DATA 605 - Homework 11

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Using the `cars` dataset in R, build a linear model for stopping distance as a function of speed and replicate the analysis of your textbook chapter 3 (visualization, quality evaluation of the model, and residual analysis.)

Load the built-in R “cars” dataset

```
data("cars")
head(cars, n = 10)
##    speed dist
## 1      4    2
## 2      4   10
## 3      7    4
## 4      7   22
## 5      8   16
## 6      9   10
## 7     10   18
## 8     10   26
## 9     10   34
## 10    11   17
```

Summary of the dataset

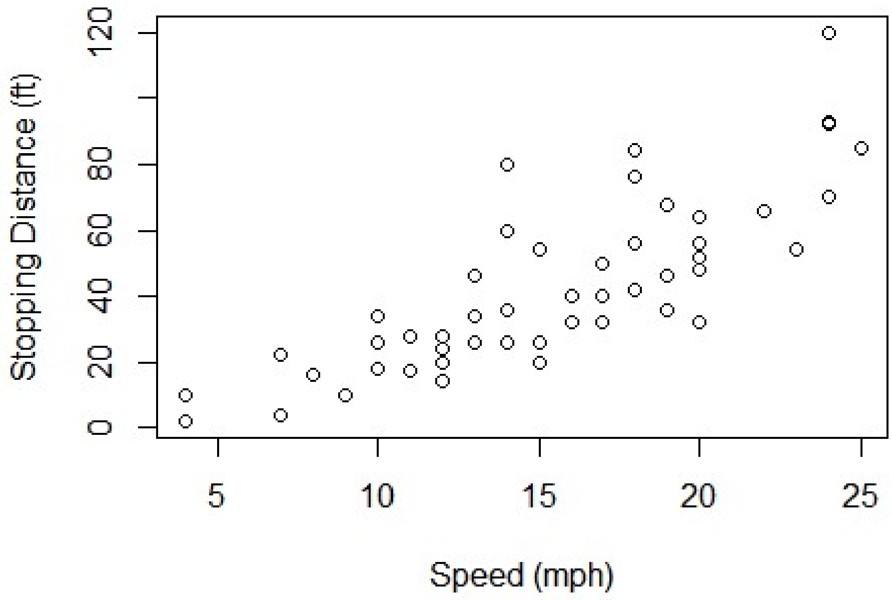
```
summary(cars)
##      speed           dist       
##  Min.   : 4.0   Min.   :  2.00  
##  1st Qu.:12.0   1st Qu.: 26.00  
##  Median :15.0   Median : 36.00  
##  Mean   :15.4   Mean   : 42.98  
##  3rd Qu.:19.0   3rd Qu.: 56.00  
##  Max.   :25.0   Max.   :120.00
```

Dimensions of the dataset

```
dim(cars)
## [1] 50  2
```

Visualize the data

```
with(cars, plot(speed, dist,
                xlab = "Speed (mph)",
                ylab = "Stopping Distance (ft)"))
```

