02-exercises

April 13, 2016

This exercise uses the **Fuel Economy** data set from the **AppliedPredicitiveModeling** package.

Note: The following will set-up your environment for this exercise. If you get an error stating that the packages have not been found, you need to install those packages.

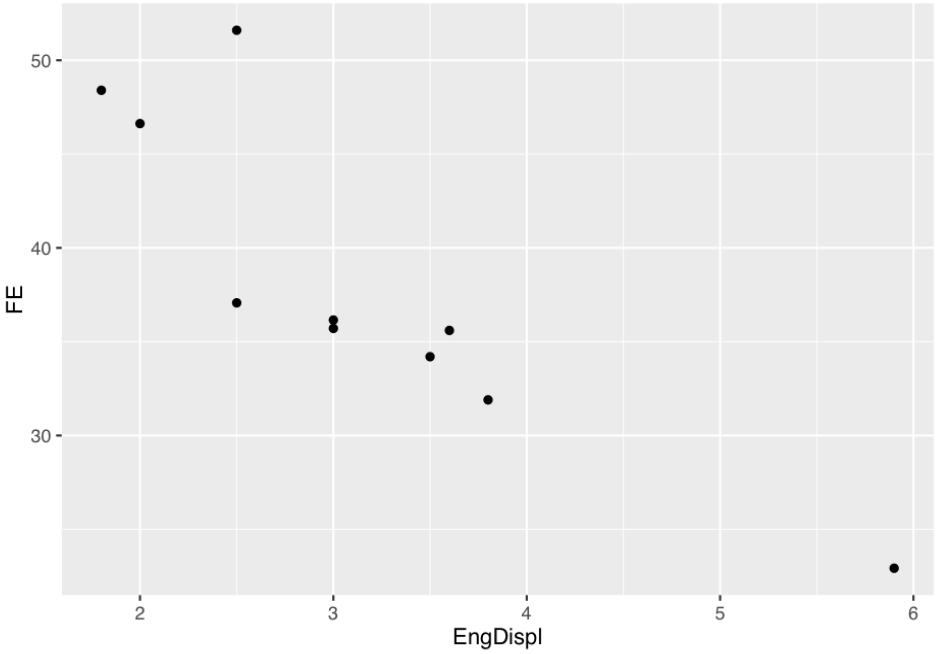
```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

Exercise 1

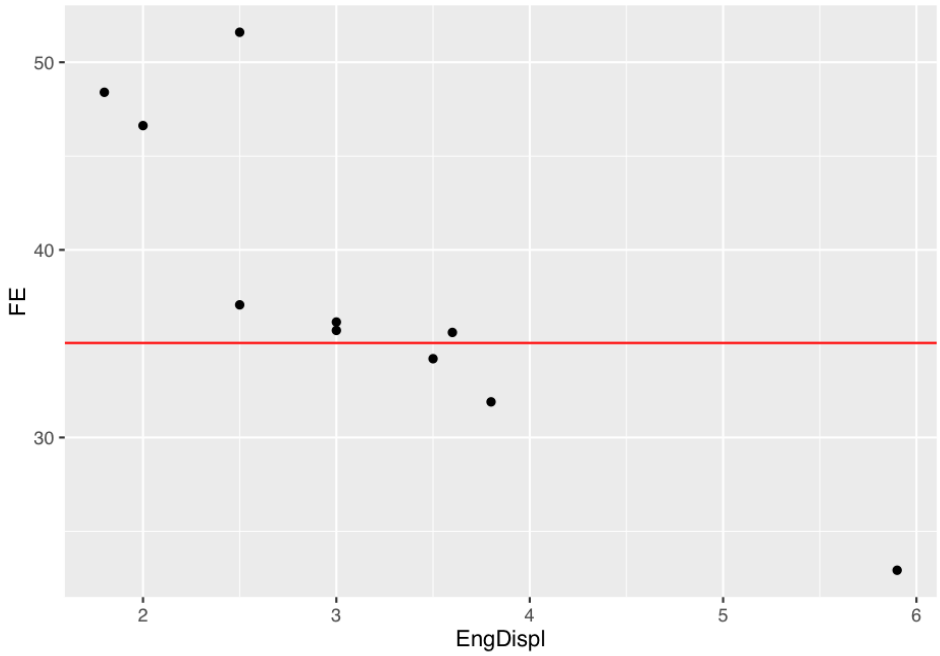
Hint: See `?cars2010`

- After the **Fuel Economy** data is loaded, combine three data sets into one data set. (Note: The name `dat` is very often used in these situations, `data` is a reserved R word.)

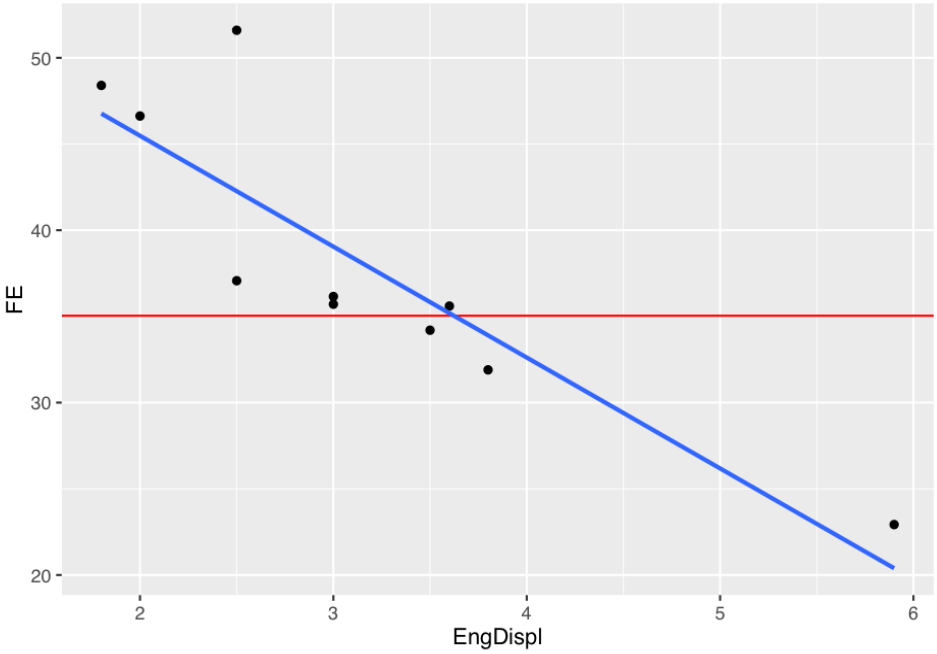
```
dat3years <- rbind(cars2010,cars2011,cars2012)

