Practical

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Load the packages.

```
library(ISLR)
library(glmnet)
```

```
## Loading required package: Matrix
```

```
## Loaded glmnet 4.0-2
```

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.2     v purrr   0.3.4
## v tibble  3.0.3     v dplyr   1.0.1
## v tidyr   1.1.1     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.0
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x tidyr::expand() masks Matrix::expand()
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## x tidyr::pack()   masks Matrix::pack()
## x tidyr::unpack() masks Matrix::unpack()
```

```
library(eply)
library(leaps)
```

1. Prepare a dataframe baseball from the Hitters dataset where you remove the baseball players for which the Salary is missing. How many baseball players are left?

```
Hitters <- Hitters %>%
  filter(!is.na(Salary))

nrow(Hitters)
```

```
## [1] 263
```

Using 'nrow()' gives us back 263 baseball players in the dataset.

2. Create baseball_train (50%), baseball_valid (30%), and baseball_test (20%) datasets.

```
baseball_train <- Hitters %>%
                    sample_frac(0.5)

baseball_valid <- Hitters %>%
                    sample_frac(0.3)

baseball_test <- Hitters %>%
                    sample_frac(0.2)
```

3. Create a function called lm_mse() with as inputs (1) a formula, (2) a training dataset, and (3) a test dataset which outputs the mse on the test dataset for predictions from a linear model.

```
lm_mse <- function(formula, train_data, valid_data) {
  y_name <- as.character(formula)[2]
  y_true <- valid_data[[y_name]]

  ##The remainder of the function here

  #Space to specify formula, now done outside of function instead
  #formula <- formula_input

  #Linear model fit, Include only subset corresponding to training set
  lm.fit <- lm(formula = formula, data=train_data)

  #Predict values, by selecting only the observations that are not in the training set
  #predict <- predict(lm.fit, data.frame(X))
  #predict_y <- predict((lm.fit, valid_data)[-train_data])
  mse <- mean((y_true - predict(lm.fit, newdata = valid_data))^2)

  #Print result of mean square error
  print(mse)

}

#mse <- function(y_true, y_pred) {
#(1/length(y_true))*sum((y_true - y_pred)^2)
#}
```

4. Try out your function with the formula Salary ~ Hits + Runs, using baseball_train and baseball_valid.

```
formula_input <- Salary ~ Hits + Runs
```

```
lm_mse(formula_input, baseball_train, baseball_valid)
```

```
## [1] 133583.8
```

```
source("generate_formulas.R")
```

5. Create a character vector of all predictor variables from the Hitters dataset. colnames() may be of help. Note that Salary is not a predictor variable.

```
column_names <- colnames(Hitters)

column_names <- column_names[!(column_names %in% "Salary")]

#I think that we should follow this and remove non-numeric variables when carrying out

#Check variable types inside Hitters data set
#lapply(Hitters,class)

#Choose only numeric variables
#column_names <- colnames(select_if(Hitters, is.numeric))

#Exclude 'Salary' from variables vector
#column_names <- column_names[!(column_names %in% "Salary")]

#Print final vector
#column_names

#Create vector which only contains the character string 'Salary
#c("Salary")
```

6. Generate all formulas with as outcome Salary and 3 predictors from the Hitters data. Assign this to a variable called formulas. There should be 969 elements in this vector.

```
formulas <- generate_formulas(3, column_names, c("Salary"))

length(formulas)
```

```
## [1] 969
```

Thus indeed our 'formulas' variable contains 969 inside of it.

7. Use a for loop to find the best set of 3 predictors in the Hitters dataset based on MSE. Use the baseball_train and baseball_valid datasets.

```
#Initialise some vector to store values
a <- numeric()

#Use for loop
```

```r
for (i in 1:length(formulas)){
  result <- lm_mse(as.formula(formulas[i]), baseball_train, baseball_valid)
  a[i] <- result
}
```

```
## [1] 132085.8
## [1] 133339.1
## [1] 130232.4
## [1] 120085.4
## [1] 115763.5
## [1] 99269.96
## [1] 98378.3
## [1] 84634.05
## [1] 94550.15
## [1] 87683.6
## [1] 99180.4
## [1] 136085.3
## [1] 131860.9
## [1] 147165.6
## [1] 136008
## [1] 135880.4
## [1] 137473.2
## [1] 136593.4
## [1] 141150.4
## [1] 129332
## [1] 124236.9
## [1] 106386.3
## [1] 102940.2
## [1] 97562.29
## [1] 100875.1
## [1] 97837
## [1] 108469.4
## [1] 142571.8
## [1] 137267.8
## [1] 153385
## [1] 143586.1
## [1] 141730.9
## [1] 143782.9
## [1] 133362.4
## [1] 130314.2
## [1] 116322.8
## [1] 99643.39
## [1] 96882.39
## [1] 95383.56
```

```
## [1] 97511.81
## [1] 90557.99
## [1] 105901.9
## [1] 132446.1
## [1] 132566.6
## [1] 145512.7
## [1] 136620.8
## [1] 134727.9
## [1] 134549.4
## [1] 127706.2
## [1] 123016.3
## [1] 105785.8
## [1] 102444.3
## [1] 102588.8
## [1] 100355.8
## [1] 99681.29
## [1] 108676.4
## [1] 139523.6
## [1] 134151.2
## [1] 149998.2
## [1] 140456.4
## [1] 138859.1
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## [1] 114845.6
## [1] 98774.62
## [1] 95494.31
## [1] 93067.04
## [1] 95365.72
## [1] 89475.81
## [1] 107960.2
## [1] 131114.8
## [1] 128643.9
## [1] 137837.9
## [1] 129443.5
## [1] 128441.4
## [1] 132511.5
## [1] 103492.9
## [1] 99687.42
## [1] 106433.9
## [1] 98063.89
## [1] 97015.24
## [1] 109216.1
## [1] 123590.6
## [1] 121753.1
## [1] 132108.2
```

```
## [1] 124219.6
## [1] 124852.5
## [1] 124897
## [1] 100494.9
## [1] 104637.7
## [1] 99304.65
## [1] 101727.4
## [1] 106136.5
## [1] 106257.1
## [1] 104174.9
## [1] 110315.9
## [1] 106242.4
## [1] 107138.3
## [1] 106860
## [1] 101979.9
## [1] 101005.1
## [1] 101771.5
## [1] 103529.3
## [1] 102840
## [1] 100834.4
## [1] 105981.2
## [1] 103296.9
## [1] 103692.5
## [1] 103484.1
## [1] 101718.7
## [1] 103027
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## [1] 95736.49
## [1] 105260.7
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## [1] 100818.6
## [1] 99008.59
## [1] 100438
## [1] 101709.9
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## [1] 103249.4
## [1] 100900.6
## [1] 101112.2
## [1] 100379.1
## [1] 99879.09
## [1] 96096.92
## [1] 93403.78
## [1] 100460.8
```

```
## [1] 97230.23
## [1] 97499.53
## [1] 96772.68
## [1] 108035.4
## [1] 106968.6
## [1] 112207.1
## [1] 107424
## [1] 108759.3
## [1] 108899.7
## [1] 141068.5
## [1] 157189
## [1] 143311.3
## [1] 141738.4
## [1] 146418.6
## [1] 152402.5
## [1] 137644.4
## [1] 136319.2
## [1] 141992.7
## [1] 154710
## [1] 150946.2
## [1] 157789
## [1] 145434.5
## [1] 144888.6
## [1] 143393.4
## [1] 131803.4
## [1] 131804
## [1] 122016.9
## [1] 114051.2
## [1] 99737.75
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## [1] 86784.96
## [1] 95088.34
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## [1] 100189
## [1] 130186.2
## [1] 126664
## [1] 142416.4
## [1] 132494.3
## [1] 129886.2
## [1] 131711
## [1] 130503.1
## [1] 124377.4
## [1] 113220.6
## [1] 98738.83
## [1] 96595.88
```

```
## [1] 89706.81
## [1] 95003.36
## [1] 88786.56
## [1] 100479.4
## [1] 129963.6
## [1] 128503.1
## [1] 142333.7
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## [1] 88658.19
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## [1] 130165.9
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## [1] 141527
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## [1] 128774.6
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## [1] 107248.1
## [1] 93889.66
## [1] 91810.51
## [1] 85579.96
## [1] 90901.12
## [1] 84376.14
## [1] 99838.2
## [1] 122615.1
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## [1] 130033.8
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## [1] 103172.7
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## [1] 123161.8
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```

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## [1] 127330
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## [1] 130446.4
## [1] 112437
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## [1] 92111.88
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## [1] 127443.5
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## [1] 93616.91
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## [1] 88071.58
```

```
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## [1] 105096.6
## [1] 113629.4
## [1] 130276.6
```

```
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## [1] 102387.6
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## [1] 104214.2
## [1] 107929
## [1] 106533.7
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## [1] 103021.9
## [1] 108363.7
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## [1] 105845.1
## [1] 106578
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## [1] 109085.9
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## [1] 104535
## [1] 102732.4
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## [1] 103381
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## [1] 107945.6
## [1] 105562.2
```

