Car Horsepower and Gas Mileage I

1. The results of `summary()` is in Table 1. Interpretations of the coefficients are below the table.

   Table 1. Summary of simple linear regression results of mpg on horsepower.

```
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 46.92659    1.92184   24.42  < 2e-16
hp          -0.21762    0.01829  -11.90 1.03e-14
---
Residual standard error: 3.096 on 40 degrees of freedom
Multiple R-squared: 0.7796,Adjusted R-squared: 0.7741
F-statistic: 141.5 on 1 and 40 DF,  p-value: 1.027e-14
```

   - The y-intercept (46.93) is the estimated mean mpg for cars with no horsepower.
   - The slope (i.e., the "hp" "Estimate") says that for every increase in one horsepower the mpg will decrease by 0.22, on average.

2. Interpretations of the p-values in Table 1 are below.

   - The "Intercept" p-value ($p < 0.00005$) shows that the mean mpg for cars with no horsepower is different than zero (a nonsensical significance test).
   - The slope (in "hp" row) p-value ($p < 0.00005$) shows that the slope is significantly different from zero, which indicates that there is a significant relationship between the horsepower and mpg of a car.

3. The coefficient of determination ("multiple r-squared"; 0.78) shows the proportion of the total variability in mpg (ignoring horsepower) that is explained away by knowing a horsepower value.

4. Confidence intervals for the model coefficients are in Table 2. Interpretations for each confidence interval are below the table.

   Table 2. Coefficient confidence intervals for simple linear regression results of mpg on horsepower.

```
                 2.5 %    97.5 %
(Intercept) 43.0424051 50.810780
hp          -0.2545932 -0.180651
```

   - The "intercept" CI says that the mean mpg for cars with no horsepower is between 43.0 and 50.8.
   - The "hp" CI says that the mpg will *decrease* between 0.18 and 0.25 for a one unit increase in horespower.

5. The ANOVA table is shown in Table 3. Interpretations of the degrees-of-freedom are below the table.

   Table 3. ANOVA table for simple linear regression results of mpg on horsepower.

```
          Df  Sum Sq Mean Sq F value    Pr(>F)
hp         1 1356.83 1356.83  141.53 1.027e-14
Residuals 40  383.48    9.59
```

   - The regression df (in the "hp" row) df is one less than the number of parameters estimated (2 – intercept and slope).
   - The residual df is the number of observations (42) minus the number of parameters estimated (2).
   - The total df is not shown on the table but is equal to the number of observations minus 1.

6. The meaning of each MS in Table 3 are below.
    - The MS regression (in the "hp" row) is the variance in mpg that can be explained by knowing the value of horespower.
    - The MS residual is the variance in mpg after considering horsepower or the variability of individuals around the best-fit line (i.e., the full model).
    - The total MS is not shown in the table but is the variance in mpg or the variability of individuals around the grand mean (i.e., the simple model).
7. The F test statistic is the ratio of variability in mpg explained by knowing the value of horespower to the variability unexplained even after knowing the value of the horsespower. The F (141.5) and corresponding p-value ($p < 0.0005$) show that the full model including the slope is significantly "better" than the simple model with no slope. Thus, a slope "is needed" and it can be concluded that there is a significant relationship between a car's horespower and its gas mileage.
8. There is a significant relationship as indicated by the very small slope and F-test p-values ($p < 0.0005$).

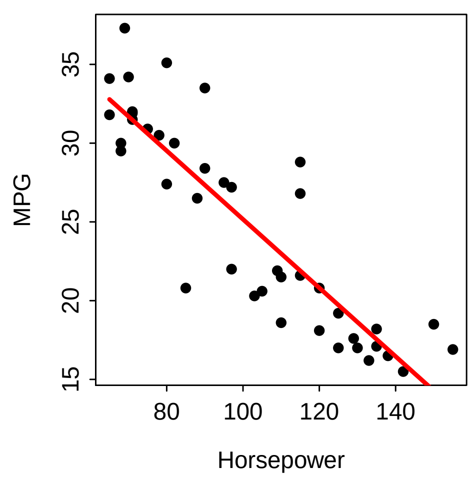

Figure 1. Fitted line plot for the linear regression of mpg on horsepower for cars.

R Appendix

```
library(NCStats)
setwd("c:/biometry/")
car <- read.csv("CarMPG.csv")
lm1 <- lm(mpg~hp,data=car)
summary(lm1)
confint(lm1)
anova(lm1)
fitPlot(lm1,xlab="Horsepower",ylab="MPG")
```