naive_guess = mean(dat3years$FE)

set.seed(314)

samp <- dat3years %>% dplyr::sample_n(10) # you can also do just sample_n(10) since no conflicts with d

samp %>% ggplot(aes(x=EngDispl, y=FE) ) + geom_point()
```



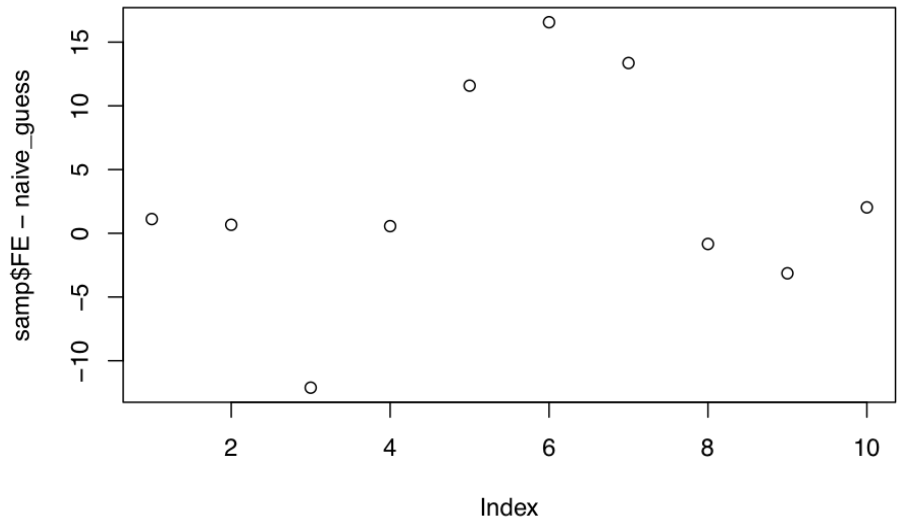

