Lesson 01

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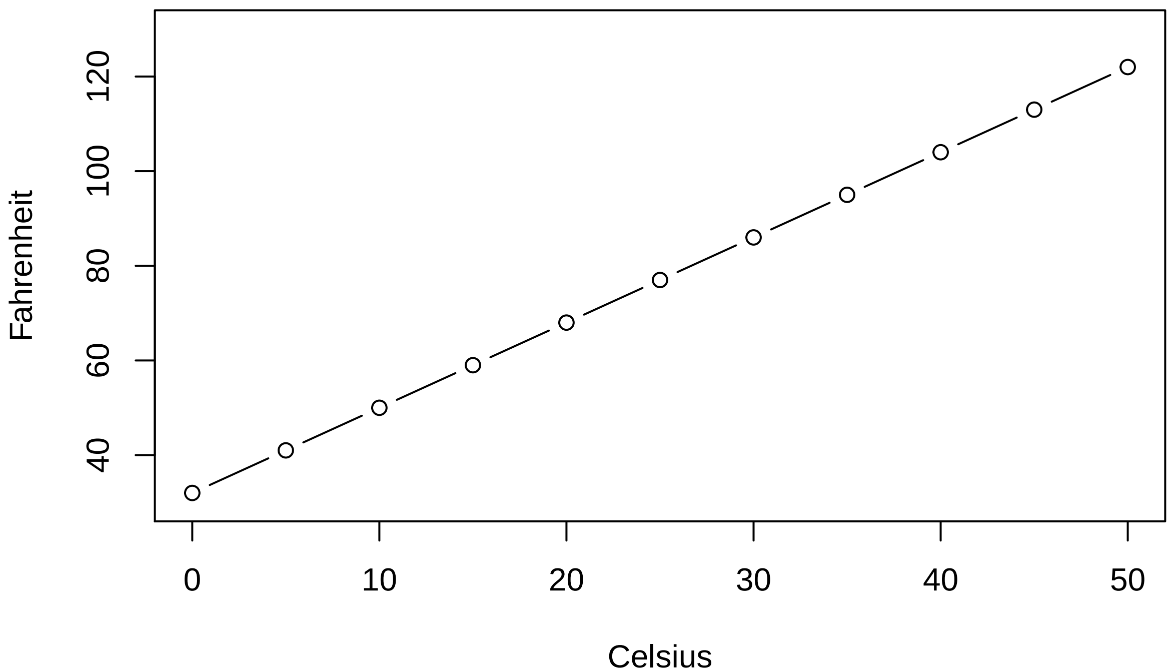
11/27/2021

Temperature

Create the temperature data and produce a scatterplot with points and lines:

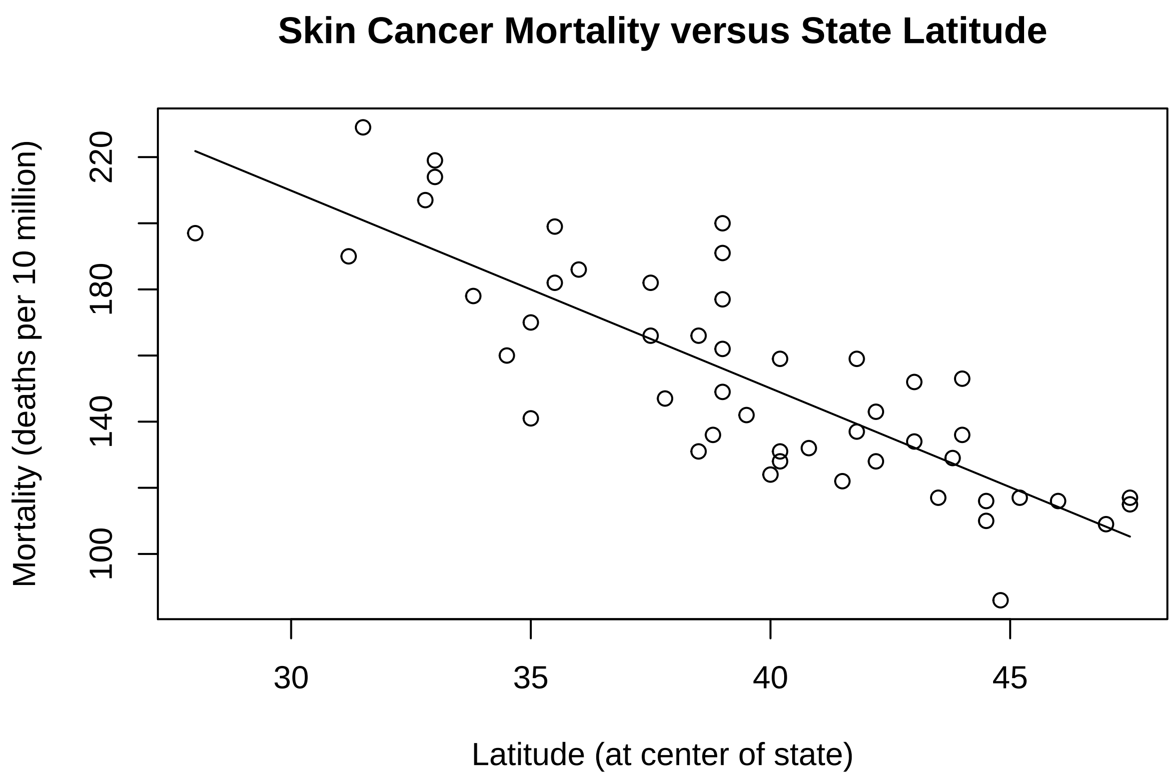
```
C <- seq(0, 50, by=5)
F <- (9/5)*C+32
plot(C, F, type="b", xlab="Celsius", ylab="Fahrenheit", ylim=c(30,130))
```