```
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## [1] 114265
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## [1] 151361.9
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## [1] 155864.9
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## [1] 148589.7
## [1] 146412.4
## [1] 147101.8
## [1] 98086.84
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## [1] 108699.9
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## [1] 130265.5
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```

```
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## [1] 100970.9
## [1] 101018.6
## [1] 101741.6
## [1] 101110.7
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## [1] 101246.4
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## [1] 99230.47
## [1] 97983.94
## [1] 103291.2
## [1] 98523.5
## [1] 100965
## [1] 100273.8
## [1] 100984.9
## [1] 94864.21
## [1] 101353
## [1] 100886.4
## [1] 102420.9
## [1] 102269.4
## [1] 102722.1
## [1] 102062.5
## [1] 93261.25
## [1] 94611.04
## [1] 93085.96
## [1] 96765.66
## [1] 94538.65
## [1] 95499.71
## [1] 95390.86
## [1] 124788.2
## [1] 123077.2
## [1] 128295.3
## [1] 125177
## [1] 125980.9
## [1] 125881.8
## [1] 142667.5
```

```
## [1] 151111.5
## [1] 145375.6
## [1] 145809.6
## [1] 145717.2
## [1] 148676.5
## [1] 142234.1
## [1] 142100.4
## [1] 143835
## [1] 150915
## [1] 149701.2
## [1] 151830.3
## [1] 148915.5
## [1] 146765.7
## [1] 147355.6
## [1] 110020.6
## [1] 118490.1
## [1] 111454.2
## [1] 115411.6
## [1] 118101.6
## [1] 118847.5
## [1] 114366.4
## [1] 117099.1
## [1] 118469.4
## [1] 119701.5
## [1] 118715.1
## [1] 110289
## [1] 109407.3
## [1] 110726.6
## [1] 110733.9
## [1] 111622
## [1] 107298
## [1] 109875.8
## [1] 111398.4
## [1] 111814.9
## [1] 111537
## [1] 113013.6
## [1] 116392.1
## [1] 131277.4
## [1] 135841
## [1] 130598.7
## [1] 141223.5
## [1] 129259.3
## [1] 133650.8
## [1] 136292.4
## [1] 110053.9
```

```
## [1] 111628.5
## [1] 110731
## [1] 108725.4
## [1] 109180.4
## [1] 111135.3
## [1] 111416.7
## [1] 110802.5
## [1] 112470.3
## [1] 112573.4
## [1] 106207.7
## [1] 117575.3
## [1] 109070.2
## [1] 111339.4
## [1] 113000.6
## [1] 145388.7
## [1] 142064.4
## [1] 144895.2
## [1] 145059.8
## [1] 145586.9
## [1] 146043.6
## [1] 183472
## [1] 188819.6
## [1] 188538.1
## [1] 188389
## [1] 190673.6
## [1] 184431.9
## [1] 182608.1
## [1] 181441.9
## [1] 184319.9
## [1] 186161.9
## [1] 186945.9
## [1] 189001.2
## [1] 191631.9
## [1] 189162
## [1] 189086.7
## [1] 113991.4
## [1] 114253.4
## [1] 116774.8
## [1] 116750.2
## [1] 119902.9
## [1] 116240.5
## [1] 118867.6
## [1] 119304.4
## [1] 118931.9
## [1] 120569.4
```

```
## [1] 122111.9
## [1] 130297.2
## [1] 135493.8
## [1] 132564.9
## [1] 128656.8
## [1] 130354.4
## [1] 129726.7
## [1] 132429.2
## [1] 132575.9
## [1] 118889.8
## [1] 121760.5
## [1] 119611.5
## [1] 119607.3
## [1] 117667
## [1] 120059.6
## [1] 119893.5
## [1] 120264.4
## [1] 130727.3
## [1] 128861.8
## [1] 123916.1
## [1] 129483.5
## [1] 124737.2
## [1] 127962.8
## [1] 129001.3
## [1] 138110.2
## [1] 134363.2
## [1] 133636.1
## [1] 137368
## [1] 137869.6
## [1] 138568.4
## [1] 134054
## [1] 134538.3
## [1] 137309.2
## [1] 138132.1
## [1] 138065.9
## [1] 132016.5
## [1] 133406.4
## [1] 133426.3
## [1] 134271.3
## [1] 132978.9
## [1] 134046.2
## [1] 134343.8
## [1] 140314.1
## [1] 137481.2
## [1] 138297.6
```

```
## [1] 126660
## [1] 127543.3
## [1] 130177.1
## [1] 127043
## [1] 123342.3
## [1] 123431.3
## [1] 124659.7
## [1] 126416.4
## [1] 127100.7
## [1] 126017.9
## [1] 126635.1
## [1] 125405.3
## [1] 123405.7
## [1] 121522.2
## [1] 125111.5
## [1] 125078.4
## [1] 125770.9
## [1] 130953.6
## [1] 128277.6
## [1] 123834
## [1] 125285.5
## [1] 125842.5
## [1] 127466
## [1] 128318
## [1] 131041.6
## [1] 127360.5
## [1] 126768
## [1] 130261
## [1] 130447.1
## [1] 131528.5
## [1] 126478.5
## [1] 126702.4
## [1] 129412.7
## [1] 129835.9
## [1] 130142.1
## [1] 124162.3
## [1] 125826.7
## [1] 125479.8
## [1] 126689.6
## [1] 125042.1
## [1] 125755.9
## [1] 126436.2
## [1] 131929.2
## [1] 129600.6
## [1] 129985.3
```

```
## [1] 126570.4
## [1] 127015.8
## [1] 125830.6
## [1] 123168
## [1] 122413.7
## [1] 124058.6
## [1] 125305.2
## [1] 125906.2
## [1] 131123.1
## [1] 127999.9
## [1] 123363.1
## [1] 125544.2
## [1] 124641.9
## [1] 126670.8
## [1] 128104.4
## [1] 134354.4
## [1] 130898.2
## [1] 132966.1
## [1] 130388.5
## [1] 133850.1
## [1] 134970.7
## [1] 123376.1
## [1] 131466
## [1] 121508.2
## [1] 126531.2
## [1] 129884.6
## [1] 127416.6
## [1] 117406.4
## [1] 120586.6
## [1] 124070.1
## [1] 122795.9
## [1] 128923.2
## [1] 131480.8
## [1] 126449.8
## [1] 121690.2
## [1] 126992.6
## [1] 126090
## [1] 125554.4
## [1] 121822.6
## [1] 122753.9
## [1] 123530.5
## [1] 124509.3
## [1] 125727.6
## [1] 125560
## [1] 123420.4
```

```
## [1] 121785.2
## [1] 125128.3
## [1] 125173.7
## [1] 126250.7
## [1] 122863.6
## [1] 122393
## [1] 124456.3
## [1] 124825.7
## [1] 125655.6
## [1] 120635.5
## [1] 122421.5
## [1] 121987.8
## [1] 123245
## [1] 120472.5
## [1] 121218.6
## [1] 122164.9
## [1] 127164.6
## [1] 124726.4
## [1] 125101.2
## [1] 125789.9
## [1] 121115.5
## [1] 124647
## [1] 122172.2
## [1] 124194.4
## [1] 126615.4
## [1] 117322
## [1] 121965.1
## [1] 118534.6
## [1] 120299.8
## [1] 122471.1
## [1] 118413.1
## [1] 114315
## [1] 114835.1
## [1] 117805.3
## [1] 117325.3
## [1] 119826.5
## [1] 121972.7
## [1] 122117.4
## [1] 118787.4
## [1] 120674.9
## [1] 144685.9
## [1] 145205.5
## [1] 146972.8
## [1] 148050.3
## [1] 148541.4
```

```
## [1] 143246.3
## [1] 143949.7
## [1] 144164.5
## [1] 145518.7
## [1] 143507.8
## [1] 144663.3
## [1] 145648.8
## [1] 150265.4
## [1] 147627
## [1] 148882.3
## [1] 221513
## [1] 213430.8
## [1] 213514.1
## [1] 213200.9
## [1] 230336.4
## [1] 231009
## [1] 230427.8
## [1] 229994
## [1] 226001.3
## [1] 226833.4
## [1] 220453.1
## [1] 219802.9
## [1] 221486
## [1] 216175
## [1] 214161.6
## [1] 214346.4
## [1] 232389.9
## [1] 230309.3
## [1] 231089.1
## [1] 230634.4
```

```
min(a)
```

```
## [1] 84376.14
```

```
min_index = which.min(a)
#Return formula which minimises the mean square error
formulas[min_index]
```

```
## [1] "Salary ~ Hits + Walks + CRBI"
```

