Discussion Week 11

Peter Gatica

2022-11-13

```
# Load needed libraries
library(tidyverse)
library(readr)
library(knitr)
library(sqldf)
```

Do other factors affect Home Run Distance besides exit velocity?

```
filename <- tempfile()
download.file("https://raw.githubusercontent.com/audiorunner13/Masters-Coursework/main/DATA605%20Fall%20
```

```
hr_stad_CFYS_2017 <- read.csv.sql(filename, "select TRUE_DISTANCE, EXIT_VELOCITY, ELEVATION_ANGLE, HORIZ
```

In my last discussion I am created a simple model to show if there is a direct correlation with the exit velocity of a ball hit out of the park and the distance that it travels. My conclusion was that there is. In this discussion I will add the other measures to determine if those also affect the distance of a homerun. I will limit the data to home runs hit out of Coors Field in Denver and Yankee Stadium for better clarity. The stadium will be my dichotimus variable.

```
coors_bp <- ifelse(hr_stad_CFYS_2017$BALLPARK == 'Coors Field', 1, 0)

(hr_stad_CFYS_2017_out <- data.frame(TRUE_DISTANCE = hr_stad_CFYS_2017$TRUE_DISTANCE, EXIT_VELOCITY = hr
```

```
##     TRUE_DISTANCE EXIT_VELOCITY ELEVATION_ANGLE HORIZONTAL_ANGLE APEX
## 1             387         106.6            25.9            121.8   69
## 2             397          98.8            29.5             78.4   91
## 3             420         106.1            27.5             71.3   86
## 4             487         118.9            25.0            103.2  104
## 5             408         104.6            23.8             80.0   69
## 6             424         102.3            33.2             94.9  124
## 7             428         104.1            30.5             78.2  107
## 8             429         108.7            32.5             61.4  112
## 9             362          97.2            38.6             62.6  121
## 10            365          96.5            24.7             80.0   66
## 11            392         104.7            27.7             60.5   76
## 12            392         104.3            26.1             66.9   71
```

```
## 13             417          110.6              19.9              82.9   60
## 14             423          103.0              26.6              92.5   90
## 15             427          112.6              26.3             118.2   82
## 16             349           96.3              27.3              65.4   68
## 17             358           97.5              29.8             116.7   81
## 18             372           97.5              34.6              70.8  113
## 19             390           99.5              32.5             102.2  112
## 20             412          102.7              34.8             107.3  124
## 21             428          106.8              25.5              99.5   87
## 22             389          101.1              26.3              73.1   73
## 23             431          110.7              24.8             106.2   83
## 24             453          109.5              24.4              94.8   85
## 25             366          110.0              21.2             124.1   49
## 26             376          100.2              28.1              68.5   80
## 27             384           98.7              31.1              74.1   99
## 28             385           98.5              31.4              79.0  107
## 29             401          105.4              33.8              99.9  144
## 30             404          102.1              31.1             104.0  109
## 31             426          106.9              26.0             104.5   83
## 32             346           93.8              31.5              62.4   80
## 33             377           98.6              32.0              66.3   95
## 34             432          110.7              19.7              93.3   65
## 35             390          108.0              23.9              63.8   63
## 36             390          103.6              34.2              77.1  138
## 37             366           94.1              33.8              79.1  105
## 38             437          108.4              27.0             101.8  100
## 39             442          109.4              31.7             112.1  117
## 40             363           97.1              30.4              70.0   92
## 41             379           97.9              33.0              63.2   95
## 42             390          102.9              24.3              76.1   69
## 43             404          106.6              27.8              66.4   89
## 44             423          105.1              24.3              93.3   85
## 45             431          109.6              26.1             110.9   81
## 46             432          114.7              37.7              65.8  171
## 47             351          100.8              24.5              62.2   59
## 48             375          100.1              33.9              64.2  108
## 49             410          103.1              28.6              79.0  101
## 50             419          109.6              25.9             116.3   75
## 51             432          103.3              31.1              97.1  113
## 52             367           97.5              32.5              64.4   94
## 53             374          102.8              37.6             117.1  134
## 54             381          106.6              22.2              70.7   56
## 55             417          105.7              24.6              79.9   78
## 56             420          102.9              26.8              87.0   92
## 57             431          104.1              28.6              92.0  106
## 58             440          117.2              23.6             115.7   72
## 59             407          101.7              29.4              73.6   91
## 60             425          106.8              32.8             115.3  113
## 61             456          112.8              30.2              65.3  109
## 62             422          107.6              30.9             120.4   97
## 63             409          104.5              30.1              61.5   89
## 64             415          106.1              28.5              62.7   83
## 65             434          104.6              27.4              80.8   90
## 66             365           97.3              29.3             122.9   70
```

```
## 67            370        98.4          28.9          118.6   70
## 68            374       106.6          22.3          113.4   54
## 69            396        98.6          35.9           70.0  116
## 70            413       102.6          28.0           94.0  104
## 71            425       103.5          32.6          106.6  113
## 72            468       119.9          22.5          106.5   77
## 73            379       101.6          34.2          111.5  120
## 74            427       109.4          30.6          108.2  120
## 75            436       105.4          24.8           88.9   80
## 76            380       101.8          26.9          117.0   68
## 77            381        98.7          36.6           64.8  117
## 78            404       104.1          27.4           72.3   85
## 79            415       106.3          22.4           83.8   69
## 80            367        95.1          30.4           76.7   89
## 81            394       102.8          34.7           77.5  135
## 82            355        96.9          35.6          118.3  108
## 83            356        96.6          33.4           59.4   93
## 84            402       100.3          30.0           80.8  102
## 85            406       104.8          37.4          106.6  148
## 86            412       103.3          28.7          110.0   86
## 87            433       103.8          26.6           87.4   88
## 88            434       105.3          32.3          108.4  113
## 89            388        98.4          32.0           68.4   95
## 90            416       103.0          31.8          106.6  110
## 91            439       105.9          28.2          101.6   96
## 92            346        96.1          28.9          116.1   76
## 93            367       103.3          22.8           70.3   57
## 94            386        99.1          26.3           79.9   77
## 95            389       106.7          24.3           66.0   66
## 96            397       105.2          28.5           63.2   86
## 97            429       106.4          27.4          107.0   86
## 98            343        93.6          37.4           66.6  113
## 99            368       101.6          38.1          116.6  134
## 100           379        99.4          33.5          110.2  110
## 101           420       106.6          21.8           87.7   71
## 102           389        98.7          37.0          114.8  118
## 103           422       112.2          26.3          127.7   74
## 104           443       111.9          21.9           98.5   68
## 105           404        99.6          29.2           75.7   85
## 106           453       109.8          23.9           95.6   82
## 107           365        99.4          26.9          118.1   65
## 108           378        96.0          30.9          110.3   84
## 109           406        98.9          34.3           79.0  116
## 110           415       102.0          30.8           74.4  100
## 111           430       105.9          23.5           88.1   75
## 112           439       104.7          26.9           88.0   92
## 113           365        95.4          36.3          117.6  106
## 114           411       101.2          27.6           80.5   85
## 115           433       106.3          23.4           89.4   74
## 116           438       108.4          27.5           72.1   90
## 117           452       108.6          24.6           85.8   84
## 118           374       111.9          20.5          123.7   47
## 119           389       102.4          38.3          111.8  140
## 120           433       105.1          25.1           88.7   83
```