Skin cancer

Load the skin cancer data and produce a scatterplot with a simple linear regression line:

```
skincancer <- read.table("./Data/skincancer.txt", header=T)
attach(skincancer)
model <- lm(Mort ~ Lat)
plot(x=Lat, y=Mort,
     xlab="Latitude (at center of state)", ylab="Mortality (deaths per 10 million)",
     main="Skin Cancer Mortality versus State Latitude",
     panel.last = lines(sort(Lat), fitted(model)[order(Lat)]))
```




```
detach(skincancer)
```

Student height and weight

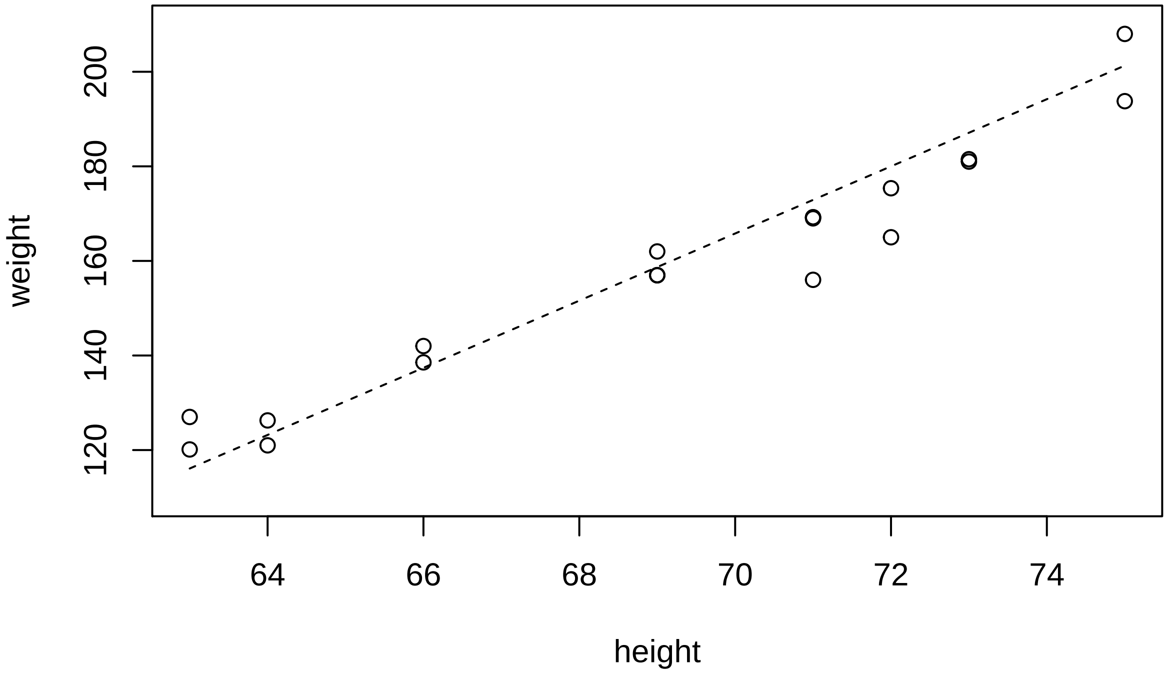
Load the student height and weight data. Fit a simple linear regression model. Produce a scatterplot with a simple linear regression line and another line with specified intercept and slope. Calculate sum of squared errors (SSE). Predict weight for height=66 and height=67.

```
heightweight <- read.table("./Data/student_height_weight.txt", header=T)
attach(heightweight)

model <- lm(wt ~ ht)
summary(model)
```

```
##
## Call:
## lm(formula = wt ~ ht)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -13.2339  -4.0804  -0.0963   4.6445  14.2158
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -266.5344    51.0320  -5.223    8e-04 ***
## ht             6.1376     0.7353   8.347 3.21e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 8.641 on 8 degrees of freedom
```

```
## Multiple R-squared:  0.897,  Adjusted R-squared:  0.8841
## F-statistic: 69.67 on 1 and 8 DF,  p-value: 3.214e-05
```

```
# Hashtag denotes comments
# Coefficients:
#              Estimate Std. Error t value Pr(>|t|)
# (Intercept) -266.5344    51.0320  -5.223    8e-04 ***
# ht             6.1376     0.7353   8.347 3.21e-05 ***

plot(x=ht, y=wt, ylim=c(110,210), xlab="height", ylab="weight",
     panel.last = c(lines(sort(ht), fitted(model[order(ht)]),
                    lines(ht, -331.2+7.1*ht, lty=2))))
```




```
sum(residuals(model)^2) # SSE = 597.386
```

```
## [1] 597.386
```

```
predict(model, newdata=data.frame(ht=c(66, 67))) # 138.5460 144.6836
```

```
##        1        2
## 138.5460 144.6836
```

