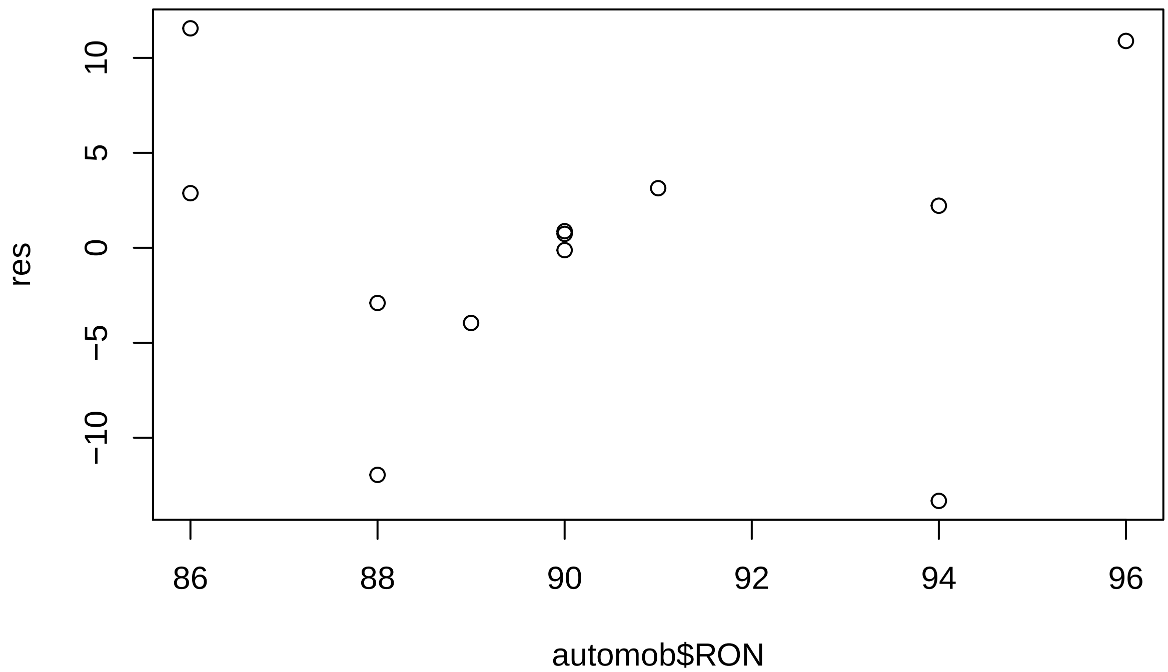
```
# defining residuals
res <-automob$Brake.HP - fitted(brake.lm)

# plotting residuals
plot(fitted(brake.lm),res)
```