8. Do the same for 1, 2 and 4 predictors. Now select the best model with 1, 2, 3, or 4 predictors in terms of its out-of-sample MSE.

```
formulas1 <- generate_formulas(1, column_names, c("Salary"))
formulas2 <- generate_formulas(2, column_names, c("Salary"))
formulas4 <- generate_formulas(4, column_names, c("Salary"))
```

```
b <- numeric()
c <- numeric()
d <- numeric()

#Use for loop for 1 variable
for (i in 1:length(formulas1)){

  result <- lm_mse(as.formula(formulas1[i]), baseball_train, baseball_valid)
  b[i] <- result
}
```

```
## [1] 148853.5
## [1] 136916.3
## [1] 177538.5
## [1] 136830.3
## [1] 146192.8
## [1] 146258.4
## [1] 190810.7
## [1] 138000.8
## [1] 130264
## [1] 130510.6
## [1] 126168.7
## [1] 122288.9
## [1] 147494.8
## [1] 226028.1
## [1] 212608.2
## [1] 228983.8
## [1] 226148
## [1] 226348.8
## [1] 226976.1
```

```
min_index1 = which.min(b)

formulas1[min_index1]
```

```
## [1] "Salary ~ CRBI"
```

```
#Use for loop for 2 variables
for (i in 1:length(formulas2)){

  #Remember to set.seed()
  set.seed(i)

  result <- lm_mse(as.formula(formulas2[i]), baseball_train, baseball_valid)
  c[i] <- result
```

```
}
```

```
## [1] 138000.1
## [1] 144748.8
## [1] 137659.2
## [1] 141162.8
## [1] 132243.2
## [1] 125360.6
## [1] 107045.7
## [1] 103678.2
## [1] 100064.5
## [1] 101019.1
## [1] 96965.98
## [1] 108778.5
## [1] 147482.4
## [1] 141713.4
## [1] 157444.6
## [1] 145154.3
## [1] 143467.1
## [1] 148697.9
## [1] 132789.5
## [1] 133583.8
## [1] 131906.5
## [1] 124218.4
## [1] 115183.3
## [1] 100356.6
## [1] 98576.64
## [1] 89609.45
## [1] 95259.5
## [1] 89853.72
## [1] 100501
## [1] 134921
## [1] 131115.2
## [1] 146424.2
## [1] 134466.5
## [1] 132284.1
## [1] 136492.3
## [1] 135826.8
## [1] 144443.1
## [1] 135424.8
## [1] 158387.1
## [1] 123449.7
## [1] 117290.5
## [1] 128940.3
```

```
## [1] 116313.4
## [1] 117176.8
## [1] 130587.6
## [1] 175657.1
## [1] 166468.7
## [1] 184289.6
## [1] 174104.8
## [1] 177794
## [1] 176116.4
## [1] 132393.9
## [1] 130028.8
## [1] 116360.5
## [1] 99648.9
## [1] 96901.74
## [1] 95443.5
## [1] 97674.66
## [1] 90489.49
## [1] 105849.1
## [1] 131773.6
## [1] 132000.8
## [1] 144796.2
## [1] 136682.6
## [1] 134044.9
## [1] 134117.2
## [1] 127907.5
## [1] 131710.3
## [1] 110035.5
## [1] 106166.1
## [1] 113990.6
## [1] 104139.2
## [1] 106413.7
## [1] 113428
## [1] 145696.1
## [1] 139001.8
## [1] 156166.2
## [1] 146571.7
## [1] 146365.4
## [1] 146511
## [1] 129987.3
## [1] 105624
## [1] 100917.7
## [1] 100465
## [1] 102163.4
## [1] 95012.28
## [1] 125023.1
```

```
## [1] 145751.7
## [1] 142610.2
## [1] 150690.8
## [1] 146042.4
## [1] 146096.1
## [1] 147078.1
## [1] 118440.3
## [1] 111325.1
## [1] 137490.6
## [1] 111393.7
## [1] 112839
## [1] 145262.2
## [1] 190295.2
## [1] 183715.7
## [1] 188136.7
## [1] 189094
## [1] 188511.1
## [1] 191129.3
## [1] 120471.9
## [1] 133276.7
## [1] 121788.6
## [1] 129406.2
## [1] 138046.3
## [1] 138014.4
## [1] 133830.5
## [1] 133693.8
## [1] 137332.3
## [1] 137784.4
## [1] 138251.7
## [1] 127606.6
## [1] 126244.2
## [1] 128552.5
## [1] 131058.8
## [1] 130214.5
## [1] 126291.6
## [1] 125817.2
## [1] 129520.7
## [1] 129564.9
## [1] 130472.8
## [1] 126649.4
## [1] 128335.9
## [1] 135095.1
## [1] 129373.4
## [1] 124015.5
## [1] 130990.8
```

```
## [1] 122638.6
## [1] 127048.6
## [1] 129985.8
## [1] 125856.1
## [1] 126380.3
## [1] 125564.8
## [1] 123190.5
## [1] 121602.5
## [1] 125110.1
## [1] 125013.5
## [1] 125950.6
## [1] 125941.1
## [1] 122166.2
## [1] 117114.2
## [1] 121024.8
## [1] 118740.7
## [1] 120024.3
## [1] 122647.5
## [1] 147616.6
## [1] 144337.4
## [1] 144128.5
## [1] 146899.6
## [1] 147520.9
## [1] 148388.9
## [1] 213167.3
## [1] 230383.2
## [1] 225917.5
## [1] 226669.3
## [1] 226186.2
## [1] 219674.3
## [1] 213160.3
## [1] 212697.7
## [1] 214036.2
## [1] 229276.3
## [1] 229327
## [1] 230483.6
## [1] 229929.2
## [1] 226703.6
## [1] 227588.5
```

```
min_index2 = which.min(c)

formulas2[min_index2]
```

```
## [1] "Salary ~ Hits + CHmRun"
```

```r
#Use for loop for 4 variables
for (i in 1:length(formulas4)){

  #Remember to set.seed()
  set.seed(i)

  result <- lm_mse(as.formula(formulas4[i]), baseball_train, baseball_valid)
  d[i] <- result
}
```

```
## [1] 130458.7
## [1] 130152.1
## [1] 115577
## [1] 113619.9
## [1] 97948.81
## [1] 97062.81
## [1] 84260.66
## [1] 94075.44
## [1] 89235.23
## [1] 98340.19
## [1] 128753
## [1] 125614.5
## [1] 141350.8
## [1] 132047.1
## [1] 132386.7
## [1] 130148.6
## [1] 127985
## [1] 120385.1
## [1] 112525.5
## [1] 96550.5
## [1] 95413.95
## [1] 84382.75
## [1] 93785.15
## [1] 85710.32
## [1] 99013.29
## [1] 129127.4
## [1] 128251.1
## [1] 141746
## [1] 132555.8
## [1] 132010.5
## [1] 131177.8
## [1] 115691.9
## [1] 113274.8
## [1] 97841.27
```

```
## [1] 96967.01
## [1] 85961.52
## [1] 93703.78
## [1] 89966.03
## [1] 98817.39
## [1] 128071
## [1] 124400.2
## [1] 139577
## [1] 130183.5
## [1] 130292.7
## [1] 129245
## [1] 104119.4
## [1] 90193.14
## [1] 89184.53
## [1] 77811.59
## [1] 87951.12
## [1] 79703.38
## [1] 97752.76
## [1] 118376.3
## [1] 118139
## [1] 125704.4
## [1] 118782.3
## [1] 118362.1
## [1] 119996.8
## [1] 96596.18
## [1] 96012.23
## [1] 91699.27
## [1] 92530.17
## [1] 87198.6
## [1] 99533.5
## [1] 113556.1
## [1] 112759.1
## [1] 123327.2
## [1] 115441.3
## [1] 116400.9
## [1] 114995
## [1] 98345.98
## [1] 93712.33
## [1] 93624.28
## [1] 92262.17
## [1] 97588.37
## [1] 98119.5
## [1] 97026.44
## [1] 103179.3
## [1] 99081.32
```

```
## [1] 99967.5
## [1] 98846.87
## [1] 93815.03
## [1] 94300.21
## [1] 93929.81
## [1] 96754.25
## [1] 97218.93
## [1] 95943.34
## [1] 101312.4
## [1] 98376.87
## [1] 98930.59
## [1] 97980.72
## [1] 93457.67
## [1] 94103.49
## [1] 92387.94
## [1] 81898.76
## [1] 81818.04
## [1] 90159.29
## [1] 83346.39
## [1] 84632.84
## [1] 82919.35
## [1] 92629.16
## [1] 94617.43
## [1] 92708.29
## [1] 92716.39
## [1] 97468.57
## [1] 94719.02
## [1] 94999.92
## [1] 93620.24
## [1] 90305.08
## [1] 86351.43
## [1] 85095.08
## [1] 91584.32
## [1] 87910.93
## [1] 87954.12
## [1] 87157.36
## [1] 98012.82
## [1] 98062.63
## [1] 103137
## [1] 98680.7
## [1] 100023.6
## [1] 98953.63
## [1] 130699
## [1] 146396.2
## [1] 133778.1
```

```
## [1] 134092.9
## [1] 135152.7
## [1] 143044.7
## [1] 129486
## [1] 129178.2
## [1] 131804.7
## [1] 145904
## [1] 144142.3
## [1] 147177
## [1] 137751.6
## [1] 135407.4
## [1] 135596.1
## [1] 132377.3
## [1] 128584.2
## [1] 116334.6
## [1] 99700.88
## [1] 96931.54
## [1] 89742.12
## [1] 97560.75
## [1] 89968.78
## [1] 105904.7
## [1] 131285
## [1] 131140.2
## [1] 144571.4
## [1] 136269.8
## [1] 134459.8
## [1] 133126.6
## [1] 128047.1
## [1] 124172.6
## [1] 106223.1
## [1] 102827.8
## [1] 97491.68
## [1] 100112.5
## [1] 99322.65
## [1] 109714.1
## [1] 140102.2
## [1] 134192.1
## [1] 150065.8
## [1] 140250.6
## [1] 138436.9
## [1] 141006
## [1] 114042.5
## [1] 98338.99
## [1] 95009.53
## [1] 90926.57
```

```
## [1] 95299.55
## [1] 90280.88
## [1] 107646.3
## [1] 127486.2
## [1] 125452.9
## [1] 134958.3
## [1] 128355
## [1] 127347.1
## [1] 128971.9
## [1] 102944.7
## [1] 98967.65
## [1] 102908.8
## [1] 98168.78
## [1] 96516
## [1] 108904.6
## [1] 122119.6
## [1] 120439.8
## [1] 131135
## [1] 123934.1
## [1] 124260.8
## [1] 123455.2
## [1] 99436.23
## [1] 105198.3
## [1] 99333.46
## [1] 101307
## [1] 105747.8
## [1] 105252.9
## [1] 103341.6
## [1] 109749
## [1] 106040.6
## [1] 106926.7
## [1] 105887.8
## [1] 102580.8
## [1] 100875.5
## [1] 102004.3
## [1] 103073
## [1] 101729.9
## [1] 99918.44
## [1] 105325.4
## [1] 102923
## [1] 103337.7
## [1] 102412.5
## [1] 102364.5
## [1] 102982.1
## [1] 104364.8
```

```
## [1] 95703.25
## [1] 93610.31
## [1] 102044.9
## [1] 97574.63
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## [1] 113316.8
## [1] 103312.5
## [1] 104774.1
## [1] 106785.4
## [1] 113622.1
## [1] 116652
## [1] 118149.5
## [1] 111855.1
## [1] 108931.6
## [1] 111780.4
## [1] 142441.7
## [1] 145830.7
## [1] 145101.8
## [1] 146104.4
## [1] 146176.9
## [1] 143779.7
## [1] 142014.6
## [1] 142216.4
## [1] 143181.4
## [1] 144773.7
## [1] 145251.2
## [1] 146079.9
## [1] 148349.6
## [1] 145645.5
## [1] 146869.7
## [1] 185311.8
## [1] 182262.6
## [1] 181536.4
```

```
## [1] 183786.2
## [1] 186633.5
## [1] 187793.2
## [1] 188973.5
## [1] 191384
## [1] 188786
## [1] 188749.5
## [1] 183060.7
## [1] 183254
## [1] 185452.6
## [1] 184453.5
## [1] 182909.9
## [1] 182237
## [1] 189639.5
## [1] 186675
## [1] 187925.4
## [1] 191890.8
## [1] 112129.4
## [1] 113223.5
## [1] 113087.5
## [1] 112468.4
## [1] 109335.9
## [1] 113493
## [1] 108700.2
## [1] 110989.4
## [1] 113246.3
## [1] 112445.5
## [1] 114287.2
## [1] 112181.2
## [1] 111435.4
## [1] 112217.4
## [1] 112464.3
## [1] 112107.5
## [1] 113313.1
## [1] 115541.7
## [1] 115853.3
## [1] 111692.8
## [1] 116880.3
## [1] 112540.1
## [1] 114240.1
## [1] 116454.6
## [1] 116153.6
## [1] 113571.2
## [1] 115060.3
## [1] 115549.6
```

```
## [1] 115053.1
## [1] 117049.2
## [1] 115978.4
## [1] 119238.4
## [1] 118666.5
## [1] 118654
## [1] 119253.8
## [1] 116790.2
## [1] 115464.9
## [1] 114725.2
## [1] 116541.5
## [1] 117274.7
## [1] 118210
## [1] 119375.6
## [1] 120699.4
## [1] 119217.5
## [1] 119152.3
## [1] 117451
## [1] 122106.2
## [1] 119659.4
## [1] 119579.3
## [1] 118295.4
## [1] 118715.4
## [1] 119908.1
## [1] 119983.2
## [1] 131737.3
## [1] 129810.8
## [1] 124856.5
## [1] 129509.4
## [1] 125960
## [1] 128894.6
## [1] 129889.6
## [1] 134804.9
## [1] 131105
## [1] 132249.1
## [1] 132067.8
## [1] 134937.8
## [1] 135007.3
## [1] 128149.9
## [1] 130742.8
## [1] 129040.8
## [1] 132138.6
## [1] 132533.1
## [1] 128273.1
## [1] 125506.6
```

```
## [1] 127510.8
## [1] 128180
## [1] 126673.9
## [1] 130563.5
## [1] 130395.3
## [1] 132454.4
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## [1] 132025.9
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## [1] 116552.9
## [1] 115719.9
## [1] 117352.7
## [1] 113965.6
## [1] 116055
## [1] 116954.2
## [1] 119287.6
## [1] 119599.1
## [1] 117645.8
## [1] 119827.2
## [1] 119758.6
## [1] 120233.4
## [1] 117837.5
## [1] 117405.8
## [1] 117789.5
## [1] 118115.4
## [1] 119718.9
## [1] 117326.2
## [1] 118215.7
## [1] 117781.1
## [1] 118481.3
## [1] 115741.9
## [1] 116756.2
## [1] 117251.9
## [1] 121494.2
## [1] 118261.2
## [1] 118613.8
## [1] 130182.6
## [1] 125476
## [1] 130945
## [1] 126032.8
## [1] 129498.7
## [1] 130505
## [1] 123593.3
## [1] 129932.3
## [1] 124249.3
```

```
## [1] 127860.6
## [1] 128896.8
## [1] 126648.9
## [1] 119586
## [1] 122083.3
## [1] 123756.9
## [1] 125158.8
## [1] 129569.9
## [1] 129650.1
## [1] 127478.1
## [1] 124270.2
## [1] 127875
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## [1] 134539.3
## [1] 137396
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## [1] 138446
## [1] 132282.2
## [1] 133909.5
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## [1] 135113
## [1] 132904.1
## [1] 134028.1
## [1] 134585.5
## [1] 140396.6
## [1] 137764
## [1] 138727.1
## [1] 133031.9
## [1] 133566.3
## [1] 133947.7
## [1] 134074.9
## [1] 133679.1
## [1] 135133.6
## [1] 134540.8
## [1] 140574
## [1] 137335.4
## [1] 138184.5
## [1] 131564.4
## [1] 132172.4
## [1] 132776
## [1] 135686.4
## [1] 133723.1
## [1] 134088.3
## [1] 136608.7
## [1] 133450.5
```

```
## [1] 134886.3
## [1] 140613
## [1] 126395
## [1] 127199.1
## [1] 125781.5
## [1] 123096.5
## [1] 122501.3
## [1] 124062
## [1] 125323.2
## [1] 125856.8
## [1] 130211.4
## [1] 126898.6
## [1] 123342.2
## [1] 122910.7
## [1] 124643.1
## [1] 126382.1
## [1] 126970
## [1] 129564.2
## [1] 125887.2
## [1] 126184.1
## [1] 127053.7
## [1] 129235.3
## [1] 129882
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## [1] 123984.1
## [1] 124096.6
## [1] 126247
## [1] 127043.9
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## [1] 120791
## [1] 121963.8
## [1] 123048.6
## [1] 120319.5
## [1] 123138.5
## [1] 123608.2
## [1] 126920.2
## [1] 124040.3
## [1] 126155.2
## [1] 126556
## [1] 125148.8
## [1] 122361.5
## [1] 122477.4
## [1] 123211.4
## [1] 124585.1
## [1] 125185.3
```

```
## [1] 125195
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## [1] 121469
## [1] 125138.2
## [1] 125380.4
## [1] 125898.7
## [1] 122921.3
## [1] 122330.6
## [1] 124203.3
## [1] 124617.7
## [1] 125489.7
## [1] 120625.1
## [1] 122599
## [1] 122245.9
## [1] 123265.1
## [1] 120329.8
## [1] 121084.6
## [1] 122126.4
## [1] 127187
## [1] 124448
## [1] 124863.3
## [1] 130648.4
## [1] 126200.4
## [1] 128090.5
## [1] 128059.4
## [1] 130117.6
## [1] 130936
## [1] 123790.3
## [1] 126011.3
## [1] 125601.2
## [1] 127583.1
## [1] 128276.3
## [1] 123019.4
## [1] 121407.4
## [1] 122501.8
## [1] 123804.1
## [1] 122693.7
## [1] 125151
## [1] 125610.6
## [1] 128096.2
## [1] 125535.2
## [1] 127474.1
## [1] 127563.2
## [1] 127674.7
## [1] 130195.8
```

```
## [1] 130774.8
## [1] 131179.4
## [1] 125324.8
## [1] 126814.4
## [1] 126602.6
## [1] 128043.3
## [1] 125912.3
## [1] 126813.2
## [1] 127706
## [1] 132805.9
## [1] 130577.4
## [1] 131195
## [1] 125243.3
## [1] 125922.7
## [1] 125943.6
## [1] 126359.9
## [1] 125758.9
## [1] 126855.7
## [1] 126674.5
## [1] 132100.8
## [1] 129339.5
## [1] 129764.2
## [1] 123680.2
## [1] 123981
## [1] 124895.8
## [1] 127598.6
## [1] 126070.6
## [1] 126046.4
## [1] 128067.1
## [1] 125458.4
## [1] 126516.3
## [1] 132143.4
## [1] 127009.9
## [1] 125826.1
## [1] 122866.4
## [1] 122511
## [1] 123979.8
## [1] 125243.7
## [1] 125900.9
## [1] 125856.5
## [1] 123490.1
## [1] 122782.5
## [1] 123952.5
## [1] 125581.8
## [1] 126317.5
```

```
## [1] 122603.1
## [1] 123041.3
## [1] 123286
## [1] 124972.1
## [1] 125824.6
## [1] 120993.4
## [1] 120809
## [1] 121664.9
## [1] 122684.1
## [1] 119753.3
## [1] 122011.7
## [1] 122577.6
## [1] 125872.1
## [1] 123214.7
## [1] 124893.8
## [1] 130764
## [1] 126411
## [1] 128385.1
## [1] 127459.3
## [1] 129939.1
## [1] 131094.2
## [1] 123288.4
## [1] 126168.3
## [1] 124227.1
## [1] 126673.9
## [1] 128020.5
## [1] 123048
## [1] 120320.3
## [1] 121588.2
## [1] 123378.3
## [1] 121547.4
## [1] 124785.2
## [1] 125914.1
## [1] 127423.2
## [1] 124195.1
## [1] 126659.8
## [1] 130381.6
## [1] 133489.8
## [1] 129691.7
## [1] 133655.1
## [1] 135122.3
## [1] 131164.8
## [1] 126540
## [1] 129325.1
## [1] 131097.6
```

```
## [1] 128014.8
## [1] 132843.5
## [1] 133724.6
## [1] 133517.4
## [1] 130137
## [1] 134280.2
## [1] 128289.9
## [1] 116663.6
## [1] 120470.6
## [1] 123926.8
## [1] 123075.9
## [1] 129778.5
## [1] 131501.5
## [1] 125579.7
## [1] 121653.5
## [1] 126951.5
## [1] 120435.9
## [1] 125358.6
## [1] 128318.4
## [1] 120482.9
## [1] 116936.7
## [1] 120999.7
## [1] 126302.6
## [1] 122768.4
## [1] 129727.7
## [1] 125636.3
## [1] 125548.1
## [1] 122002
## [1] 123071.2
## [1] 123438.6
## [1] 124668.6
## [1] 126064.2
## [1] 121851.7
## [1] 123763.6
## [1] 123330.3
## [1] 124709.2
## [1] 125603.1
## [1] 120970.2
## [1] 119645.5
## [1] 120284.7
## [1] 122025.5
## [1] 120581.3
## [1] 122400.1
## [1] 123328.4
## [1] 125447.8
```

```
## [1] 123374.1
## [1] 124744.8
## [1] 122849.4
## [1] 122387.6
## [1] 124274
## [1] 124778.6
## [1] 125723.1
## [1] 120831.6
## [1] 122444.6
## [1] 122145.3
## [1] 123568.1
## [1] 120421.2
## [1] 121383.5
## [1] 122420
## [1] 127227.3
## [1] 124825.4
## [1] 125374.8
## [1] 121653.7
## [1] 122005.4
## [1] 122030.5
## [1] 122943
## [1] 121094.8
## [1] 122272.8
## [1] 122389.4
## [1] 126836.4
## [1] 124502.4
## [1] 124911.5
## [1] 119793.1
## [1] 120198.3
## [1] 121379.7
## [1] 124005.3
## [1] 122275.8
## [1] 122299.7
## [1] 123141.4
## [1] 120785.9
## [1] 121981.8
## [1] 126951.2
## [1] 121220.1
## [1] 125521.5
## [1] 122012.6
## [1] 124501.1
## [1] 126547.5
## [1] 122317.1
## [1] 117741.4
## [1] 119117.6
```

```
## [1] 122090.6
## [1] 120786.6
## [1] 124044.5
## [1] 125924.8
## [1] 125360.9
## [1] 122618.6
## [1] 125298.3
## [1] 119622.3
## [1] 114370.8
## [1] 115369.8
## [1] 117606.9
## [1] 118012.7
## [1] 120998.4
## [1] 122050.6
## [1] 122193.8
## [1] 118685.3
## [1] 120578.6
## [1] 115448.1
## [1] 117184
## [1] 119583.6
## [1] 116930.1
## [1] 114634.3
## [1] 115738.1
## [1] 120923.2
## [1] 117865.3
## [1] 120959.3
## [1] 122319.9
## [1] 144512.8
## [1] 144224.5
## [1] 144880
## [1] 145625.2
## [1] 144429.3
## [1] 146058.8
## [1] 145549.1
## [1] 150682.3
## [1] 147764.5
## [1] 148990.5
## [1] 142848.4
## [1] 143567.6
## [1] 144948.6
## [1] 146622.9
## [1] 144941.6
## [1] 145752.1
## [1] 147516.9
## [1] 144757
```

```
## [1] 146562.9
## [1] 151237.4
## [1] 221896.1
## [1] 221847.7
## [1] 221479.2
## [1] 216742
## [1] 213409.9
## [1] 213549.6
## [1] 233858.8
## [1] 230337.6
## [1] 231057.8
## [1] 230001.2
## [1] 222953.2
## [1] 221764.3
## [1] 221802.6
## [1] 217332.9
## [1] 233597.3
```

```
min_index4 = which.min(d)

formulas4[min_index4]
```

```
## [1] "Salary ~ AtBat + Hits + Walks + CHmRun"
```

```
#Select best number of parameters by number of variables first
selected_formula <- formulas2[min_index2]
```