```
#Naive guess (red line) is just a good place to start, always need a good place to start
samp %>% ggplot(aes(x=EngDispl, y=FE) ) + geom_point() + geom_hline(yintercept=naive_guess, color="red")
```




```
#graph showing naive guess and linear model
samp %>% ggplot(aes(x=EngDispl, y=FE) ) + geom_point() + geom_hline(yintercept=naive_guess, color="red"
```

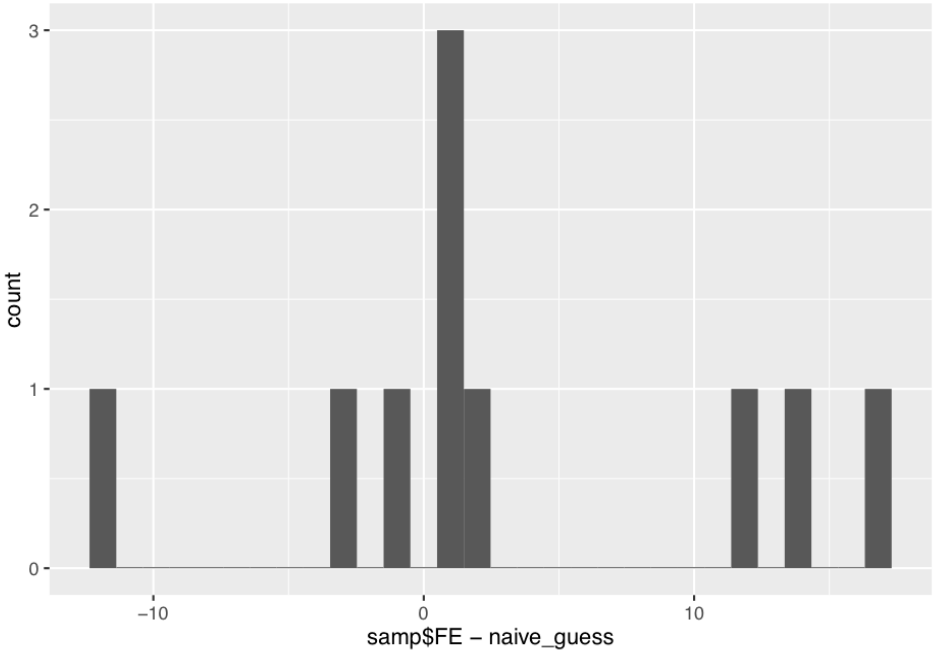



```
plot(samp$FE - naive_guess)
```




```
qplot(samp$FE - naive_guess)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
#dat3years$FE

(dat3years$FE - naive_guess)^2 %>% mean %>% sqrt
```

```
## [1] 8.096176
```

```
fit.dat3years <- lm(FE ~ EngDispl, data = dat3years)

fit.dat3years
```

```
##
## Call:
## lm(formula = FE ~ EngDispl, data = dat3years)
##
## Coefficients:
## (Intercept)     EngDispl
##      51.840       -4.792
```

```
fit.dat3years <- lm(FE ~ EngDispl + NumCyl, data = dat3years)

fit.dat3years
```

```
##
## Call:
```

```
## lm(formula = FE ~ EngDispl + NumCyl, data = dat3years)
##
## Coefficients:
## (Intercept)     EngDispl       NumCyl
##     52.6096      -4.1561      -0.5015
```

```
fit.dat3years <- lm(FE ~ EngDispl + NumCyl + NumGears, data = dat3years)

fit.dat3years
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + NumCyl + NumGears, data = dat3years)
##
## Coefficients:
## (Intercept)     EngDispl       NumCyl     NumGears
##    52.75736     -4.16766     -0.48663     -0.03659
```