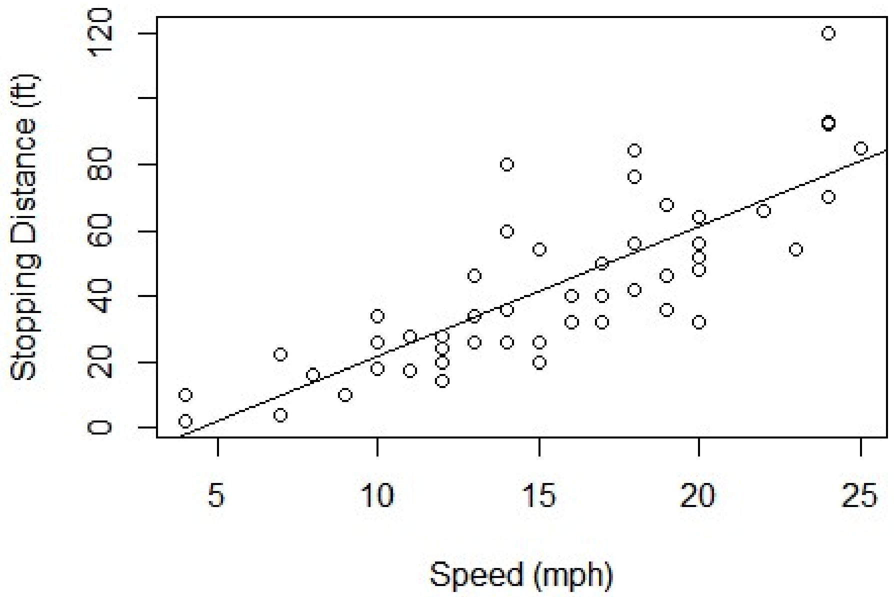


Fit a Linear Model $distance = a_0 + a_1 * speed$

```
# linear model
lm_cars <- lm(dist ~ speed, data = cars)
lm_cars
##
## Call:
## lm(formula = dist ~ speed, data = cars)
##
## Coefficients:
## (Intercept)        speed
##     -17.579        3.932
```

- Thus y-intercept or $a_0 = -17.579$ and the slope $a_1 = 3.932$ and the linear model is

```
with(cars, plot(speed, dist,
                xlab = "Speed (mph)",
                ylab = "Stopping Distance (ft)"))
abline(lm_cars)
```



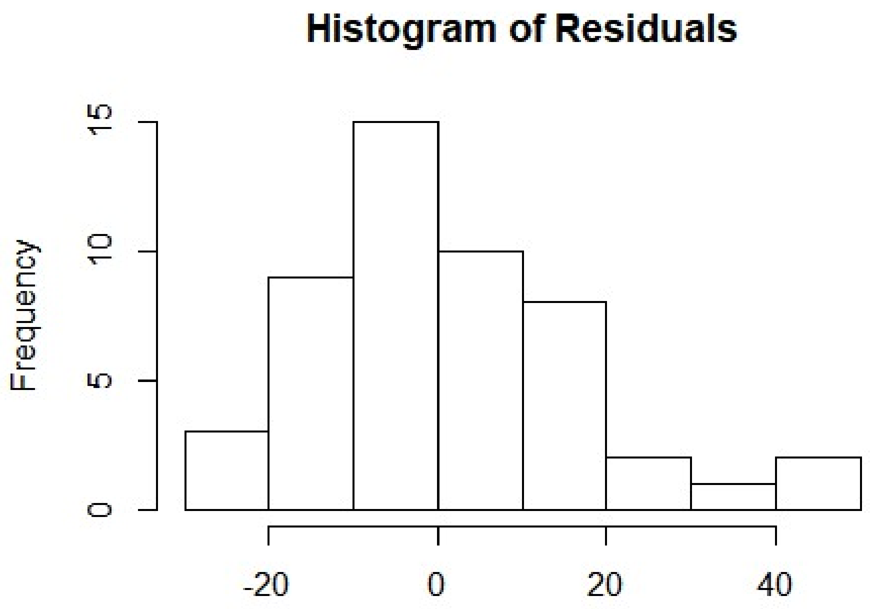
$$dist = -17.579 + 3.932 * speed$$

Quality of the Model

```
summary(lm_cars)
##
## Call:
## lm(formula = dist ~ speed, data = cars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -29.069  -9.525  -2.272   9.215  43.201
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -17.5791     6.7584  -2.601   0.0123 *
## speed         3.9324     0.4155   9.464 1.49e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.38 on 48 degrees of freedom
## Multiple R-squared:  0.6511, Adjusted R-squared:  0.6438
## F-statistic: 89.57 on 1 and 48 DF,  p-value: 1.49e-12
```

- We can see the summary statistics of the residuals which are the differences between the actual measured values and the values on the line. A good-fit model would have the residuals to be nearly standard normal. The median should be near 0 which is the case here.