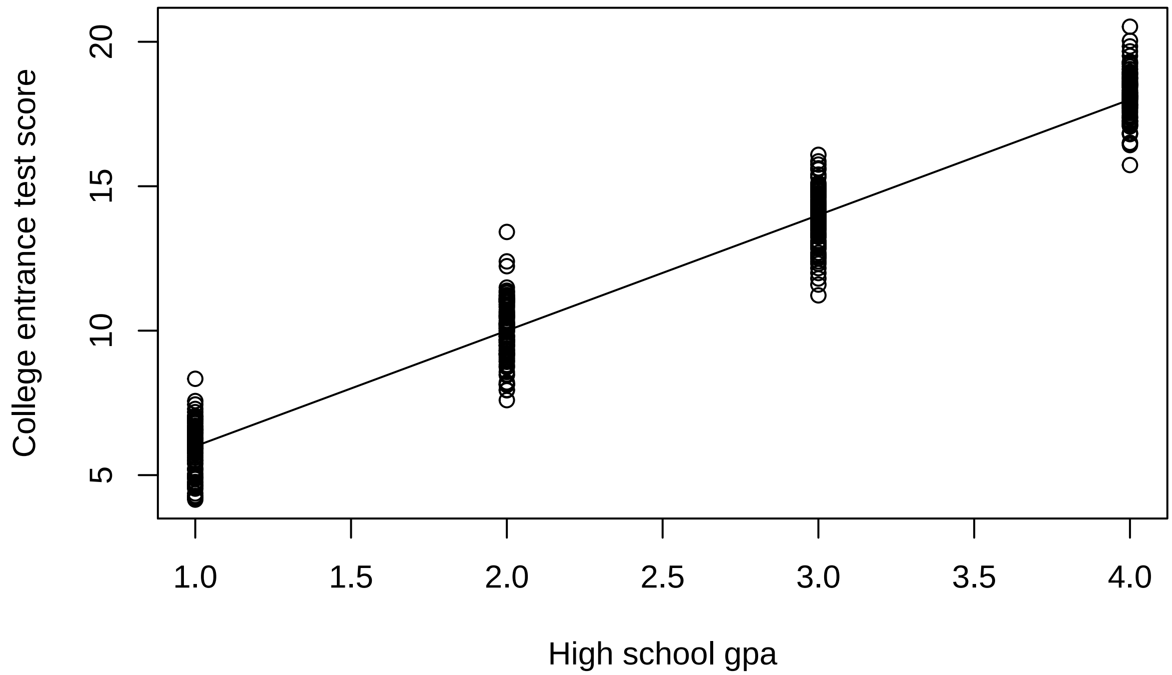
```
detach(heightweight)
```

High school GPA and college test scores

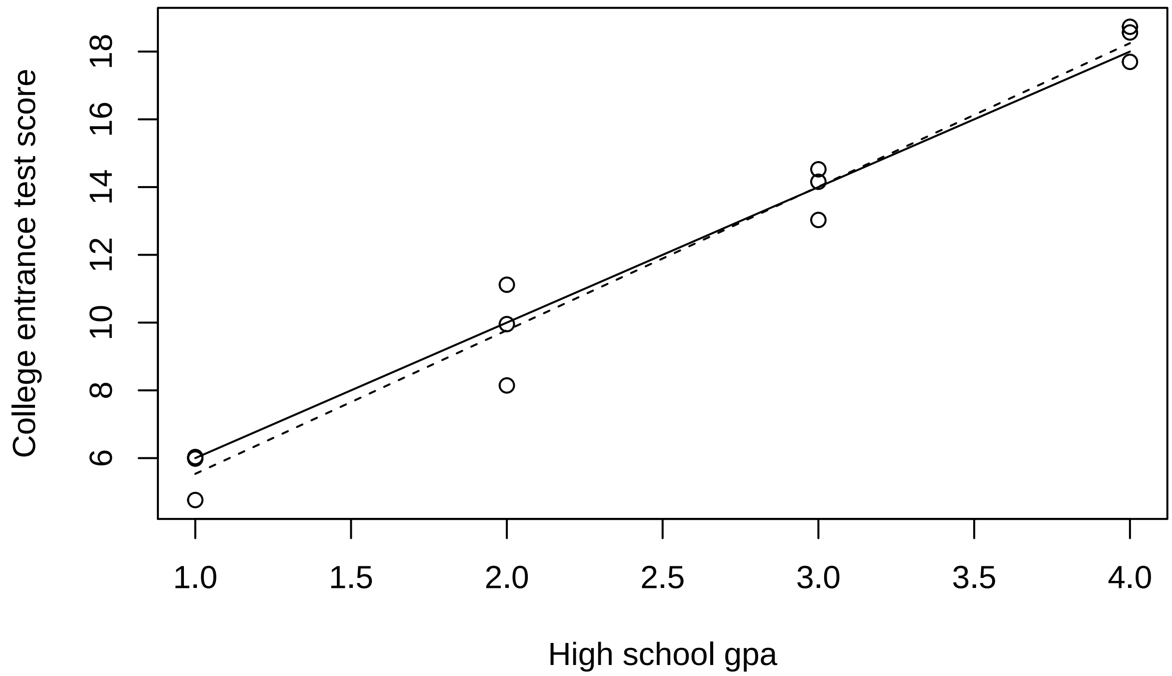
Generate the high school GPA and college test score (population) data. Produce a scatterplot of the population data with the population regression line. Sample the data (your results will differ since we're randomly sampling here). Produce a scatterplot of the sample data with a simple linear regression line and the the population regression line. Calculate sum of squared errors (SSE), mean square error (MSE), and regression (or residual) standard error (S).

```
X <- c(rep(1, 100), rep(2, 100), rep(3, 100), rep(4, 100))
Y <- 2 + 4*X + rnorm(400, 0, 1)
plot(X, Y, xlab="High school gpa", ylab="College entrance test score",
```

```
     panel.last = lines(X, 2+4*X))
```




```
Xs <- c(rep(1, 3), rep(2, 3), rep(3, 3), rep(4, 3))
Ys <- Y[c(rep(0, 3), rep(100, 3), rep(200, 3), rep(300, 3)) + sample.int(100, 12)]
model <- lm(Ys ~ Xs)
plot(Xs, Ys, xlab="High school gpa", ylab="College entrance test score",
     panel.last = c(lines(Xs, 2+4*Xs),
                    lines(sort(Xs), fitted(model[order(Xs)]),lty=2)))
```




```
sum(residuals(model)^2) # SSE = 8.677833
```

```
## [1] 7.4255
```

```r
sum(residuals(model)^2)/10 # MSE = 0.8677833
```

```
## [1] 0.74255
```

```r
sqrt(sum(residuals(model)^2)/10) # S = 0.9315489
```

```
## [1] 0.8617134
```

```r
summary(model) # Residual standard error: 0.9315 on 10 degrees of freedom
```

```
##
## Call:
## lm(formula = Ys ~ Xs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.6280 -0.6075  0.2490  0.4868  1.3453
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   1.2973     0.6093   2.129   0.0591 .
## Xs            4.2376     0.2225  19.046 3.46e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8617 on 10 degrees of freedom
## Multiple R-squared:  0.9732, Adjusted R-squared:  0.9705
## F-statistic: 362.8 on 1 and 10 DF,  p-value: 3.459e-09
```