```
fit.dat3years <- lm(FE ~ EngDispl + CarlineClassDesc + EngDispl, data = dat3years)

fit.dat3years
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + CarlineClassDesc + EngDispl, data = dat3years)
##
## Coefficients:
##                                       (Intercept)
##                                           47.3513
##                                           EngDispl
##                                           -4.2855
##                           CarlineClassDesc2Seaters
##                                            3.3389
##                       CarlineClassDescCompactCars
##                                            5.7699
##                         CarlineClassDescLargeCars
##                                            3.9337
##                       CarlineClassDescMidsizeCars
##                                            5.4664
##                   CarlineClassDescMinicompactCars
##                                            4.8408
##              CarlineClassDescSmallPickupTrucks2WD
##                                           -1.4834
##              CarlineClassDescSmallPickupTrucks4WD
##                                           -1.8652
##                CarlineClassDescSmallStationWagons
##                                            2.7078
## CarlineClassDescSpecialPurposeVehicleminivan2WD
##                                            1.8885
##     CarlineClassDescSpecialPurposeVehicleSUV2WD
##                                            1.7443
##     CarlineClassDescSpecialPurposeVehicleSUV4WD
##                                           -0.7989
```

```
##         CarlineClassDescStandardPickupTrucks2WD
##                                          1.1908
##         CarlineClassDescStandardPickupTrucks4WD
##                                         -0.8495
##                  CarlineClassDescSubcompactCars
##                                          4.0061
##                  CarlineClassDescVansCargoTypes
##                                         -1.4134
##               CarlineClassDescVansPassengerType
##                                         -1.9240
```

```
fit.dat3years %>% summary()
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + CarlineClassDesc + EngDispl, data = dat3years)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -15.5863  -2.5786  -0.3323   2.0675  24.5366
##
## Coefficients:
##                                              Estimate Std. Error
## (Intercept)                                  47.35133    1.08855
## EngDispl                                     -4.28549    0.09444
## CarlineClassDesc2Seaters                      3.33895    1.13930
## CarlineClassDescCompactCars                   5.76985    1.09449
## CarlineClassDescLargeCars                     3.93368    1.14347
## CarlineClassDescMidsizeCars                   5.46636    1.10046
## CarlineClassDescMinicompactCars               4.84079    1.17630
## CarlineClassDescSmallPickupTrucks2WD         -1.48338    1.26635
## CarlineClassDescSmallPickupTrucks4WD         -1.86522    1.37416
## CarlineClassDescSmallStationWagons            2.70785    1.15035
## CarlineClassDescSpecialPurposeVehicleminivan2WD  1.88848    1.41360
## CarlineClassDescSpecialPurposeVehicleSUV2WD   1.74434    1.10760
## CarlineClassDescSpecialPurposeVehicleSUV4WD  -0.79885    1.09391
## CarlineClassDescStandardPickupTrucks2WD       1.19076    1.27855
## CarlineClassDescStandardPickupTrucks4WD      -0.84945    1.26361
## CarlineClassDescSubcompactCars                4.00608    1.10918
## CarlineClassDescVansCargoTypes               -1.41338    1.40369
## CarlineClassDescVansPassengerType            -1.92396    1.46703
##                                              t value Pr(>|t|)
## (Intercept)                                   43.500  < 2e-16 ***
## EngDispl                                     -45.377  < 2e-16 ***
## CarlineClassDesc2Seaters                       2.931 0.003436 **
## CarlineClassDescCompactCars                    5.272 1.56e-07 ***
## CarlineClassDescLargeCars                      3.440 0.000598 ***
## CarlineClassDescMidsizeCars                    4.967 7.61e-07 ***
## CarlineClassDescMinicompactCars                4.115 4.09e-05 ***
## CarlineClassDescSmallPickupTrucks2WD          -1.171 0.241643
## CarlineClassDescSmallPickupTrucks4WD          -1.357 0.174883
## CarlineClassDescSmallStationWagons             2.354 0.018711 *
## CarlineClassDescSpecialPurposeVehicleminivan2WD   1.336 0.181784
## CarlineClassDescSpecialPurposeVehicleSUV2WD    1.575 0.115505
```

```
## CarlineClassDescSpecialPurposeVehicleSUV4WD      -0.730 0.465343
## CarlineClassDescStandardPickupTrucks2WD           0.931 0.351834
## CarlineClassDescStandardPickupTrucks4WD          -0.672 0.501537
## CarlineClassDescSubcompactCars                    3.612 0.000315 ***
## CarlineClassDescVansCargoTypes                   -1.007 0.314149
## CarlineClassDescVansPassengerType                -1.311 0.189913
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.212 on 1429 degrees of freedom
## Multiple R-squared:  0.7328, Adjusted R-squared:  0.7296
## F-statistic: 230.5 on 17 and 1429 DF,  p-value: < 2.2e-16
```