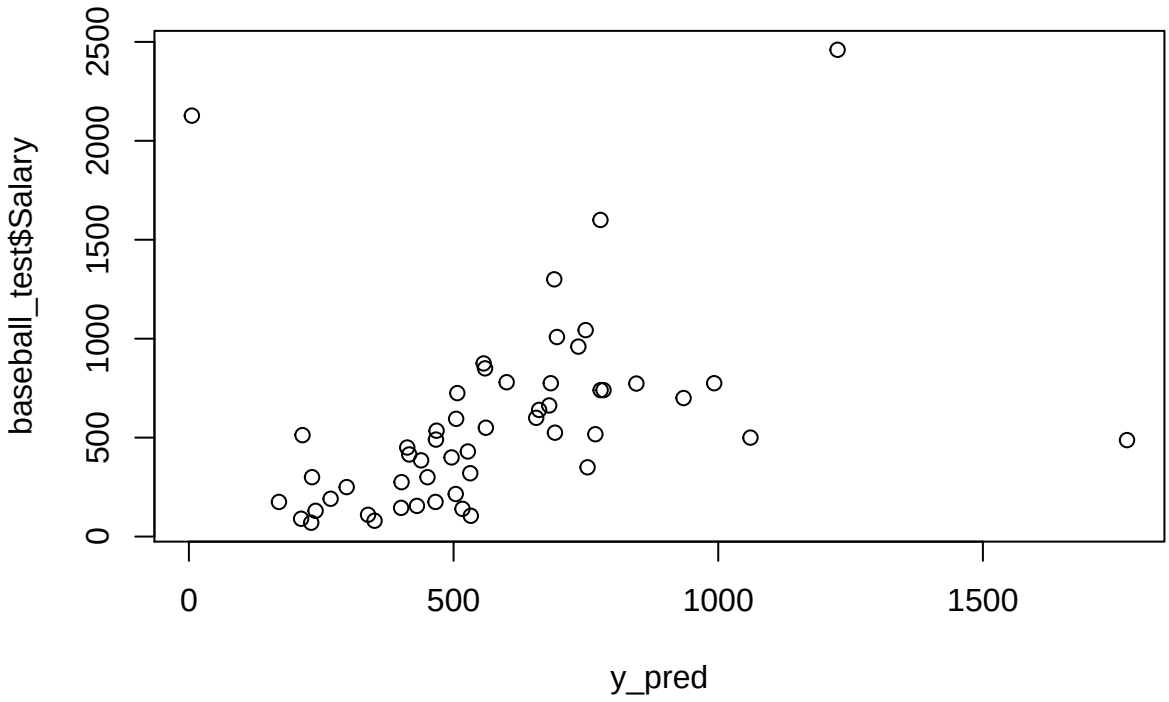
We observe that the smallest mse is for model with 1 variable used in predictor.

9. Calculate the test MSE for this model. Then, create a plot comparing predicted values (mapped to x position) versus observed values (mapped to y position) of baseball_test.

```
selected_formula <- formulas2[min_index2]

lm_mse(as.formula(selected_formula),baseball_train,baseball_valid)
```

```
## [1] 89609.45
```

```
#Build linear regression model with 2 predictorvariables
lm.fit_2 <- lm(as.formula(selected_formula),baseball_train)

y_pred <- predict(lm.fit_2, newdata = baseball_test)

plot(y_pred, baseball_test$Salary)
```



10. Read through the help file of glmnet. We are going to perform a linear regression with normal (gaussian) error terms. What format should our data be in?

The data needs to be in the form of x <- matrix, and y <- vector.