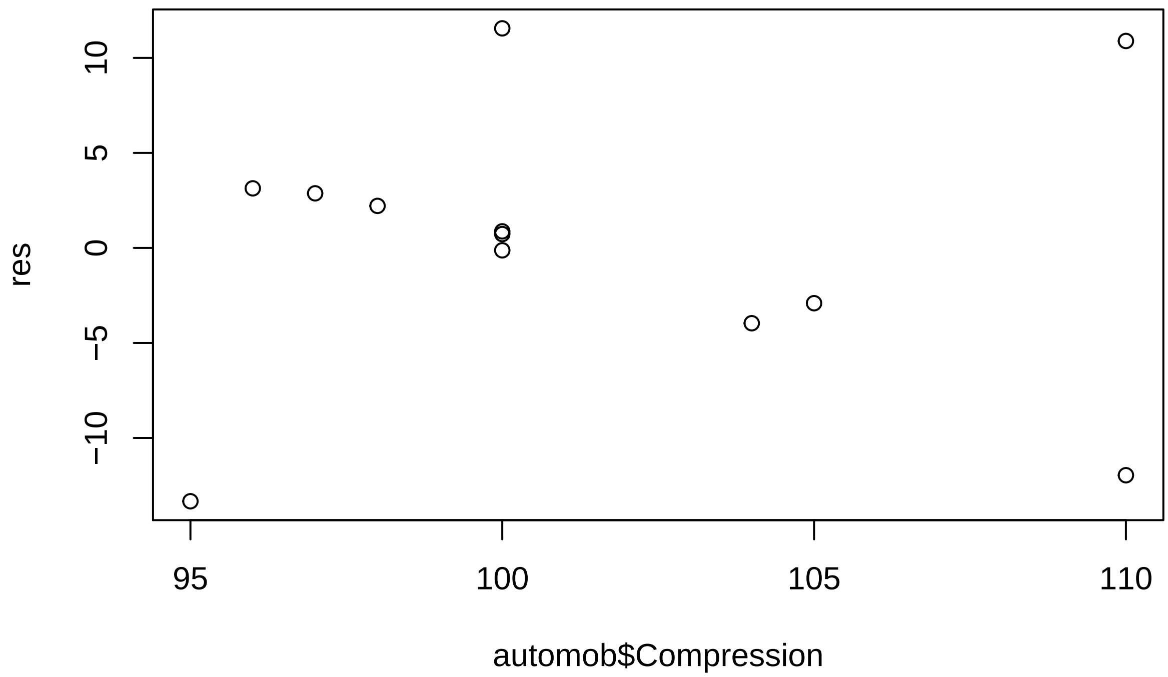
```r
plot(automob$RPM,res)
```



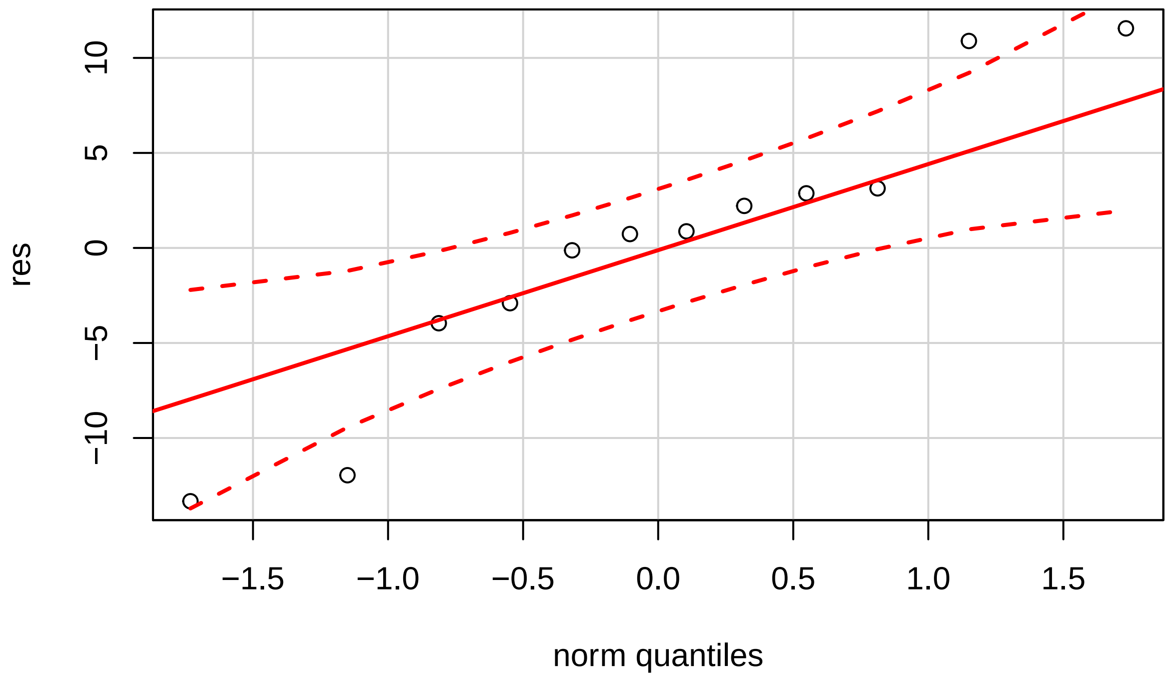

```r
plot(automob$RON,res)
```




```
plot(automob$Compression,res)
```




```r
# checking normality
qqPlot(res)
```



10.10

Consider the 2^4 factorial experiment in Example 6.2. Suppose that the last observation is missing. Reanalyze the data and draw conclusions. How do these conclusions compare with those from the original example?