```
#dot means use all variables
fit.dat3years <- lm(FE ~ . + EngDispl, data = dat3years)

fit.dat3years
```

```
##
## Call:
## lm(formula = FE ~ . + EngDispl, data = dat3years)
##
## Coefficients:
##                                     (Intercept)
##                                        57.23884
##                                        EngDispl
##                                        -2.34608
##                                          NumCyl
##                                        -1.08024
##                                 TransmissionA4
##                                        -6.85302
##                                 TransmissionA5
##                                        -5.44388
##                                 TransmissionA6
##                                        -3.56074
##                                 TransmissionA7
##                                        -2.96101
##                                TransmissionAM6
##                                        -5.54718
##                                TransmissionAM7
##                                        -6.46621
##                                 TransmissionAV
##                                        -4.87101
##                                TransmissionAVS6
##                                        -7.71471
##                                 TransmissionM5
##                                        -6.08294
##                                 TransmissionM6
##                                        -5.82397
##                                 TransmissionS4
##                                        -9.49087
##                                 TransmissionS5
##                                        -7.02958
##                                 TransmissionS6
```

```
##                                     -4.41966
##                                TransmissionS7
##                                     -4.30174
##                                TransmissionS8
##                                     -1.09346
##                AirAspirationMethodSupercharged
##                                     -1.07233
##                AirAspirationMethodTurbocharged
##                                     -0.49004
##                                     NumGears
##                                     -0.54137
##                                   TransLockup
##                                     -0.86099
##                                TransCreeperGear
##                                     -0.53964
##                         DriveDescFourWheelDrive
##                                     -0.17575
##                DriveDescParttimeFourWheelDrive
##                                      0.08028
##                    DriveDescTwoWheelDriveFront
##                                      5.48985
##                     DriveDescTwoWheelDriveRear
##                                      1.52322
##                               IntakeValvePerCyl
##                                     -0.88678
##                             ExhaustValvesPerCyl
##                                     -1.07324
##                       CarlineClassDesc2Seaters
##                                      3.69574
##                    CarlineClassDescCompactCars
##                                      4.50549
##                      CarlineClassDescLargeCars
##                                      3.46899
##                    CarlineClassDescMidsizeCars
##                                      4.22037
##                CarlineClassDescMinicompactCars
##                                      4.09843
##            CarlineClassDescSmallPickupTrucks2WD
##                                     -1.23092
##            CarlineClassDescSmallPickupTrucks4WD
##                                     -0.28463
##              CarlineClassDescSmallStationWagons
##                                      2.73308
## CarlineClassDescSpecialPurposeVehicleminivan2WD
##                                     -2.37816
##     CarlineClassDescSpecialPurposeVehicleSUV2WD
##                                     -1.14331
##     CarlineClassDescSpecialPurposeVehicleSUV4WD
##                                      0.39161
##         CarlineClassDescStandardPickupTrucks2WD
##                                     -0.53602
##         CarlineClassDescStandardPickupTrucks4WD
##                                     -0.99735
##                  CarlineClassDescSubcompactCars
```

```
##                                     3.85189
##                 CarlineClassDescVansCargoTypes
##                                    -3.30398
##              CarlineClassDescVansPassengerType
##                                    -4.51100
##                                VarValveTiming
##                                      0.21536
##                                  VarValveLift
##                                      1.07734
```

```
#sample 10 CarlineClassDesc
dat3years %>% select(CarlineClassDesc) %>% sample_n(10)
```

```
##                 CarlineClassDesc
## 1622                  LargeCars
## 1255              SubcompactCars
## 1438                 CompactCars
## 1396                 CompactCars
## 1817     StandardPickupTrucks2WD
## 1653                  LargeCars
## 2129 SpecialPurposeVehicleSUV4WD
## 1837     StandardPickupTrucks4WD
## 1143                   2Seaters
## 1573                MidsizeCars
```

```
#print table count for each CarlineClassDesc type
dat3years %>% select(CarlineClassDesc) %>% table
```