```
## 121          375       97.8          33.2           106.3  109
## 122          376      103.4          41.0           116.0  154
## 123          378      109.9          19.9            72.0   49
## 124          381       97.3          29.2            79.1   90
## 125          403       98.0          34.9            73.6  109
## 126          425      107.9          25.7           104.4   85
## 127          427      101.7          29.5            90.7  101
## 128          433      102.8          30.4            83.2  105
## 129          387       97.6          29.8            81.5   96
## 130          390       99.3          32.7            76.6  111
## 131          390      103.7          31.6            60.1   98
## 132          407      103.1          29.1            75.4  100
## 133          417      107.1          27.2            71.1   90
## 134          418      106.0          24.0            99.0   76
## 135          352      100.9          25.7            53.9   58
## 136          355       97.0          30.3            62.9   83
## 137          375      110.6          18.7            75.8   45
## 138          407      103.8          30.9            73.7  112
## 139          411      103.8          28.9           101.3  106
## 140          336       97.4          40.3            63.6  135
## 141          388      107.4          24.0            65.1   65
## 142          426      104.8          28.7            98.7  105
## 143          391      100.4          28.6           109.5   82
## 144          406      110.2          24.5           120.2   65
## 145          423      104.6          24.3            94.0   77
## 146          432      108.9          22.6            97.8   71
## 147          380       97.2          35.3           108.9  113
## 148          404      107.7          24.9           114.6   67
## 149          411      111.8          24.3           120.8   66
## 150          397       99.9          29.3           107.0   86
## 151          431      104.3          27.7            82.2   95
## 152          437      109.3          21.2            88.7   69
## 153          341       93.7          34.3            64.7  100
## 154          346      105.4          21.9            52.8   48
## 155          388      101.9          37.4            59.1  123
## 156          391      100.6          31.9           109.1  103
## 157          421      103.1          26.8            81.4   85
## 158          408      103.8          27.4           104.2   89
## 159          351      101.3          24.8           123.3   56
## 160          332       97.8          40.4           116.9  137
## 161          371      100.9          34.5           111.6  121
## 162          378      105.0          23.0           110.2   59
## 163          409      107.7          32.8            61.0  114
## 164          414      102.3          28.1            96.2   98
## 165          387      108.6          22.5           113.4   58
## 166          393      105.2          29.2            60.2   87
## 167          397       99.7          27.5            82.9   91
## 168          458      113.4          25.3           101.4  101
## 169          364       96.6          26.4            75.6   72
## 170          380       98.6          32.7           107.1  106
## 171          384      100.3          29.8            69.6   91
## 172          385      110.2          21.2            67.6   53
## 173          327       91.6          32.2            59.4   79
## 174          335       95.4          36.9            63.1  116
```

```
## 175   390  102.4  34.2  111.5  119
## 176   384   99.5  24.8   82.3   76
## 177   400  102.2  28.7  112.5   83
## 178   410  101.9  32.5   69.5  105
## 179   412  110.3  24.8  118.8   68
## 180   419  106.2  33.9  120.9  112
## 181   445  110.0  22.4   94.6   73
## 182   465  108.6  29.6   96.4  115
## 183   402  113.4  21.1   66.0   54
## 184   418  107.2  28.9  118.3   87
## 185   424  107.3  27.3  110.9   84
## 186   391  102.0  30.4  123.9   83
## 187   415  102.2  32.0  107.1  107
## 188   421  103.3  25.9   82.3   79
## 189   435  106.0  24.1   87.9   77
## 190   441  109.1  30.6  112.6  108
## 191   442  104.3  28.4   86.2   98
## 192   421  102.7  27.7   80.9   89
## 193   434  101.9  29.7   87.5   98
## 194   444  111.3  22.8   99.8   73
## 195   399  101.5  26.5   75.4   76
## 196   404  104.4  24.5  104.1   69
## 197   453  111.6  29.0   66.4   99
## 198   454  108.8  24.7   85.9   85
## 199   382   97.1  28.5   79.1   84
## 200   413  102.1  26.5   84.8   85
## 201   423  105.4  31.7  114.9  103
## 202   452  109.6  25.2   82.3   90
## 203   469  113.2  23.3   83.7   82
## 204   345   93.2  33.6   58.8   85
## 205   397  100.5  34.2  115.5  107
## 206   414  108.8  24.3  109.2   70
## 207   443  102.8  31.3   87.6  108
## 208   357  103.0  40.1   68.9  156
## 209   384   99.9  29.9   70.8   92
## 210   395  110.2  21.5   69.3   55
## 211   426  104.2  26.9   93.2   98
## 212   428  103.3  27.8   97.7   92
## 213   433  108.3  29.5  114.2   96
## 214   445  105.2  28.1   87.7  100
## 215   445  107.1  29.5   91.5  121
## 216   400   98.9  31.0   74.5   94
## 217   361   99.6  24.3   72.2   62
## 218   390   99.2  31.1   82.8  112
## 219   397  100.4  27.3   75.2   77
## 220   400  102.1  28.0   80.9  102
## 221   401  101.1  33.1   82.1  126
## 222   418  100.9  27.9   86.9   84
## 223   455  116.1  22.1   78.3   80
## 224   457  107.2  27.0   93.4   96
## 225   405  103.3  36.9   69.7  135
## 226   428  111.8  21.0   80.4   62
## 227   438  110.3  29.2  118.9   92
## 228   453  118.0  18.2   94.8   61
```

```
## 229          382         100.6             30.0             58.8   80
## 230          397          99.8             31.8             70.7   99
## 231          437         104.0             33.6             85.4  129
## 232          453         110.3             27.9             73.2   97
## 233          355          98.2             27.7            119.1   69
## 234          366          98.2             37.2             66.6  122
## 235          408         102.0             30.7            102.8  106
## 236          418         102.4             29.8             83.4  107
## 237          420         103.0             26.1             89.5   88
## 238          401         103.8             29.3            116.2   86
## 239          406         107.2             24.2            107.9   69
## 240          440         105.3             31.2             97.9  117
## 241          343          96.5             27.4             60.8   66
## 242          387          96.8             37.7             70.1  119
## 243          398         101.5             34.3            106.5  122
## 244          405         106.9             23.4            106.2   65
## 245          422         102.8             29.5             89.6  110
## 246          430         104.0             27.2             83.3   92
## 247          345          94.8             34.9             61.6  100
## 248          375          97.1             34.8             66.0  106
## 249          382          98.4             27.3             78.1   80
## 250          387         100.5             30.1             71.9   96
## 251          402         105.4             32.7            113.8  116
## 252          419         100.9             30.2             83.0  101
## 253          385         107.5             21.8            108.0   57
## 254          388          99.9             34.7             79.4  128
## 255          391         100.9             28.8             66.5   80
## 256          400         110.7             21.6             71.5   59
## 257          420         105.5             22.9             92.7   74
## 258          430         102.8             35.0             88.8  135
## 259          450         114.8             28.0             56.2   89
## 260          361          95.7             36.8            120.6  107
## 261          376          95.2             33.6            111.3   96
## 262          388         101.8             37.1            110.1  135
## 263          434         107.8             28.8            109.4   98
## 264          440         106.8             33.0            102.3  130
## 265          373          95.4             34.2             63.6   95
## 266          373          95.3             36.6             67.3  110
## 267          384          99.1             32.8             57.7   91
## 268          430         102.2             29.3             84.3   98
## 269          440         111.6             21.0             84.3   64
## 270          385         101.8             26.5            113.0   70
## 271          414         106.0             23.3             80.0   68
## 272          438         105.3             31.1            101.7  113
## 273          392         101.4             32.0            108.6  108
## 274          401         112.4             19.4             77.3   52
## 275          450         114.5             22.2            101.1   73
## 276          496         119.6             26.4            102.8  117
## 277          379          99.9             27.0             70.7   73
## 278          391         101.2             29.3            109.8   89
## 279          397         116.0             21.6            131.4   53
## 280          400         100.0             29.3            101.7   93
## 281          402         102.4             27.9             71.1   79
## 282          405         116.5             18.4            103.3   49
```