Skin cancer

Load the skin cancer data. Fit a simple linear regression model with y = Mort and x = Lat and display the coefficient of determination, . Calculate the correlation between Mort and Lat.

```r
skincancer <- read.table("./Data/skincancer.txt", header=T)
attach(skincancer)
model <- lm(Mort ~ Lat)
summary(model) # Multiple R-squared:  0.6798
```

```
##
## Call:
## lm(formula = Mort ~ Lat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -38.972 -13.185   0.972  12.006  43.938
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 389.1894    23.8123   16.34  < 2e-16 ***
## Lat          -5.9776     0.5984   -9.99 3.31e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19.12 on 47 degrees of freedom
```

```
## Multiple R-squared:  0.6798, Adjusted R-squared:  0.673
## F-statistic:  99.8 on 1 and 47 DF,  p-value: 3.309e-13
```

```
cor(Mort, Lat) # correlation = -0.8245178
```

```
## [1] -0.8245178
```

```
detach(skincancer)
```

Temperature

Create the temperature data. Fit a simple linear regression model with y = F and x = C and display the coefficient of determination, . Calculate the correlation between F and C.

```
C <- seq(0, 50, by=5)
F <- (9/5)*C+32
model <- lm(F ~ C)
summary(model) # Multiple R-squared:      1
```

```
## Warning in summary.lm(model): essentially perfect fit: summary may be unreliable
```

```
##
## Call:
## lm(formula = F ~ C)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.963e-14 -5.603e-16  1.615e-15  4.749e-15  7.715e-15
##
## Coefficients:
##              Estimate Std. Error   t value Pr(>|t|)
## (Intercept) 3.200e+01  4.550e-15 7.033e+15   <2e-16 ***
## C           1.800e+00  1.538e-16 1.170e+16   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 8.067e-15 on 9 degrees of freedom
## Multiple R-squared:      1,  Adjusted R-squared:      1
## F-statistic: 1.369e+32 on 1 and 9 DF,  p-value: < 2.2e-16
```

```
cor(F, C) # correlation = 1
```

```
## [1] 1
```

Building stories

Load the building stories data. Fit a simple linear regression model with y = Height and x = Stories and display the coefficient of determination, . Calculate the correlation between Height and Stories.

```
bldgstories <- read.table("./Data/bldgstories.txt", header=T)
attach(bldgstories)
model <- lm(HGHT ~ STORIES)
summary(model) # Multiple R-squared:  0.9036
```

```
##
## Call:
## lm(formula = HGHT ~ STORIES)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -156.759  -33.239    5.995   28.450  167.487
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  90.3096    20.9622   4.308 6.44e-05 ***
## STORIES      11.2924     0.4844  23.310  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 58.33 on 58 degrees of freedom
## Multiple R-squared:  0.9036, Adjusted R-squared:  0.9019
## F-statistic: 543.4 on 1 and 58 DF,  p-value: < 2.2e-16
```

```
cor(HGHT, STORIES) # correlation = 0.9505549
```

```
## [1] 0.9505549
```

```
detach(bldgstories)
```

Driver's age and distance

Load the driver's age and distance data. Fit a simple linear regression model with y = Distance and x = Age and display the coefficient of determination, . Calculate the correlation between Distance and Age.

```
signdist <- read.table("./Data/signdist.txt", header=T)
attach(signdist)
model <- lm(Distance ~ Age)
summary(model) # Multiple R-squared:  0.642
```

```
##
## Call:
## lm(formula = Distance ~ Age)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -78.231 -41.710   7.646  33.552 108.831
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 576.6819    23.4709  24.570  < 2e-16 ***
## Age          -3.0068     0.4243  -7.086 1.04e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 49.76 on 28 degrees of freedom
## Multiple R-squared:  0.642,  Adjusted R-squared:  0.6292
## F-statistic: 50.21 on 1 and 28 DF,  p-value: 1.041e-07
```

```
cor(Distance, Age) # correlation = -0.8012447
```

```
## [1] -0.8012447
```

```
detach(signdist)
```