```
## .
##                           Other                       2Seaters
##                              16                             98
##                      CompactCars                     LargeCars
##                             199                             98
##                      MidsizeCars                MinicompactCars
##                             175                             65
##            SmallPickupTrucks2WD            SmallPickupTrucks4WD
##                              36                             23
##              SmallStationWagons SpecialPurposeVehicleminivan2WD
##                              84                             20
##     SpecialPurposeVehicleSUV2WD     SpecialPurposeVehicleSUV4WD
##                             154                            218
##         StandardPickupTrucks2WD         StandardPickupTrucks4WD
##                              36                             39
##                  SubcompactCars                  VansCargoTypes
##                             146                             22
##               VansPassengerType
##                              18
```

- What is a good "naive guess" of FE? Show your work

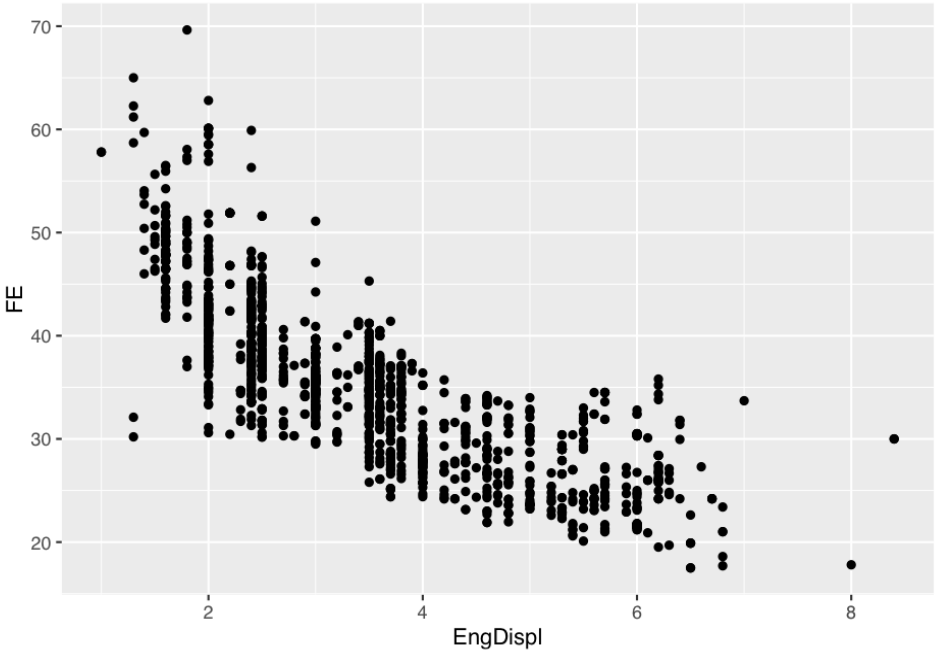
```
dat3years <- rbind(cars2010,cars2011,cars2012)
```

```
naive_guess = mean(dat3years$FE)

naive_guess
```

```
## [1] 35.03823
```

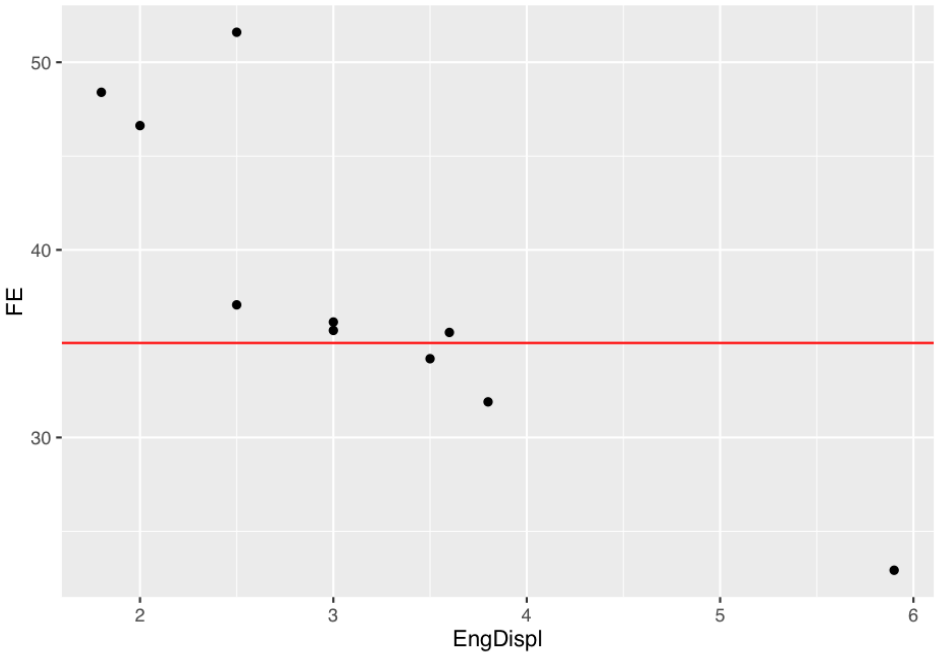
- plot FE (Fuel Econonomy) vs. EngDisp. Plot the naive guess.