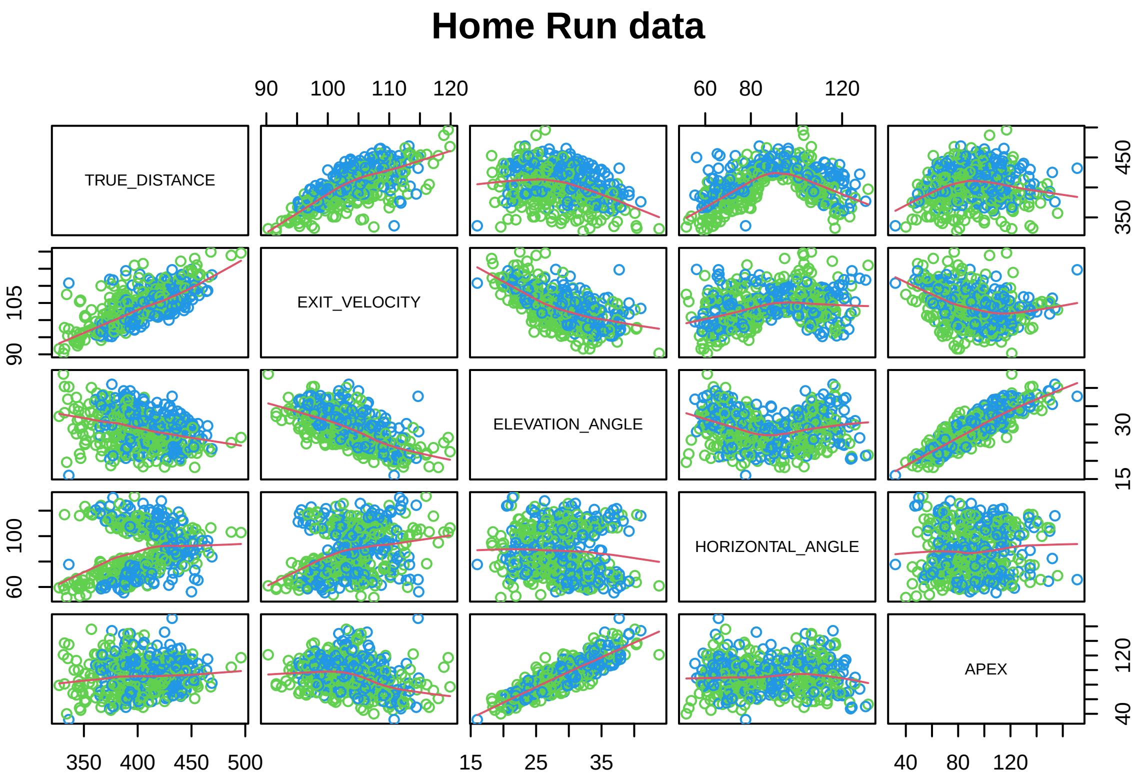
```
## 283          440          110.1            25.2            102.7   87
## 284          367           97.9            34.4             64.9  106
## 285          390           98.5            33.4             78.2  113
## 286          409          107.0            25.8             70.4   78
## 287          456          113.2            23.4             99.8   77
## 288          408          101.9            27.4             83.2   94
## 289          415          105.9            24.9             78.5   79
## 290          415          110.3            22.6            105.3   67
## 291          399          101.6            32.6            108.9  109
## 292          399           99.9            27.2             83.4   86
## 293          440          105.0            27.3             85.3   94
## 294          384          106.4            23.1            110.5   63
## 295          387           99.5            36.9             55.5  109
## 296          391          103.5            29.2            110.8   96
## 297          402          104.0            26.3             70.4   74
## 298          408          102.4            29.2            108.5   89
## 299          408          107.4            27.5             68.9   92
## 300          426          111.3            20.4             82.2   61
## 301          438          112.0            25.8             73.9   94
## 302          460          109.4            26.0             96.4   94
## 303          430          103.5            29.1             80.4   98
## 304          436          106.2            25.9             80.8   84
## 305          400          102.1            27.9             70.8   80
## 306          401          109.1            21.4             75.6   57
## 307          377          104.8            22.7             71.3   60
## 308          382          106.1            21.9            106.7   57
## 309          388           99.2            33.5             70.0  108
## 310          393          101.8            39.2            103.9  150
## 311          429          100.0            34.7             89.0  120
## 312          439          110.9            20.4             88.3   66
## 313          447          103.7            31.3             83.9  108
## 314          406          103.6            36.3            106.8  138
## 315          408          106.8            28.3            114.3   90
## 316          413          104.2            33.1            101.1  130
## 317          387          105.0            39.2             64.5  149
## 318          407          102.7            30.9             78.0  112
## 319          420          108.4            28.5            117.3   90
## 320          392          101.5            28.0             73.1   86
## 321          340           95.3            28.8             57.5   68
## 322          371          102.0            24.7             68.6   64
## 323          374          104.7            37.4             65.8  143
## 324          385          101.3            25.4             75.4   73
## 325          398          102.7            28.3            107.5   90
## 326          420          106.3            30.8            106.1  115
## 327          376          101.0            35.1            111.0  124
## 328          387          100.9            33.6            103.4  124
## 329          398          105.9            23.5             75.2   68
## 330          403          104.8            30.7             67.7  104
## 331          344           92.5            31.1             65.0   77
## 332          380           98.6            27.3             75.3   77
## 333          389          113.0            21.5             59.8   54
## 334          389           96.2            36.2             78.1  115
## 335          389          114.4            20.7            124.3   49
## 336          395           99.1            34.5            106.0  116
```

```
## 337           420         108.2             25.3             106.0   83
## 338           421         109.1             24.5              74.0   77
## 339           425         106.4             35.5              82.4  152
## 340           426         104.2             24.7              91.8   80
## 341           428         109.7             20.0              90.4   65
## 342           451         107.4             29.7             103.3  105
## 343           457         108.4             25.3              90.6   97
## 344           464         108.4             27.0              92.0  100
## 345           366          99.6             32.2              60.0   94
## 346           397          97.3             37.9              66.0  115
## 347           397         104.0             24.5              75.5   72
## 348           435         108.2             21.9              90.0   70
## 349           370          99.0             29.8              59.4   78
## 350           379          97.9             37.3              71.9  126
## 351           408         103.8             24.9              78.3   73
## 352           393          99.7             37.3             121.6  114
## 353           433         104.3             32.7              71.0  110
## 354           444         103.7             32.1              98.6  114
## 355           397          97.1             35.1             104.7  112
## 356           413         111.2             21.3             104.4   57
## 357           377         111.7             21.4             130.3   50
## 358           418         101.3             33.9             100.6  120
## 359           451         106.0             30.2              94.6  115
## 360           397         103.6             24.7             104.9   71
## 361           426         103.0             30.1              93.0  116
## 362           440         