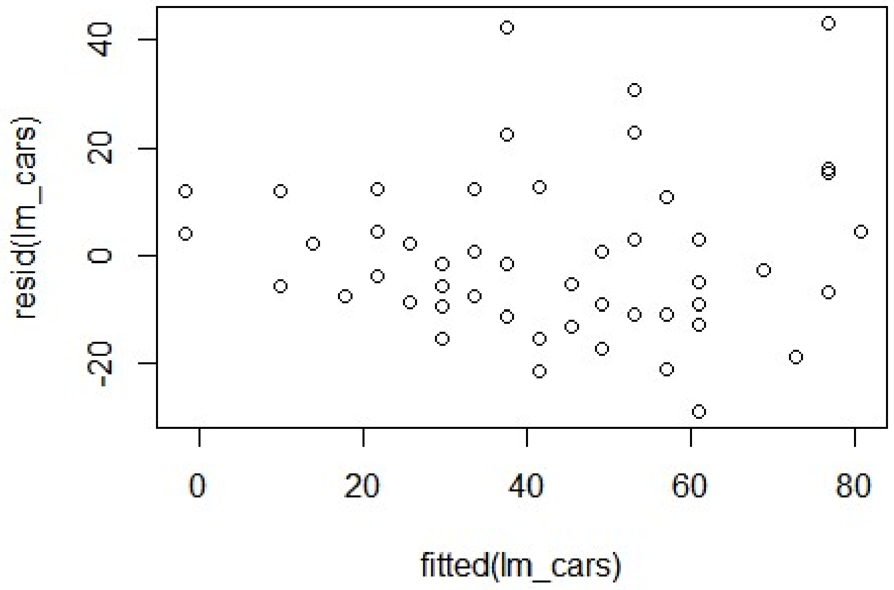
```
hist(lm_cars$residuals, xlab = "", main = "Histogram of Residuals")
```



- A key statistic is R^2 value which shows that the model explains about 65% of the data's variation which for a linear model is not too bad.
- Also looking at the p-values, we see that the probability that the speed variable is not relevant is very small at about $1.49 * 10^{-12}$ This means that speed plays a key predictor in determining stopping distance and a strong dependency.

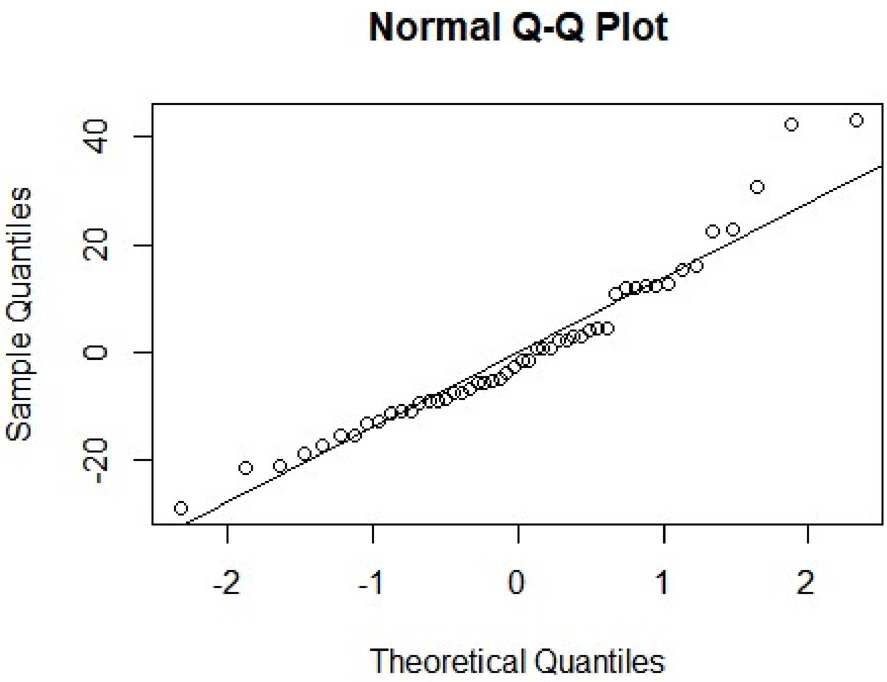
Residual Analysis

```
plot(fitted(lm_cars), resid(lm_cars))
```



- Residuals are nearly uniformly scattered and approximately constant variance.
- A Quantile vs Quantile or Q-Q plot

```
qqnorm(resid(lm_cars))
qqline(resid(lm_cars))
```


Normal Q-Q Plot
Sample Quantiles
40
20
0
-20
-2
-1
0
1
2
Theoretical Quantiles