11. First generate the input matrix using (a variation on) the following code. Remember that the "." in a formula means "all available variables". Make sure to check that this x_train looks like what you would expect.

```
x_train <- model.matrix(Salary~. , data = baseball_train)[, -1]

#Use the formula we worked with earlier
#x_train <- model.matrix(as.formula(selected_formula), data = baseball_train)[, -1]
```

12. Using glmnet(), perform a LASSO regression with the generated x_train as the predictor matrix and Salary as the response variable. Set the lambda parameter of the penalty to 15. NB: Remove the intercept column from the x_matrix – glmnet adds an intercept internally.

```
y_train <- baseball_train$Salary

lasso.mod = glmnet(x_train, y_train, alpha=1, lambda=15)
```

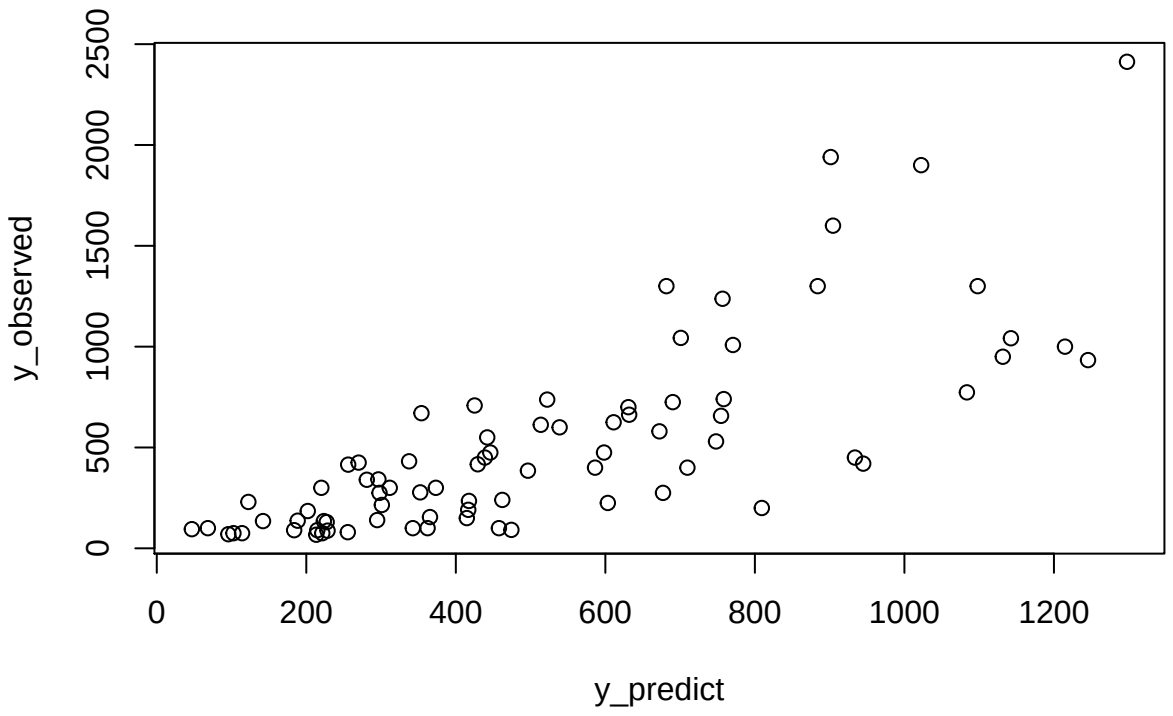
13. The coefficients for the variables are in the beta element of the list generated by the glmnet() function. Which variables have been selected? You may use the coef() function.

```
coef(lasso.mod)
```

```
## 20 x 1 sparse Matrix of class "dgCMatrix"
##                       s0
## (Intercept) -37.8712027
## AtBat         .
## Hits          0.9015727
## HmRun         .
## Runs          0.7693405
## RBI           .
## Walks         2.7963966
## Years         .
## CAtBat        .
## CHits         0.1642483
## CHmRun        .
## CRuns         0.4151650
## CRBI          .
## CWalks        .
## LeagueN      45.3653623
## DivisionW   -62.0627053
## PutOuts       0.2992321
## Assists       .
## Errors       -0.7276444
## NewLeagueN    .
```

14. Create a predicted versus observed plot for the model you generated with the baseball_valid data. Use the predict() function for this! What is the MSE on the validation set?

```
x_validation <- model.matrix(Salary~. , data = baseball_valid)[, -1]
#Observed value to go on y-axis
y_observed <- baseball_valid$Salary

#Use x_validation to predict new data points using the lasso func
y_predict <- predict(lasso.mod, x_validation)

#Plot graph
plot(y_predict, y_observed)
```




```
#Calculate mse
mse <- mean((y_observed - y_predict)^2)
mse
```

```
## [1] 94275.89
```