Student's height and GPA

Load the student's height and GPA data. Fit a simple linear regression model with y = GPA and x = Height and display the coefficient of determination, . Calculate the correlation between GPA and Height.

```
heightgpa <- read.table("./Data/heightgpa.txt", header=T)
attach(heightgpa)
model <- lm(gpa ~ height)
summary(model) # Multiple R-squared:  0.002835
```

```
##
## Call:
## lm(formula = gpa ~ height)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.45081 -0.24878  0.00325  0.35622  0.90263
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.410214   1.434616   2.377   0.0234 *
## height      -0.006563   0.021428  -0.306   0.7613
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5423 on 33 degrees of freedom
## Multiple R-squared:  0.002835,   Adjusted R-squared:  -0.02738
## F-statistic: 0.09381 on 1 and 33 DF,  p-value: 0.7613
```

```
cor(gpa, height) # correlation = -0.05324126
```

```
## [1] -0.05324126
```

```
detach(heightgpa)
```

Teen birth rate and poverty

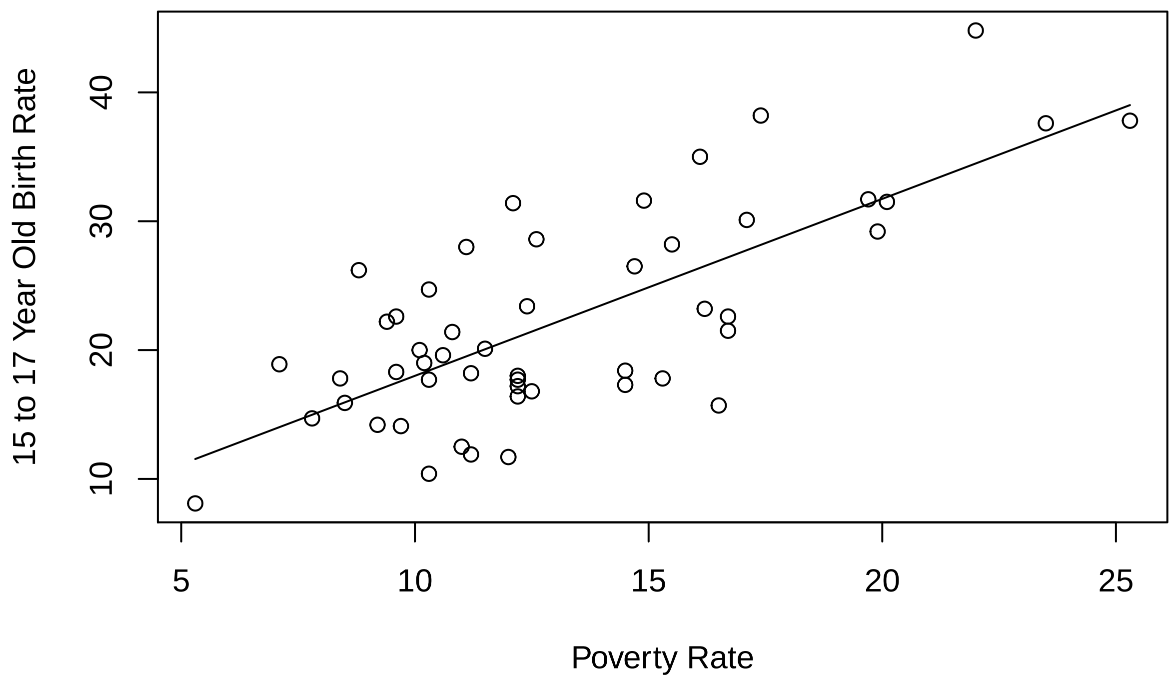
Load the teen birth rate and poverty data. Fit a simple linear regression model with y = Brth15to17 and x = PovPct and display the model results. Produce a scatterplot with a simple linear regression line.

```
poverty <- read.table("./Data/poverty.txt", header=T)
attach(poverty)

model <- lm(Brth15to17 ~ PovPct)
summary(model)
```

```
##
## Call:
## lm(formula = Brth15to17 ~ PovPct)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11.2275  -3.6554  -0.0407   2.4972  10.5152
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   4.2673     2.5297   1.687    0.098 .
```

```
## PovPct        1.3733     0.1835   7.483 1.19e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.551 on 49 degrees of freedom
## Multiple R-squared:  0.5333, Adjusted R-squared:  0.5238
## F-statistic:    56 on 1 and 49 DF,  p-value: 1.188e-09
```

```
# Coefficients:
#              Estimate Std. Error t value Pr(>|t|)
# (Intercept)   4.2673     2.5297   1.687    0.098 .
# PovPct        1.3733     0.1835   7.483 1.19e-09 ***
# ---
# Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#
# Residual standard error: 5.551 on 49 degrees of freedom
# Multiple R-squared:  0.5333,  Adjusted R-squared:  0.5238

plot(PovPct, Brth15to17, xlab="Poverty Rate", ylab="15 to 17 Year Old Birth Rate",
     panel.last = lines(sort(PovPct), fitted(model)[order(PovPct)]))
```




```
detach(poverty)
```