112.7             20.0              94.5   65
## 363           332          91.6             33.2              58.2   81
## 364           360          97.1             36.2              71.6  122
## 365           383         102.5             29.9             125.6   81
## 366           384          97.7             32.3              82.5  112
## 367           384         104.0             25.4              68.0   71
## 368           391         104.9             35.0             110.1  141
## 369           406         106.8             30.0             111.5  110
## 370           379          99.8             26.4              72.3   72
## 371           408         103.0             27.3              76.8   86
## 372           425         107.1             23.7              97.4   84
## 373           430         106.1             26.7              99.5   93
## 374           370         100.1             37.4              68.4  131
## 375           381          98.0             31.9             105.9  102
## 376           410         102.2             25.3              85.9   81
## 377           415         107.6             22.6             101.5   69
## 378           435         105.4             30.7              83.9  120
## 379           348          95.5             29.3              60.7   71
## 380           410         112.2             19.6             100.3   56
## 381           412         105.1             29.1             108.7   97
## 382           414         103.3             24.9              85.4   82
## 383           417         109.1             23.2              75.4   70
## 384           425         112.3             18.3              92.6   57
## 385           454         115.1             23.8             105.4   83
## 386           466         112.6             23.3              86.9   90
## 387           396         103.0             34.8              74.9  135
## 388           413         104.5             30.2              70.7  102
## 389           420         107.1             29.8             115.9   95
## 390           441         113.3             22.1              77.5   71
```

```
## 391         394     104.4        25.0         70.3  67
## 392         398     102.6        32.5         64.3 104
## 393         440     104.8        30.1         95.6 113
## 394         367      98.8        37.9         60.7 121
## 395         370      98.1        30.8         61.6  83
## 396         411     105.7        33.3         65.8 119
## 397         435     106.8        23.4         89.3  78
## 398         441     106.9        24.7         91.5  85
## 399         370      96.4        34.1        111.9 102
## 400         415     107.2        29.6         63.6  96
## 401         426     102.7        28.5         89.1 101
## 402         389     105.9        23.3         69.7  59
## 403         398     100.0        33.9         72.6 113
## 404         411     102.2        30.6        108.3  97
## 405         418     106.6        36.0        114.7 134
## 406         426     102.6        27.2         90.7  91
## 407         336     110.8        16.0         77.7  32
## 408         388     100.2        34.5         63.3 107
## 409         449     106.8        29.1         87.9 115
## 410         334     107.5        19.6         51.7  40
## 411         405     108.3        21.7        101.7  63
## 412         423     106.0        24.2         83.3  81
## 413         451     113.9        29.1        106.5 122
## 414         423     104.2        30.0         99.6 109
## 415         426     104.7        26.5         80.7  89
## 416         399     104.7        29.8        115.9  93
## 417         405     101.7        29.6        102.4 100
## 418         447     114.4        23.1        104.9  82
## 419         331      90.3        43.8         60.9 121
## 420         357      96.7        31.3        117.1  89
## 421         444     109.4        27.5         76.4  99
## 422         363      96.0        32.9         73.8 106
## 423         376     101.3        24.5         71.8  61
## 424         371      99.7        26.4         70.6  72
## 425         389     105.0        21.6         79.4  60
## 426         421     106.9        25.2         77.9  84
## 427         351      94.2        33.0         68.4  95
## 428         373     101.2        26.6        113.0  73
## 429         397     104.3        26.7        110.2  81
## 430         390     104.9        23.6         71.7  61
## 431         391     102.8        34.0        107.3 127
## 432         435     105.9        26.8         87.4 101
## 433         397      98.8        30.3         76.4  93
## 434         400     103.0        30.6         64.4  93
## 435         421     104.9        29.0        104.9 101
## 436         452     109.0        23.8         89.0  86
## 437         347     105.8        20.7         62.5  45
## 438         366      96.7        35.3         58.6 100
## 439         376      98.5        29.8         63.6  79
## 440         378      98.1        26.2         80.2  80
## 441         378      96.6        32.0         79.8 105
## 442         391     105.4        36.7        106.5 150
## 443         393      97.8        32.9         77.0 106
## 444         416     101.3        32.1        101.0 110
```

```
## 445            433        106.1          23.9           89.1   75
## 446            436        104.2          28.8           86.2  105
## 447            393        102.1          25.9          107.5   70
## 448            430        101.8          31.7           91.7  113
## 449            432        103.9          33.9          100.5  127
## 450            433        109.1          21.9           94.7   65
## 451            405        105.3          31.0          125.7   90
```

```
pairs(hr_stad_CFYS_2017_out, gap=0.5, panel = panel.smooth, main = "Home Run data", col = 3 + (coors_bp
```