15. Fit a LASSO regression model on the same data as before, but now do not enter a specific lambda value. What is different about the object that is generated? Hint: use the coef() and plot() methods on the resulting object.

```
#Create an array of different lambda functions ranging from 10^-1 and 10^2
grid = 10^seq(2,-1, length =100)

lasso.mod2 = glmnet(x_train, y_train, alpha=1, lambda=grid)

coef(lasso.mod2)
```

```
## 20 x 100 sparse Matrix of class "dgCMatrix"
##    [[ suppressing 100 column names 's0', 's1', 's2' ... ]]
##
## (Intercept) 207.96596972 187.12043658 167.68405904 149.5554892 132.64699561
## AtBat         .            .            .            .           .
```

```
## Hits          0.55027850   0.60355682   0.65334573   0.6997227   0.74291477
## HmRun         .            .            .            .           .
## Runs          .            .            .            .           .
## RBI           .            .            .            .           .
## Walks         1.57969159   1.67646547   1.76633990   1.8503599   1.92891541
## Years         .            .            .            .           .
## CAtBat        .            .            .            .           .
## CHits         0.03467316   0.04034899   0.04548136   0.0503547   0.05498351
## CHmRun        .            .            .            .           .
## CRuns         0.48754662   0.49222177   0.49689394   0.5010828   0.50482693
## CRBI          .            .            .            .           .
## CWalks        .            .            .            .           .
## LeagueN       .            .            .            .           .
## DivisionW     .            .            .            .           .
## PutOuts       0.04773584   0.06825504   0.08740027   0.1052504   0.12189311
## Assists       .            .            .            .           .
## Errors        .            .            .            .           .
## NewLeagueN    .            .            .            .           .
##
## (Intercept) 116.88103413 102.18066096 88.4984341 75.67291762 63.7767949
## AtBat         .            .            .           .          .
## Hits          0.78328955   0.82101543   0.8547660   0.88871169 0.9181614
## HmRun         .            .            .           .          .
## Runs          .            .            .           .          .
## RBI           .            .            .           .          .
## Walks         2.00185693   2.06961355   2.1356909   2.19284849 2.2499645
## Years         .            .            .           .          .
## CAtBat        .            .            .           .          .
## CHits         0.05916413   0.06294876   0.0672717   0.07024312 0.0738523
## CHmRun        .            .            .           .          .
## CRuns         0.50858251   0.51230655   0.5142598   0.51810088 0.5200920
## CRBI          .            .            .           .          .
## CWalks        .            .            .           .          .
## LeagueN       .            .            .           .          .
## DivisionW     .            .            .           .          .
## PutOuts       0.13742138   0.15190948   0.1653945   0.17799574 0.1897327
## Assists       .            .            .           .          .
## Errors        .            .            .           .          .
## NewLeagueN    .            .            .           .          .
##
## (Intercept) 52.6238155 44.83501286  38.57597156  32.70529902  27.20643858
## AtBat         .           .            .           .           .
## Hits          0.9476772   0.97372206   0.99583371  1.01677762  1.03603495
## HmRun         .           .            .           .           .
## Runs          .           .            .           .           .
```

```
## RBI           .          .            .            .            .
## Walks         2.2996381  2.34891533   2.40046610   2.44891565   2.49604551
## Years         .          .            .            .            .
## CAtBat        .          .            .            .            .
## CHits         0.0764175  0.07858411   0.08178043   0.08533819   0.08962987
## CHmRun        .          .            .            .            .
## CRuns         0.5234708  0.52609126   0.52588294   0.52455727   0.52141713
## CRBI          .          .            .            .            .
## CWalks        .          .            .            .            .
## LeagueN       .          .            .            .            .
## DivisionW     .         -4.32645132 -10.03804148 -15.38398349 -20.40371743
## PutOuts       0.2006945  0.21100994   0.22059790   0.22949988   0.23774127
## Assists       .          .            .            .            .
## Errors        .          .            .            .            .
## NewLeagueN    .          .            .            .            .
##
## (Intercept)  20.45229023  13.2588008   6.38225211  -0.06707315  -5.9999442
## AtBat         .           .           .            .            .
## Hits          1.05442645  1.0766065   1.09411901   1.08742103   1.0766467
## HmRun         .           .           .            .            .
## Runs          .           .           0.01375803   0.07737232   0.1432227
## RBI           .           .           .            .            .
## Walks         2.54922464  2.5872670   2.61565235   2.63060414   2.6449446
## Years         .           .           .            .            .
## CAtBat        .           .           .            .            .
## CHits         0.09795892  0.1006264   0.10300316   0.10560083   0.1082284
## CHmRun        .           .           .            .            .
## CRuns         0.50988748  0.5089455   0.50824564   0.50691381   0.5053132
## CRBI          .           .           .            .            .
## CWalks        .           .           .            .            .
## LeagueN       3.09105864  7.6940190  12.07243626  16.37784281  20.4061110
## DivisionW   -25.24484824 -29.5814706 -33.59496694 -37.26987024 -40.6962759
## PutOuts       0.24477772  0.2513688   0.25749534   0.26328343   0.2687139
## Assists       .           .           .            .            .
## Errors        .           .           .            .            .
## NewLeagueN    .           .           .            .            .
##
## (Intercept) -11.5234675 -16.6702077 -21.4831283 -25.9614859 -30.1329252
## AtBat         .           .           .            .           .
## Hits          1.0650770   1.0534297   1.0443209   1.0342096   1.0239309
## HmRun         .           .           .            .           .
## Runs          0.2074060   0.2687919   0.3227106   0.3759970   0.4272295
## RBI           .           .           .            .           .
## Walks         2.6582424   2.6707444   2.6830007   2.6941861   2.7046105
## Years         .           .           .            .           .
```

```
## CAtBat        .           .           .           .           .
## CHits         0.1108721   0.1135160   0.1160025   0.1184507   0.1208588
## CHmRun        .           .           .           .           .
## CRuns         0.5034514   0.5013711   0.4993800   0.4972795   0.4950812
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
## LeagueN      24.1671129  27.6742884  30.9304834  33.9748835  36.8157845
## DivisionW   -43.8944019 -46.8809509 -49.6718702 -52.2747532 -54.7042988
## PutOuts       0.2737772   0.2784943   0.2828802   0.2869736   0.2907894
## Assists       .           .           .           .           .
## Errors        .           .           .           .           .
## NewLeagueN    .           .           .           .           .
##
## (Intercept) -33.1451485 -35.7358659 -38.0350868 -40.16879296 -42.1930787
## AtBat         .           .           .           .           .
## Hits          1.0165625   1.0267441   1.0146425   1.00389241   1.0015917
## HmRun         .           .           .           0.03795565   0.1108435
## Runs          0.4825535   0.5043842   0.5647408   0.61058774   0.6303355
## RBI           .           .           .           .           .
## Walks         2.7186665   2.7385138   2.7546702   2.77278016   2.7919890
## Years         .           .           .           .           .
## CAtBat        .           .           .           .           .
## CHits         0.1232583   0.1247015   0.1283070   0.13282406   0.1365912
## CHmRun        .           .           .           .           .
## CRuns         0.4920638   0.4904854   0.4847188   0.47695657   0.4704078
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
## LeagueN      39.8194317  42.6341939  45.3398043  47.88504875  50.2784937
## DivisionW   -56.8762742 -58.8899205 -60.7878306 -62.65310786 -64.4544033
## PutOuts       0.2941929   0.2972577   0.3001231   0.30270340   0.3050498
## Assists       .           .           .           .           .
## Errors       -0.1906713  -0.4326532  -0.6569602  -0.86240169  -1.0497086
## NewLeagueN    .           .           .           .           .
##
## (Intercept) -43.985788217 -44.76775019 -45.43971887 -46.08523867 -46.69400288
## AtBat         .             .            .            .            .
## Hits          0.998212874   0.95472869   0.90587367   0.86307353   0.82423669
## HmRun         0.184599186   0.37812181   0.55059900   0.71206654   0.86272952
## Runs          0.648429592   0.70906831   0.78190746   0.84459727   0.90110503
## RBI           .             .            .            .            .
## Walks         2.809481088   2.80604048   2.80336097   2.80136250   2.79941884
## Years         .             .            .            .            .
## CAtBat        .             .            .            .            .
## CHits         0.140260713   0.14415265   0.14913250   0.15356482   0.15748907
## CHmRun        .             .            .            .            .
```

```
## CRuns         0.464011122   0.45687013   0.44766756   0.43948215   0.43225224
## CRBI          .             .            .            .            .
## CWalks        .             .            .            .            .
## LeagueN      52.499450340  55.00722342  57.32963720  59.48405110  61.49308297
## DivisionW   -66.114665271 -67.27963118 -68.39529347 -69.43955185 -70.40996072
## PutOuts       0.307342132   0.31100440   0.31436908   0.31749255   0.32040868
## Assists       0.002063703   0.02869191   0.05300586   0.07555012   0.09653692
## Errors       -1.256066026  -1.82047338  -2.33926988  -2.82120124  -3.26994395
## NewLeagueN    .             .            .            .            .
##
## (Intercept) -47.2511697 -47.7814178 -48.2743480 -48.7260050 -49.1507626
## AtBat         .           .           .           .           .
## Hits          0.7863808   0.7527566   0.7211912   0.6904442   0.6623925
## HmRun         1.0030330   1.1340489   1.2561514   1.3699439   1.4760652
## Runs          0.9568210   1.0056766   1.0516500   1.0969284   1.1379809
## RBI           .           .           .           .           .
## Walks         2.7975807   2.7959334   2.7943055   2.7927803   2.7914772
## Years         .           .           .           .           .
## CAtBat        .           .           .           .           .
## CHits         0.1613990   0.1648073   0.1679767   0.1711391   0.1740430
## CHmRun        .           .           .           .           .
## CRuns         0.4250295   0.4187505   0.4129141   0.4070736   0.4017131
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
## LeagueN      63.3692742  65.1154149  66.7455436  68.2680335  69.6844887
## DivisionW   -71.3175976 -72.1622357 -72.9487049 -73.6843525 -74.3716908
## PutOuts       0.3231281   0.3256629   0.3280296   0.3302366   0.3322908
## Assists       0.1161739   0.1344105   0.1514296   0.1673626   0.1821731
## Errors       -3.6895331  -4.0795774  -4.4434693  -4.7838699  -5.1005886
## NewLeagueN    .           .           .           .           .
##
## (Intercept) -44.9298184 -39.0112220 -33.5267258 -28.3859873 -23.6197732
## AtBat         .           .           .           .           .
## Hits          0.5925091   0.5284876   0.4701312   0.4152562   0.3646204
## HmRun         1.5549159   1.6210247   1.6827650   1.7402679   1.7939693
## Runs          1.2233391   1.2858412   1.3419620   1.3949197   1.4435489
## RBI           .           .           .           .           .
## Walks         2.7925367   2.7929126   2.7928869   2.7929061   2.7928401
## Years        -0.8671535  -2.0705662  -3.1873506  -4.2332803  -5.2039531
## CAtBat        .           .           .           .           .
## CHits         0.1896208   0.2058978   0.2206593   0.2345451   0.2473411
## CHmRun        .           .           .           .           .
## CRuns         0.3843558   0.3704789   0.3582698   0.3467175   0.3361724
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
```

```
## LeagueN      70.8971115  71.9735114  72.9823201  73.9221397  74.8001780
## DivisionW   -75.3865903 -76.4355754 -77.4029788 -78.3082566 -79.1484550
## PutOuts       0.3329711   0.3331141   0.3332678   0.3334041   0.3335401
## Assists       0.1964805   0.2093124   0.2212560   0.2324050   0.2427915
## Errors       -5.4204582  -5.7158723  -5.9906086  -6.2470876  -6.4859721
## NewLeagueN    .           .           .           .           .
##
## (Intercept) -19.1552474 -14.9860808 -11.0949126  -7.5049038  -4.0954482
## AtBat         .           .           .           .           .
## Hits          0.3170294   0.2724665   0.2307958   0.1926303   0.1559930
## HmRun         1.8439981   1.8906455   1.9341450   1.9748165   2.0125796
## Runs          1.4894146   1.5324679   1.5727956   1.6094482   1.6450421
## RBI           .           .           .           .           .
## Walks         2.7928299   2.7928753   2.7929554   2.7929373   2.7930380
## Years        -6.1125267  -6.9607645  -7.7523117  -8.4838693  -9.1766361
## CAtBat        .           .           .           .           .
## CHits         0.2593773   0.2706612   0.2812223   0.2908770   0.3001665
## CHmRun        .           .           .           .           .
## CRuns         0.3261877   0.3167747   0.3079298   0.2999607   0.2921298
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
## LeagueN      75.6180450  76.3800233  77.0901332  77.7542726  78.3710147
## DivisionW   -79.9347214 -80.6695831 -81.3559402 -81.9908991 -82.5905830
## PutOuts       0.3336611   0.3337708   0.3338712   0.3339762   0.3340572
## Assists       0.2524858   0.2615294   0.2699652   0.2778175   0.2851636
## Errors       -6.7089667  -6.9170336  -7.1111400  -7.2917654  -7.4608154
## NewLeagueN    .           .           .           .           .
##
## (Intercept)  -0.3362827   5.38749722  11.4285464  17.0506138  22.3011199
## AtBat        -0.0124866  -0.06621778  -0.1299791  -0.1897046  -0.2454844
## Hits          0.1559285   0.26641284   0.4043762   0.5339031   0.6548022
## HmRun         2.0715504   2.20557380   2.3600152   2.5046542   2.6397124
## Runs          1.6792466   1.72058341   1.7626761   1.8018426   1.8385468
## RBI           .           .           .           .           .
## Walks         2.7989750   2.82498627   2.8569228   2.8869979   2.9151282
## Years        -9.8181997 -10.44809059 -11.0385311 -11.5849002 -12.0949998
## CAtBat        .           .           .           .           .
## CHits         0.3088490   0.31839930   0.3282084   0.3373824   0.3459799
## CHmRun        .           .           .           .           .
## CRuns         0.2847007   0.27533597   0.2648570   0.2549683   0.2456726
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
## LeagueN      78.9615650  79.54829902  80.0982333  80.6096068  81.0859950
## DivisionW   -83.1911407 -83.92845573 -84.6883436 -85.3991347 -86.0634633
## PutOuts       0.3341652   0.33428642   0.3344038   0.3345131   0.3346132
```

```
## Assists       0.2928838   0.30309072   0.3137153   0.3236301   0.3328843
## Errors       -7.6054933  -7.69934038  -7.7753277  -7.8458087  -7.9115280
## NewLeagueN    .           .            .           .           .
##
## (Intercept)  27.2005957  31.7706757  36.0324285  40.0058275  43.7096367
## AtBat        -0.2975116  -0.3460199  -0.3912398  -0.4333893  -0.4726718
## Hits          0.7674895   0.8724964   0.9703455   1.0615257   1.1464904
## HmRun         2.7656787   2.8831258   2.9926151   3.0946758   3.1898017
## Runs          1.8729046   1.9050282   1.9350341   1.9630396   1.9891597
## RBI           .           .           .           .           .
## Walks         2.9413936   2.9659011   2.9887599   3.0100745   3.0299439
## Years       -12.5711285 -13.0154005 -13.4298296 -13.8163252 -14.1766878
## CAtBat        .           .           .           .           .
## CHits         0.3540261   0.3615480   0.3685735   0.3751308   0.3812472
## CHmRun        .           .           .           .           .
## CRuns         0.2369547   0.2287928   0.2211618   0.2140349   0.2073850
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .           .
## LeagueN      81.5298942  81.9436046  82.3292454  82.6887713  83.0239889
## DivisionW   -86.6838131 -87.2628042 -87.8030039 -88.3068678 -88.7767204
## PutOuts       0.3347051   0.3347897   0.3348681   0.3349408   0.3350085
## Assists       0.3415164   0.3495664   0.3570725   0.3640709   0.3705953
## Errors       -7.9728572  -8.0300930  -8.0835043  -8.1333426  -8.1798445
## NewLeagueN    .           .           .           .           .
##
## (Intercept)  47.2349218  50.3991595  53.4141204  56.2199608  59.045934536
## AtBat        -0.5092766  -0.5420918  -0.5729615  -0.6016046  -0.639981984
## Hits          1.2256590   1.3012995   1.3705898   1.4346730   1.509222529
## HmRun         3.2784527   3.3542668   3.4269026   3.4943294   3.582177038
## Runs          2.0135051   2.0280715   2.0445457   2.0601631   2.089932536
## RBI           .           .           .           .           .
## Walks         3.0484609   3.0668119   3.0837087   3.0993772   3.154190982
## Years       -14.5126085 -14.8360780 -15.1359249 -15.4155504 -15.581746377
## CAtBat        .           .           .           .           .
## CHits         0.3869490   0.3926597   0.3979866   0.4029657   0.410956679
## CHmRun        .           .           .           .           .
## CRuns         0.2011856   0.1947162   0.1886777   0.1830253   0.175385508
## CRBI          .           .           .           .           .
## CWalks        .           .           .           .          -0.008666449
## LeagueN      83.3365726  85.1912047  86.3884170  87.5042595  88.750589500
## DivisionW   -89.2147494 -89.6684487 -90.0804256 -90.4639740 -91.005309277
## PutOuts       0.3350716   0.3350506   0.3350480   0.3350460   0.334846888
## Assists       0.3766770   0.3821113   0.3872340   0.3920073   0.397768885
## Errors       -8.2232318  -8.2660849  -8.3054023  -8.3423109  -8.367385410
## NewLeagueN   -0.1565039  -1.8616201  -2.9720703  -4.0071529  -5.225518255
```