Lung function

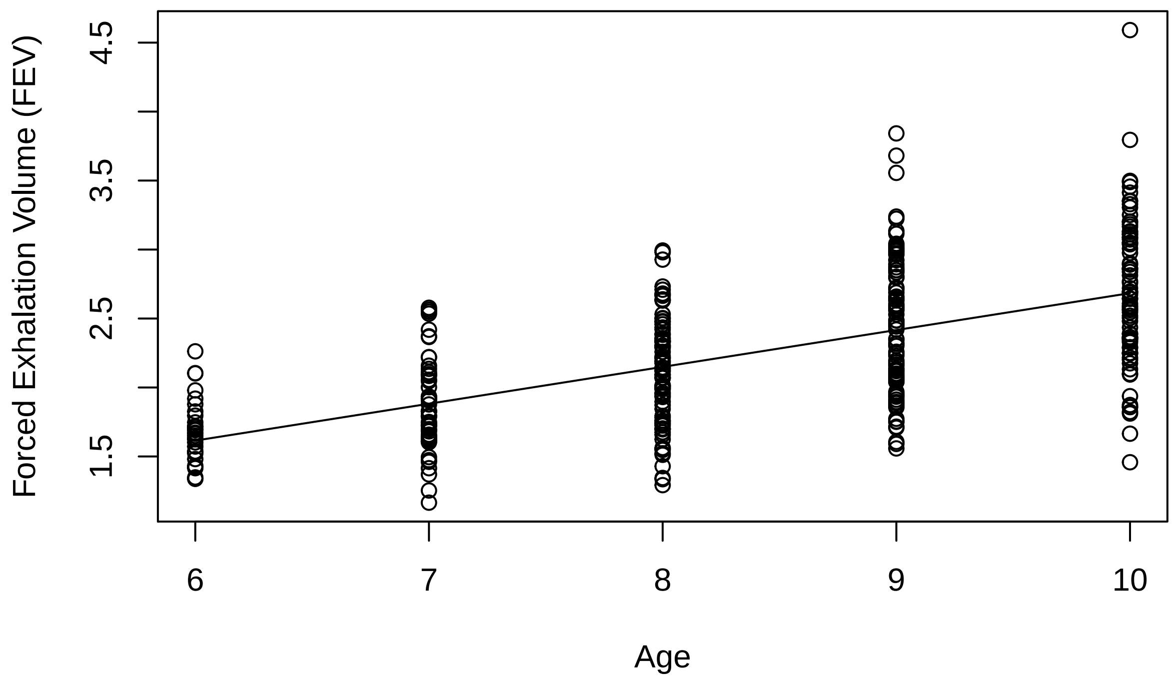
Load the lung function data. Fit a simple linear regression model with y = FEV and x = age for ages 6-10 only and display the model results. Produce a scatterplot for ages 6-10 only with a simple linear regression line. Fit a simple linear regression model with y = FEV and x = age for the full dataset and display the model results. Produce a scatterplot for the full dataset with a simple linear regression line.

```
lungfunction <- read.table("./Data/fev_dat.txt", header=T)
attach(lungfunction)
```

```r
model.1 <- lm(FEV ~ age, subset = age>=6 & age<=10)
summary(model.1)
```

```
##
## Call:
## lm(formula = FEV ~ age, subset = age >= 6 & age <= 10)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.22576 -0.28855 -0.00534  0.27106  1.90724
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.01165    0.15237   0.076    0.939
## age          0.26721    0.01801  14.839   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4312 on 349 degrees of freedom
## Multiple R-squared:  0.3869, Adjusted R-squared:  0.3851
## F-statistic: 220.2 on 1 and 349 DF,  p-value: < 2.2e-16
```