From the pairs view we can see that the elevation angle of the ball's trajectory has a negative impact on distance. I'll now create a multiple regression model to determine how the othr factors come into play.

```
(hr_stad_CFYS_2017_lm <- lm(TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE + HORIZONTAL_ANGLE + APEX ,
```

```
##
## Call:
## lm(formula = TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE +
##     HORIZONTAL_ANGLE + APEX, data = hr_stad_CFYS_2017_out)
##
## Coefficients:
##      (Intercept)     EXIT_VELOCITY   ELEVATION_ANGLE  HORIZONTAL_ANGLE
##        237.87211           2.07560          -6.48694           0.05274
##             APEX
##          1.43415
```

```
summary(hr_stad_CFYS_2017_lm)
```

```
##
```

```
## Call:
## lm(formula = TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE +
##     HORIZONTAL_ANGLE + APEX, data = hr_stad_CFYS_2017_out)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -78.049  -9.454   1.385  12.643  37.616
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      237.87211   34.88470   6.819  3.0e-11 ***
## EXIT_VELOCITY      2.07560    0.27259   7.614  1.6e-13 ***
## ELEVATION_ANGLE   -6.48694    0.55444 -11.700  < 2e-16 ***
## HORIZONTAL_ANGLE   0.05274    0.04449   1.185    0.236
## APEX               1.43415    0.09581  14.969  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17.05 on 446 degrees of freedom
## Multiple R-squared:  0.6752, Adjusted R-squared:  0.6722
## F-statistic: 231.7 on 4 and 446 DF,  p-value: < 2.2e-16
```