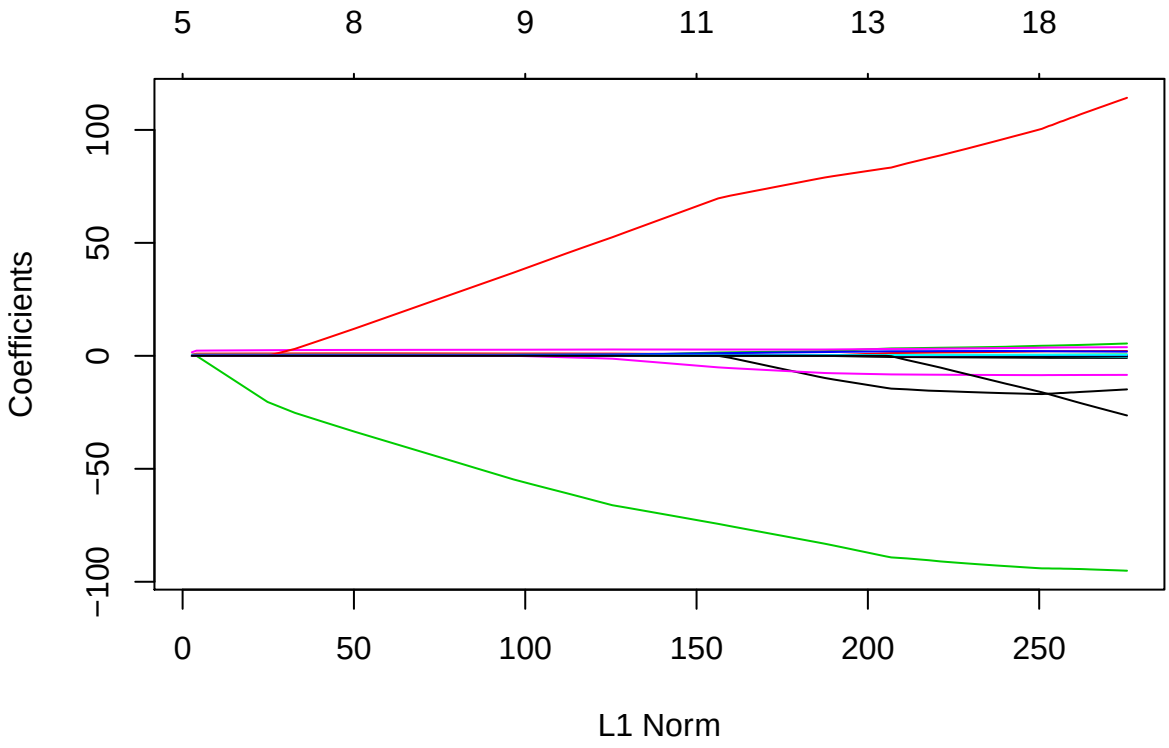
```
##
## (Intercept)  61.48988611  6.396794e+01  66.124738850  68.08347674  69.95268406
## AtBat        -0.66697399 -6.942332e-01  -0.719522835  -0.74299942  -0.76569022
## Hits          1.55336916  1.601770e+00   1.648798627   1.69382733   1.73840300
## HmRun         3.64752726  3.717496e+00   3.794767486   3.86771365   3.93698328
## Runs          2.10671072  2.117451e+00   2.123189723   2.12566204   2.12598171
## RBI           .           .              .             .            .
## Walks         3.21194975  3.266091e+00   3.314555901   3.35980129   3.40361756
## Years       -15.77794347 -1.597996e+01 -16.145432039 -16.29237054 -16.42969717
## CAtBat        .           .              .             .            .
## CHits         0.41694131  4.218503e-01   0.425699483   0.42879411   0.43133719
## CHmRun        .          -4.587631e-04  -0.004207438  -0.00790405  -0.01117109
## CRuns         0.17438217  1.751779e-01   0.177218355   0.18010905   0.18377285
## CRBI          .           .              .             .            .
## CWalks       -0.02031118 -3.127492e-02  -0.040861066  -0.04993698  -0.05887417
## LeagueN      90.22784284  9.159490e+01  92.864610790  94.05930195  95.18187642
## DivisionW   -91.44942312 -9.185759e+01 -92.209902578 -92.52579454 -92.81575032
## PutOuts       0.33465759  3.345041e-01   0.334413033   0.33435000   0.33430484
## Assists       0.40279934  4.076900e-01   0.412109311   0.41620047   0.42010546
## Errors       -8.39640828 -8.420922e+00  -8.443067768  -8.46287729  -8.47987249
## NewLeagueN   -6.68228556 -7.999961e+00  -9.198987823 -10.31986964 -11.36613706
##
## (Intercept)  71.629581385  72.82975006  74.21675052  75.42177349  7.659794e+01
## AtBat        -0.786414756  -0.80190478  -0.81933234  -0.83540139 -8.510870e-01
## Hits          1.780221052   1.81857354   1.86109931   1.90036222  1.938347e+00
## HmRun         4.000791665   4.12609763   4.22413216   4.30689284  4.384781e+00
## Runs          2.124579999   2.11835689   2.10813549   2.09945648  2.091151e+00
## RBI          -0.001056323  -0.03511119  -0.05523309  -0.07101734 -8.541903e-02
## Walks         3.444289800   3.48192148   3.51969826   3.55342690  3.586174e+00
## Years       -16.546219230 -16.63003329 -16.72588528 -16.80205457 -1.687282e+01
## CAtBat        .             .            .            .          -8.552287e-05
## CHits         0.433299824   0.43483937   0.43615678   0.43711998  4.382150e-01
## CHmRun       -0.014243174  -0.01713028  -0.01957180  -0.02186645 -2.379911e-02
## CRuns         0.187754150   0.19151874   0.19572521   0.19980663  2.040016e-01
## CRBI          .             .            .            .           .
## CWalks       -0.067116154  -0.07446867  -0.08177001  -0.08835278 -9.480773e-02
## LeagueN      96.216133475  97.17959046  98.10904643  98.94818635  9.974214e+01
## DivisionW   -93.072779203 -93.29813027 -93.52586772 -93.72533063 -9.391241e+01
## PutOuts       0.334293822   0.33427814   0.33426579   0.33427365  3.342734e-01
## Assists       0.423665487   0.42662574   0.42965294   0.43238510  4.350439e-01
## Errors       -8.495075262  -8.50785041  -8.51799505  -8.52727225 -8.534808e+00
## NewLeagueN  -12.330608609 -13.16978433 -14.00941343 -14.76802124 -1.547994e+01
##
## (Intercept)  7.761650e+01  79.280426450  79.271623698  80.09320149  80.09326861
## AtBat       -8.643873e-01  -0.886894196  -0.888033239  -0.89741779  -0.89825982
```

```
## Hits          1.970336e+00   2.029354023   2.034956334   2.06125134   2.06540414
## HmRun         4.453828e+00   4.503936289   4.527844086   4.62534924   4.64704405
## Runs          2.084018e+00   2.042449643   2.039731885   2.00575830   2.00390136
## RBI          -9.837597e-02  -0.094162920  -0.101440272  -0.12011854  -0.12671474
## Walks         3.614299e+00   3.658082572   3.663039860   3.69200733   3.69617247
## Years        -1.692284e+01 -16.735372890 -16.713784023 -16.45397830 -16.43623358
## CAtBat       -5.157639e-04  -0.007096378  -0.007432315  -0.01514358  -0.01547786
## CHits         4.402495e-01   0.453560944   0.454561244   0.47383064   0.47496228
## CHmRun       -2.539754e-02  -0.015845325  -0.017980478  -0.01146348  -0.01339014
## CRuns         2.076803e-01   0.229268317   0.230015070   0.24414311   0.24454717
## CRBI          .              .             .             .            .
## CWalks       -1.002283e-01  -0.109842954  -0.110471527  -0.11533364  -0.11579451
## LeagueN       1.004918e+02 101.724568424 102.147044931 103.63170834 104.00444796
## DivisionW    -9.407709e+01 -94.079176776 -94.142305546 -94.15631311 -94.21423539
## PutOuts       3.342451e-01   0.334027845   0.334083559   0.33363649   0.33367363
## Assists       4.374612e-01   0.442855873   0.443669576   0.44807162   0.44877902
## Errors       -8.541646e+00  -8.503519429  -8.519714228  -8.49011165  -8.50435046
## NewLeagueN   -1.614623e+01 -16.972010922 -17.385281336 -18.41175425 -18.77618152
##
## (Intercept)  80.890794036  80.89344594  8.162247e+01  81.944835410
## AtBat        -0.904039956  -0.90467789 -9.084665e-01  -0.908340069
## Hits          2.077988109   2.08118218  2.086915e+00   2.087014284
## HmRun         4.734160942   4.75333306  4.830124e+00   4.886748431
## Runs          1.981429821   1.98004698  1.963833e+00   1.957008584
## RBI          -0.145064437  -0.15089248 -1.678358e-01  -0.186163591
## Walks         3.718133591   3.72164970  3.739098e+00   3.745750825
## Years       -16.204858051 -16.18896143 -1.598315e+01 -15.875402261
## CAtBat       -0.023134287  -0.02346716 -3.063436e-02  -0.034412917
## CHits         0.496264767   0.49743038  5.182766e-01   0.528126817
## CHmRun       -0.006904042  -0.00858129 -2.505836e-03  -0.008841767
## CRuns         0.253309502   0.25355951  2.595271e-01   0.262093035
## CRBI          .             .           4.044614e-05   0.004494728
## CWalks       -0.118531468  -0.11888169 -1.205675e-01  -0.120755980
## LeagueN     105.370727560 105.69893118  1.069282e+02 107.644545821
## DivisionW   -94.260591446 -94.31193751 -9.436839e+01 -94.443169997
## PutOuts       0.333117184   0.33314290  3.325734e-01   0.332195604
## Assists       0.452727071   0.45334752  4.568559e-01   0.458732198
## Errors       -8.480328015  -8.49272133 -8.472542e+00  -8.469966454
## NewLeagueN  -19.740596345 -20.06059898 -2.093717e+01 -21.479187764
##
## (Intercept)  82.249338737  82.51884669  82.77155603  82.99704368  83.21292474
## AtBat        -0.908868111  -0.90943403  -0.91008863  -0.91069650  -0.91137812
## Hits          2.089393143   2.09232771   2.09565813   2.09907172   2.10264744
## HmRun         4.942978672   4.99593115   5.04483872   5.09143482   5.13446173
## Runs          1.949284688   1.94102939   1.93309520   1.92518584   1.91789011
```

```
## RBI          -0.204225166  -0.22123888  -0.23696887  -0.25205503  -0.26600497
## Walks         3.753805863   3.76157351   3.76879328   3.77570181   3.78212511
## Years       -15.776210392 -15.67787099 -15.58940143 -15.50351666 -15.42832130
## CAtBat       -0.037788129  -0.04099174  -0.04387904  -0.04660163  -0.04902350
## CHits         0.536686049   0.54456802   0.55151074   0.55790852   0.56350872
## CHmRun       -0.015042760  -0.02099580  -0.02680674  -0.03256755  -0.03813026
## CRuns         0.264968427   0.26811606   0.27120106   0.27430640   0.27720132
## CRBI          0.008772874   0.01291034   0.01685896   0.02074151   0.02440033
## CWalks       -0.121406949  -0.12212129  -0.12284189  -0.12357293  -0.12429062
## LeagueN     108.312959627 108.94192698 109.51771757 110.05842264 110.55106003
## DivisionW   -94.515183015 -94.57796324 -94.63555454 -94.68811183 -94.73784103
## PutOuts       0.331856532   0.33154360   0.33126276   0.33099918   0.33076289
## Assists       0.460510262   0.46219442   0.46374169   0.46519861   0.46652818
## Errors       -8.466971482  -8.46347908  -8.46037099  -8.45715602  -8.45450579
## NewLeagueN  -21.985864006 -22.45853671 -22.89112500 -23.29525436 -23.66475062
##
## (Intercept)  83.40277557  83.58012132  83.75071081  83.90454750  84.04498800
## AtBat        -0.91197741  -0.91256731  -0.91320711  -0.91380126  -0.91434557
## Hits          2.10615710   2.10959953   2.11304869   2.11640978   2.11959369
## HmRun         5.17602415   5.21433734   5.24988601   5.28411316   5.31585318
## Runs          1.91054877   1.90372288   1.89747270   1.89130694   1.88550890
## RBI          -0.27957453  -0.29211631  -0.30375352  -0.31499851  -0.32546306
## Walks         3.78836881   3.79408993   3.79947489   3.80471625   3.80954631
## Years       -15.35273168 -15.28499046 -15.22492470 -15.16539169 -15.11036573
## CAtBat       -0.05136236  -0.05347353  -0.05537141  -0.05719726  -0.05887749
## CHits         0.56881096   0.57353232   0.57773269   0.58171756   0.58534548
## CHmRun       -0.04363276  -0.04884431  -0.05380242  -0.05864601  -0.06319512
## CRuns         0.28012449   0.28285566   0.28537593   0.28786651   0.29021320
## CRBI          0.02802404   0.03140791   0.03457948   0.03768407   0.04058586
## CWalks       -0.12501483  -0.12569589  -0.12636065  -0.12702390  -0.12764378
## LeagueN     111.01970574 111.44944769 111.84348189 112.21757009 112.56399681
## DivisionW   -94.78332441 -94.82554549 -94.86587167 -94.90330381 -94.93769463
## PutOuts       0.33053561   0.33033042   0.33014405   0.32996468   0.32980035
## Assists       0.46779754   0.46895872   0.47002687   0.47104635   0.47198746
## Errors       -8.45155792  -8.44903878  -8.44690382  -8.44457931  -8.44247577
## NewLeagueN  -24.01368227 -24.33432122 -24.62934333 -24.90779363 -25.16570331
##
## (Intercept)  84.17138740  84.29291029  84.40845265  84.51286717  84.54955700
## AtBat        -0.91483219  -0.91532804  -0.91583407  -0.91629385  -0.91640900
## Hits          2.12262962   2.12550129   2.12833419   2.13101264   2.13194269
## HmRun         5.34602820   5.37303065   5.39897519   5.42349446   5.42721890
## Runs          1.87985994   1.87490798   1.87014277   1.86556703   1.86465495
## RBI          -0.33544345  -0.34438499  -0.35295664  -0.36108239  -0.36315698
## Walks         3.81412943   3.81822707   3.82223901   3.82603813   3.82728386
## Years       -15.05674876 -15.01149237 -14.96801551 -14.92606188 -14.92026749
```

```
## CAtBat       -0.06048078  -0.06187438  -0.06320095  -0.06445787  -0.06465334
## CHits         0.58876738   0.59172894   0.59452787   0.59715774   0.59760368
## CHmRun       -0.06757062  -0.07153168  -0.07538012  -0.07903919  -0.07954873
## CRuns         0.29249923   0.29451483   0.29645743   0.29832410   0.29859532
## CRBI          0.04338088   0.04587537   0.04829508   0.05060073   0.05096924
## CWalks       -0.12823860  -0.12877903  -0.12931743  -0.12983244  -0.13003925
## LeagueN     112.89102357 113.18504657 113.46287756 113.72418189 113.80443332
## DivisionW   -94.96928134 -94.99901737 -95.02740165 -95.05358433 -95.07159206
## PutOuts       0.32964408   0.32950792   0.32937692   0.32925319   0.32925322
## Assists       0.47287728   0.47367242   0.47443115   0.47514552   0.47535053
## Errors       -8.44030854  -8.43872210  -8.43705999  -8.43539337  -8.43797546
## NewLeagueN  -25.40802525 -25.62786609 -25.83485643 -26.02891601 -26.11238619
##
## (Intercept)  84.72895992
## AtBat        -0.91750528
## Hits          2.13679597
## HmRun         5.47178150
## Runs          1.85680068
## RBI          -0.37682097
## Walks         3.83415292
## Years       -14.84603065
## CAtBat       -0.06685000
## CHits         0.60213892
## CHmRun       -0.08632843
## CRuns         0.30192940
## CRBI          0.05517926
## CWalks       -0.13098369
## LeagueN     114.21432437
## DivisionW   -95.10635434
## PutOuts       0.32900753
## Assists       0.47653684
## Errors       -8.43145977
## NewLeagueN  -26.39021214
```

```
plot(lasso.mod2)
```