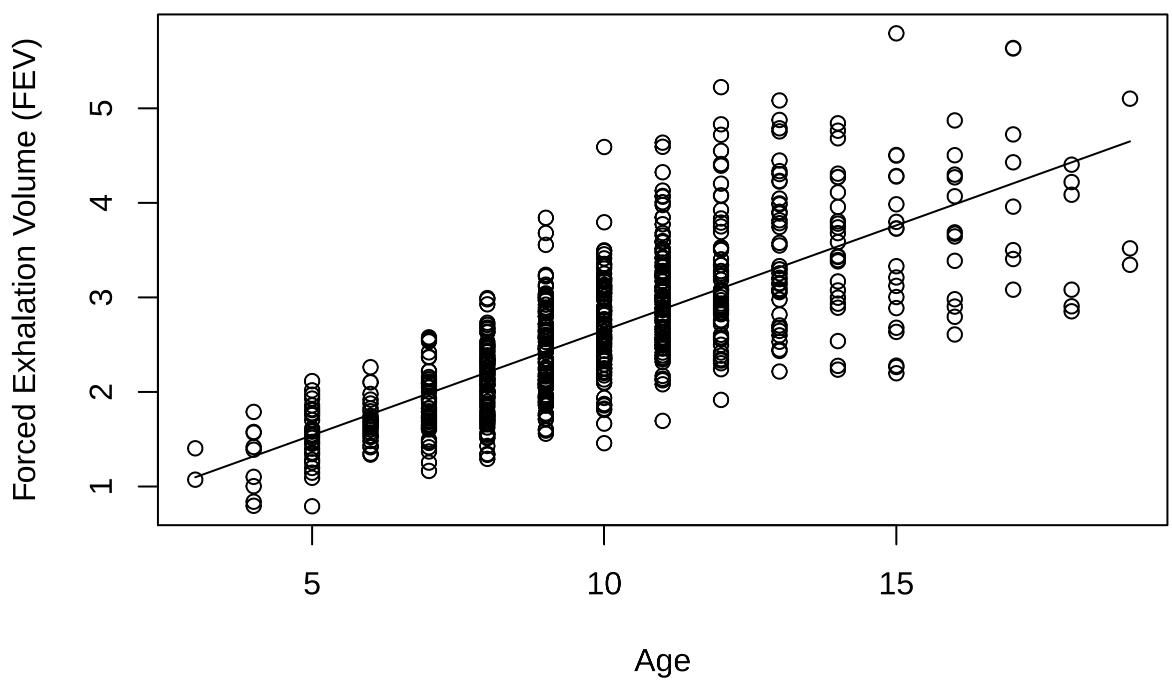
```r
# Coefficients:
#             Estimate Std. Error t value Pr(>|t|)
# (Intercept)  0.01165    0.15237   0.076    0.939
# age          0.26721    0.01801  14.839   <2e-16 ***

plot(age[age>=6 & age<=10], FEV[age>=6 & age<=10],
     xlab="Age", ylab="Forced Exhalation Volume (FEV)",
     panel.last = lines(sort(age[age>=6 & age<=10]),
                        fitted(model.1)[order(age[age>=6 & age<=10])]))
```



```r
model.2 <- lm(FEV ~ age)
summary(model.2)
```

```
##
## Call:
## lm(formula = FEV ~ age)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.57539 -0.34567 -0.04989  0.32124  2.12786
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.431648   0.077895   5.541 4.36e-08 ***
## age         0.222041   0.007518  29.533  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5675 on 652 degrees of freedom
## Multiple R-squared:  0.5722, Adjusted R-squared:  0.5716
## F-statistic: 872.2 on 1 and 652 DF,  p-value: < 2.2e-16
```

```r
# Coefficients:
#             Estimate Std. Error t value Pr(>|t|)
# (Intercept) 0.431648   0.077895   5.541 4.36e-08 ***
# age         0.222041   0.007518  29.533  < 2e-16 ***

plot(age, FEV, xlab="Age", ylab="Forced Exhalation Volume (FEV)",
     panel.last = lines(sort(age), fitted(model.2)[order(age)]))
```




```r
detach(lungfunction)
```