Since horizontal angle p-value > .05, let's remove that factor and recalculate.

```
(hr_stad_CFYS_2017_lm <- lm(TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE + APEX , data = hr_stad_CFYS
```

```
##
## Call:
## lm(formula = TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE +
##     APEX, data = hr_stad_CFYS_2017_out)
##
## Coefficients:
##     (Intercept)    EXIT_VELOCITY  ELEVATION_ANGLE             APEX
##         234.365            2.146           -6.460            1.436
```

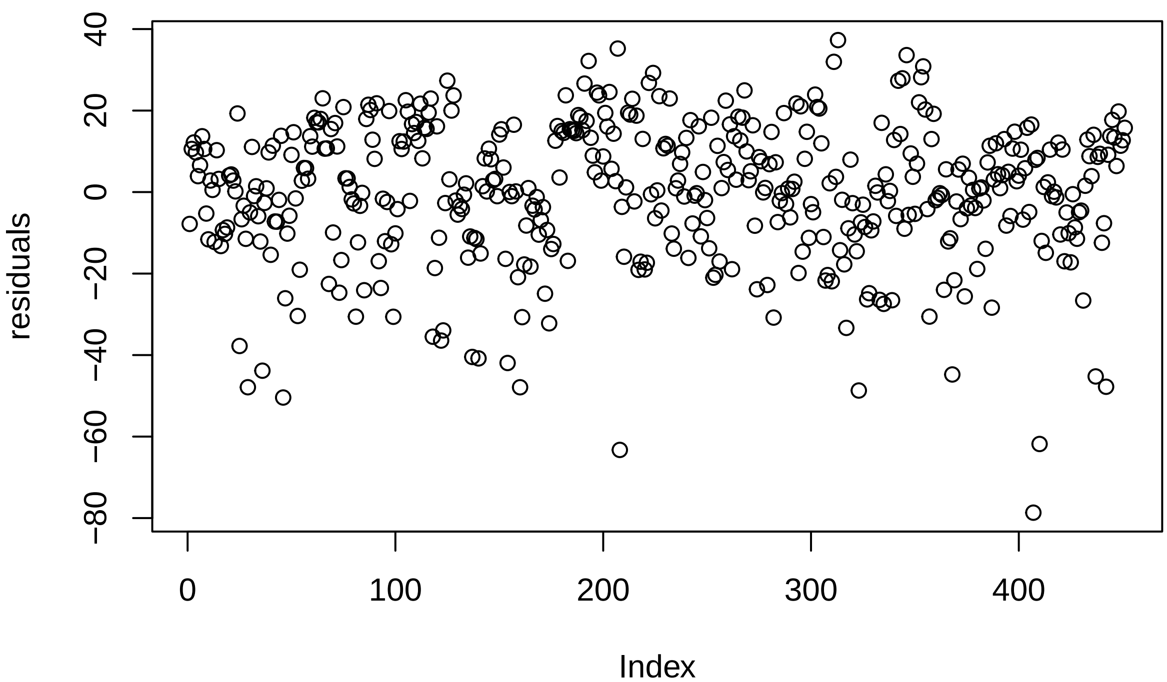
```
summary(hr_stad_CFYS_2017_lm)
```

```
##
## Call:
## lm(formula = TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE +
##     APEX, data = hr_stad_CFYS_2017_out)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -78.669  -9.361   1.133  12.644  37.291
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     234.36522   34.77479   6.740 4.92e-11 ***
## EXIT_VELOCITY     2.14553    0.26625   8.058 7.12e-15 ***
## ELEVATION_ANGLE  -6.46031    0.55423 -11.656  < 2e-16 ***
## APEX              1.43574    0.09584  14.980  < 2e-16 ***
```

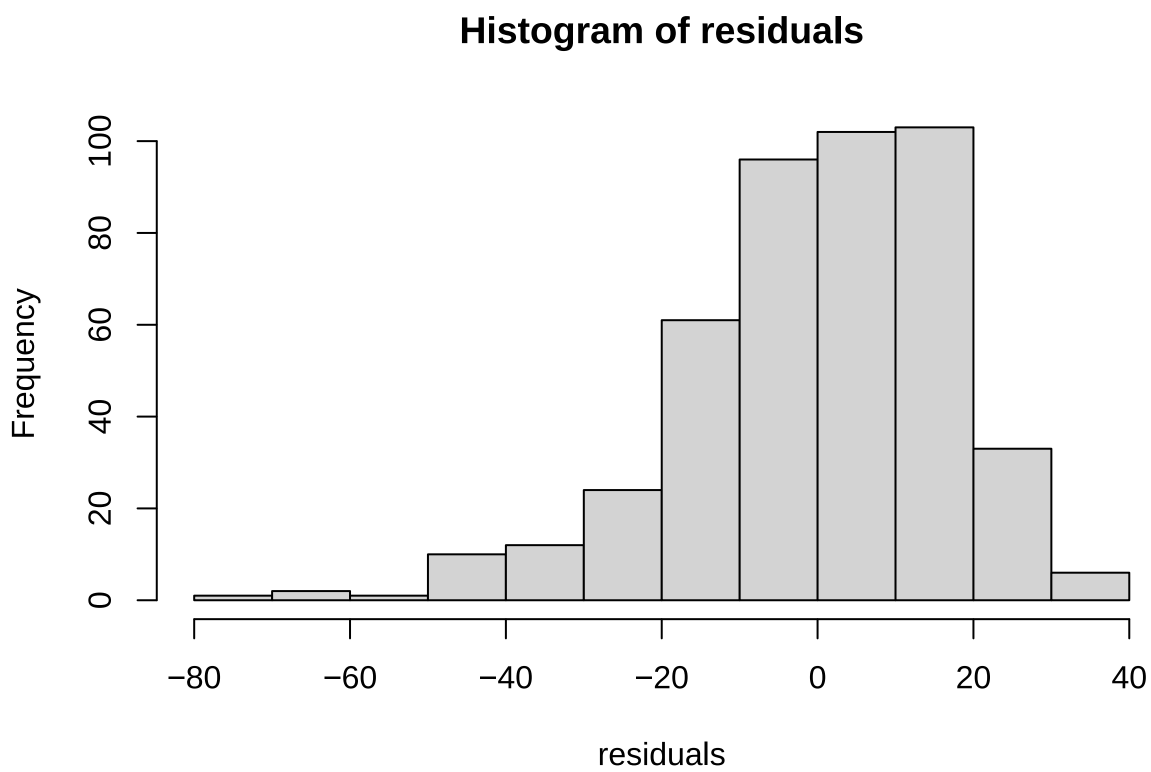
```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17.06 on 447 degrees of freedom
## Multiple R-squared:  0.6741, Adjusted R-squared:  0.6719
## F-statistic: 308.2 on 3 and 447 DF,  p-value: < 2.2e-16
```

Now that all p-values are below .05, I am still not confortable to call this a good model but let's analyze the residuals.