We observe that the the intercept of the coefficient increase with larger values for lambda.

16. Use the cv.glmnet function to determine the lambda value for which the out-of-sample MSE is lowest using 15-fold cross validation. As your dataset, you may use the training and validation sets bound together with bind_rows(). What is the best lambda value?

```
set.seed (1)

cv.out =cv.glmnet(x_train, y_train, alpha=1)

#Bind the training and validation data
x_value <- rbind(x_train, x_validation)
y_value <- c(y_train, y_observed)

cv_output <- cv.glmnet(x_value, y_value, alpha=1, nfolds = 15)

#Look at this output
cv_output
```

```
##
## Call:  cv.glmnet(x = x_value, y = y_value, nfolds = 15, alpha = 1)
##
## Measure: Mean-Squared Error
```

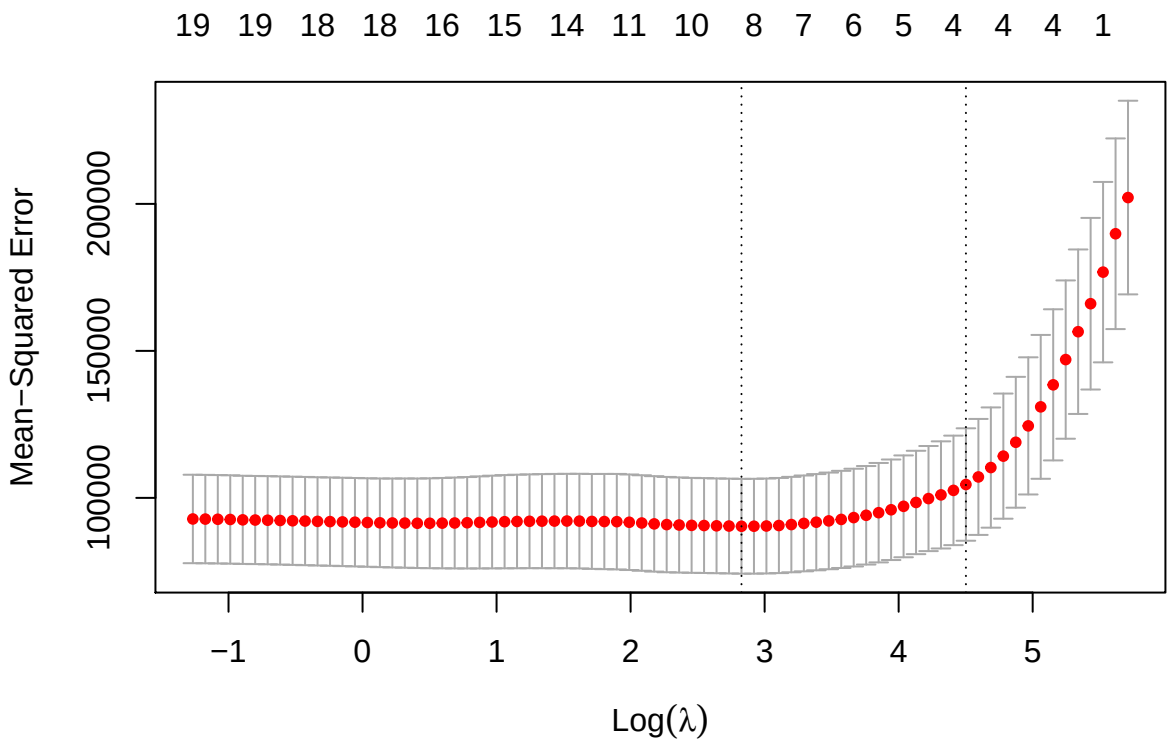
```
##
##      Lambda Measure    SE Nonzero
## min  16.90    90339 16118       8
## 1se  90.19   104545 19122       4
```

```
#Obtain smallest lambda
min_lambda <- cv_output$lambda.min
min_lambda
```

```
## [1] 16.9008
```

17. Try out the plot() method on this object. What do you see? What does this tell you about the bias-variance tradeoff?

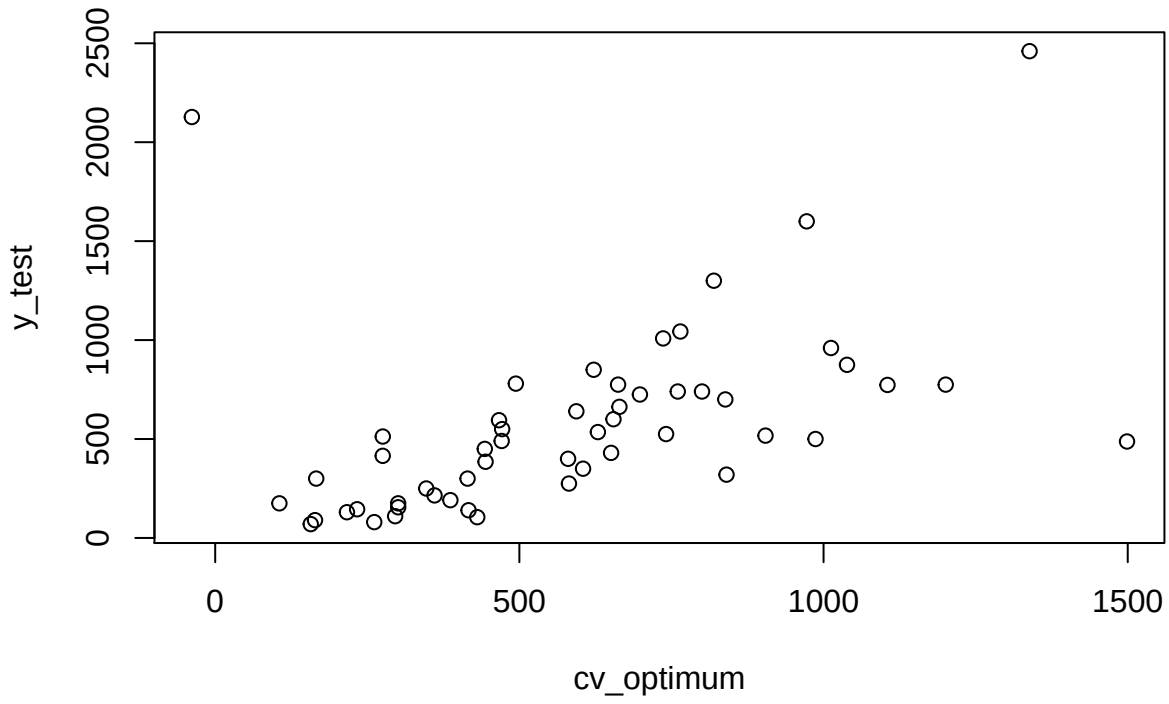
```
plot(cv_output)
```



We observe that larger lambda leads to greater degree of variance (due to larger mean squared error on the y-axis). This is due to a overfitting the model.

18. Use the predict() method directly on the object you just created to predict new salaries for the baseball players in the baseball_test dataset using the best lambda value you just created (hint: you need to use the s argument, look at ?predict.cv.glmnet for help). Create another predicted-observed scatter plot.

```r
#First create lasso model variables
x_test <- model.matrix(Salary~. , data = baseball_test)[, -1]
y_test <- baseball_test$Salary

# predict(cv.object, newx = x_data, s=c())
cv_optimum = predict(cv_output, x_test, s=min_lambda)

plot(cv_optimum, y_test)
```




```r
mse_optimum = mean((y_test - cv_optimum)^2)
mse_optimum
```

```
## [1] 183380.8
```