```
# ... ggplot2

dat3years %>% ggplot(aes(x=EngDispl, y=FE) ) + geom_point()
```



- Sample 10 observations from `dat`
- Plot this data. Add a line for the naive_guess.

```
set.seed(314)

# Sample

samp <- dat3years %>% dplyr::sample_n(10)

#Naive guess (red line) is just a good place to start, always need a good place to start
samp %>% ggplot(aes(x=EngDispl, y=FE) ) + geom_point() + geom_hline(yintercept=naive_guess, color="red"
```



Exercise 2:

Write a loss functions for calculating:

- Root Mean Square Error
- Mean Absolute Error
- Median Absolute Error

All functions should accept two arguments:

```
rmse <- function(y,yhat) {

  ( y - yhat )^2  %>% mean %>% sqrt
}

mae <- function(y, yhat) {

  abs( y - yhat ) %>% mean()
}

medae <- function(y, yhat) {

  abs( y - yhat ) %>% median()
}
```

Use these functions to evaluate the loss/performance of: - the naive guess

Exercise 3: Linear Model and Model Performance

- Use `lm` to create a linear model fitting the relationship between FE and EngDispl for the cars2010 data set

```
fit.2010 <- lm( FE ~ EngDispl, data=cars2010 )
```

- Use your functions to evaluate the training error
- Use your model to: – predict the FE for 2011. What is the RMSE errors associated with the predictions. – predict the FE for 2012. What is the RMSE errors associated with the predictions.

```
#Predict FE for 2010, 2011, 2012 using lm from 2010
y.2010 <- predict( fit.2010, data=cars2010 )
y.2011 <- predict( fit.2010, data=cars2011 )
y.2012 <- predict( fit.2010, data=cars2012 )

#Calculate RMSE error
rmse.2010 <- rmse( cars2010$FE,y.2010)
rmse.2011 <- rmse( cars2011$FE,y.2011)
```

```
## Warning in y - yhat: longer object length is not a multiple of shorter
## object length
```

```
rmse.2012 <- rmse( cars2012$FE,y.2012)
```

```
## Warning in y - yhat: longer object length is not a multiple of shorter
## object length
```

```
# DO NOT EDIT
rmse.2010
```

```
## [1] 4.620076
```

```
rmse.2011
```

```
## [1] 11.33028
```

```
rmse.2012
```

```
## [1] 12.94582
```

Exercise 4:

- Model the fuel economy (`FE`) as a function of `EngDispl`, `NumCyl` and `VarValve` using the `cars2011` data set.

- Provide betas

```r
fit.2011 <- lm( FE ~ EngDispl + NumCyl + VarValveTiming, data=cars2011 )

summary(fit.2011)
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + NumCyl + VarValveTiming, data = cars2011)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -10.687  -2.768  -0.960   2.279  19.124
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)     52.6644     1.4701  35.823  < 2e-16 ***
## EngDispl        -3.9056     0.5246  -7.445 1.71e-12 ***
## NumCyl          -1.1102     0.4268  -2.601  0.00987 **
## VarValveTiming   3.5937     0.8862   4.055 6.76e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.828 on 241 degrees of freedom
## Multiple R-squared:  0.7283, Adjusted R-squared:  0.725
## F-statistic: 215.4 on 3 and 241 DF,  p-value: < 2.2e-16
```

```r
coef(fit.2011)
```

```
##    (Intercept)       EngDispl         NumCyl VarValveTiming
##      52.664445      -3.905643      -1.110172       3.593704
```