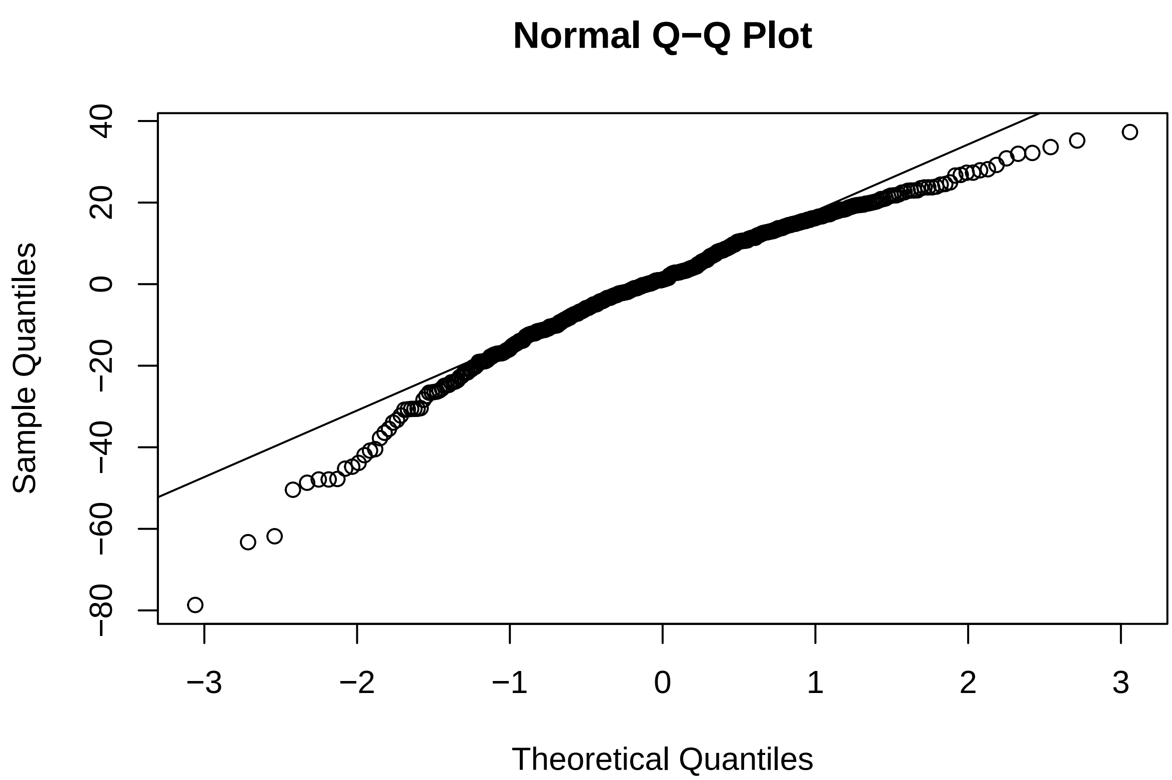
```
residuals <- resid(hr_stad_CFYS_2017_lm)
plot(residuals)
```




```
hist(residuals)
```




```
qqnorm(resid(hr_stad_CFYS_2017_lm))
qqline(resid(hr_stad_CFYS_2017_lm))
```



After removing the horizontal angle factor and plotting the residuals, it appears to have a normal distribution but the histogram shows a skew to the right. I will select the elevation angle as my quadratic variable because of it's negative affect on the distribution and recalculate.

```
elevation_sq <- hr_stad_CFYS_2017_out$ELEVATION_ANGLE ^ 2
```

```
(hr_stad_CFYS_2017_lm_2 <- lm(TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE + APEX + elevation_sq, da
```

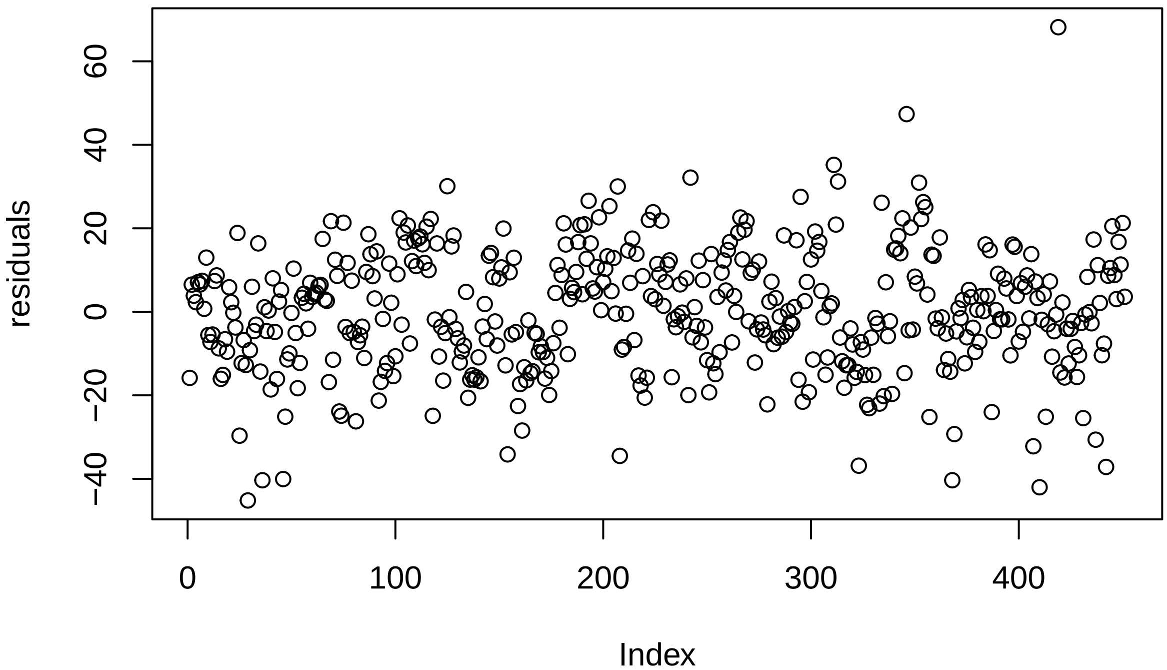
```
##
## Call:
## lm(formula = TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE +
##     APEX + elevation_sq, data = hr_stad_CFYS_2017_out)
##
## Coefficients:
##     (Intercept)    EXIT_VELOCITY  ELEVATION_ANGLE             APEX
##       -153.6721           3.1230          13.7079           1.1787
##    elevation_sq
##         -0.3172
```

```
summary(hr_stad_CFYS_2017_lm_2)
```

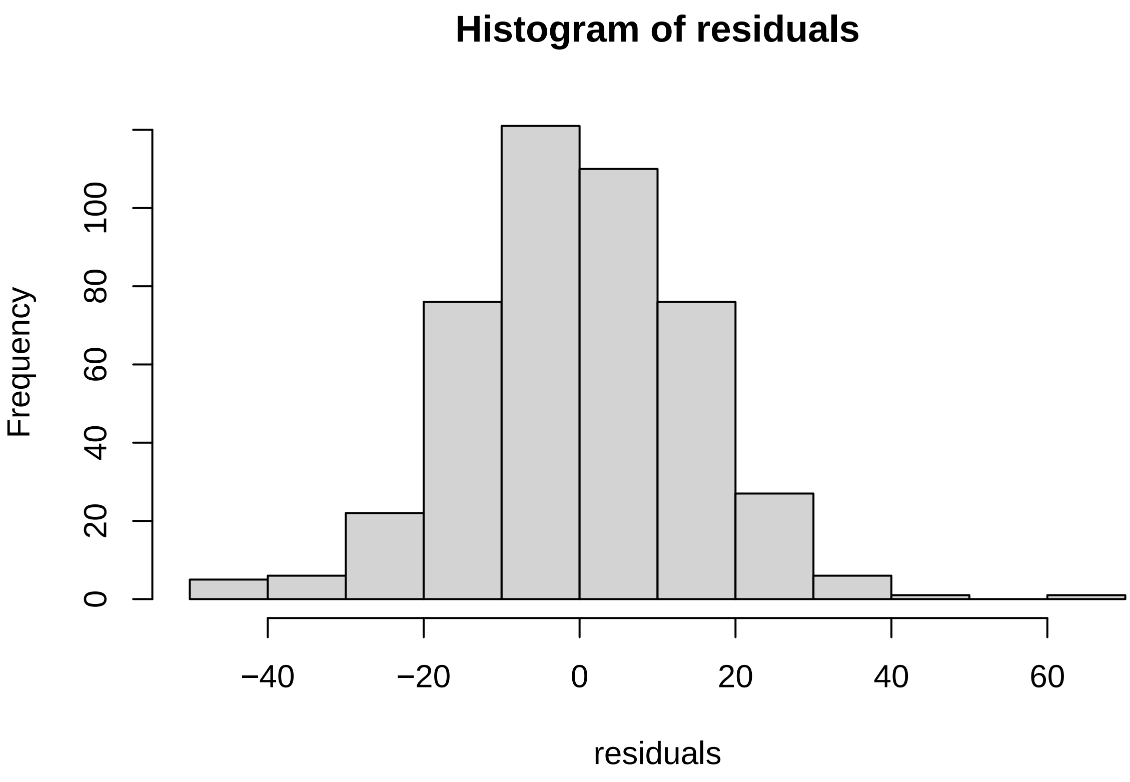
```
##
## Call:
## lm(formula = TRUE_DISTANCE ~ EXIT_VELOCITY + ELEVATION_ANGLE +
##     APEX + elevation_sq, data = hr_stad_CFYS_2017_out)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -45.175  -9.616  -0.269   9.544  68.166
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     -153.67212   42.77902  -3.592 0.000364 ***
## EXIT_VELOCITY      3.12304    0.24127  12.944  < 2e-16 ***
## ELEVATION_ANGLE   13.70788    1.66196   8.248 1.82e-15 ***
## APEX               1.17875    0.08475  13.908  < 2e-16 ***
## elevation_sq      -0.31720    0.02504 -12.665  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.64 on 446 degrees of freedom
## Multiple R-squared:  0.7603, Adjusted R-squared:  0.7582
## F-statistic: 353.7 on 4 and 446 DF,  p-value: < 2.2e-16
```

After doing so, you'll notivce the median is now very close to 0 and the min/max range seems to have improved. Plotting the residuals does seem to show more of a normal distribution in all plots below.

```
residuals <- resid(hr_stad_CFYS_2017_lm_2)
plot(residuals)
```

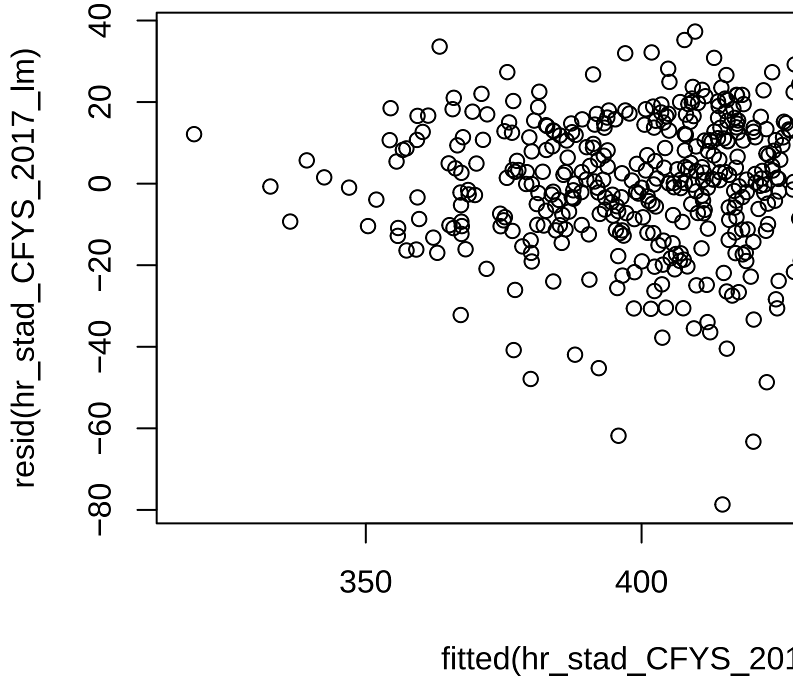



```
hist(residuals)
```




```
plot(fitted(hr_stad_CFYS_2017_lm),resid(hr_stad_CFYS_2017_lm))
```

The large t-value ratio of 30.62 there is strong evidence of a correlation between the exit veloc-



ity of the hit ball and the distance that it travels.

```
par(mfrow=c(2,2))
plot(hr_stad_CFYS_2017_lm)
```