Program 2 Graph Analysis

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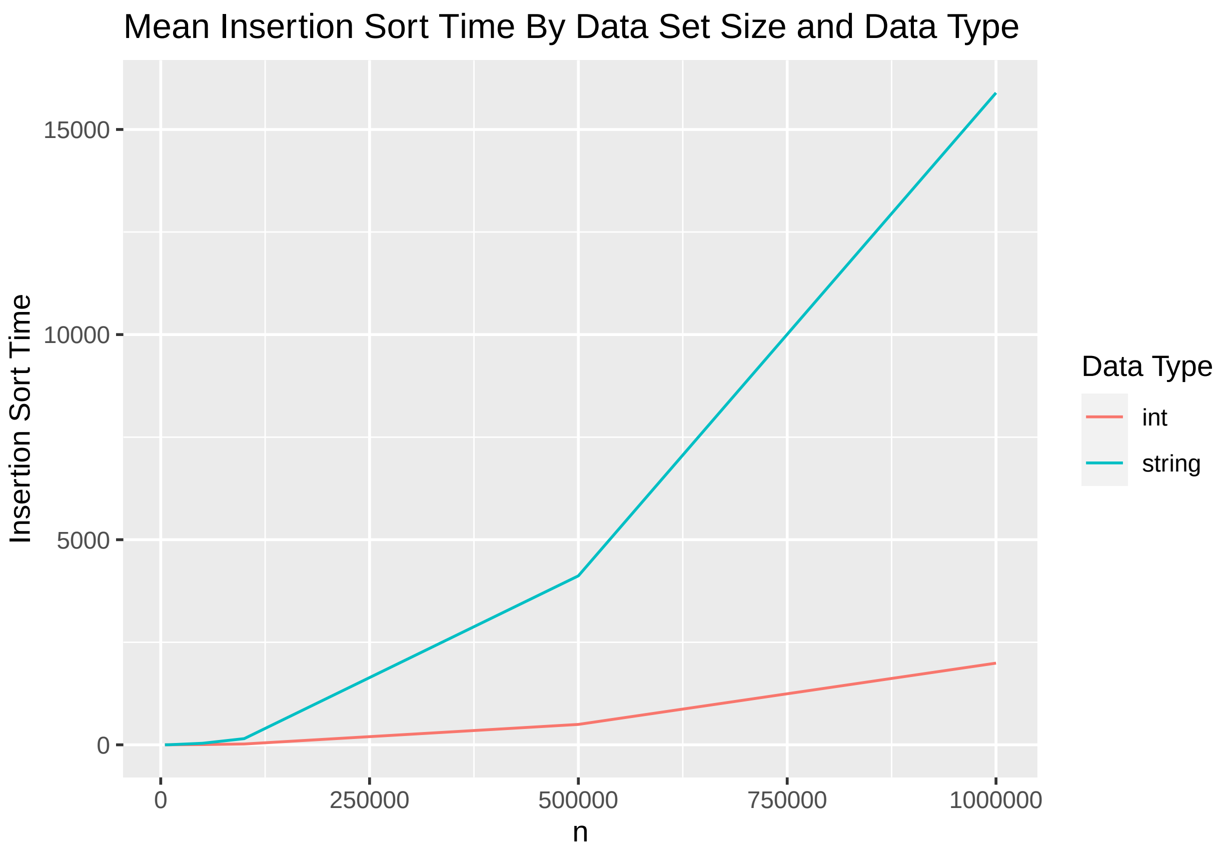
Create Dataset

```
library(ggplot2)
library(ggpubr)
data = read.csv("WesDataRun1.csv")
data$n2 = data$size ^ 2
data$nlogn = log(data$size) * data$size
data
```

```
##    var_type    size       format insertion_time quick_time merge_time
## 1       int  500000 noDuplicates    7.95005e+02 0.16505100  2.1168700
## 2       int 1000000 40duplicates    3.16407e+03 0.32676400  4.2730800
## 3       int  100000 40duplicates    3.15688e+01 0.03059860  0.4175630
## 4       int   10000 40duplicates    3.32033e-01 0.00240456  0.0348771
## 5       int   50000       sorted    6.90529e-04 0.01030740  0.1977440
## 6       int   50000 20duplicates    7.85778e+00 0.01516270  0.2023640
## 7       int    5000 noDuplicates    8.12401e-02 0.00139387  0.0193010
## 8       int  500000       sorted    7.13136e-03 0.09585230  2.0201300
## 9       int  500000     60sorted    1.26520e+02 0.11619200  2.0642600
## 10      int   10000     60sorted    4.75302e-02 0.00199900  0.0372471
## 11      int 1000000 noDuplicates    3.13320e+03 0.31941900  4.3305400
## 12      int 1000000 20duplicates    3.16243e+03 0.34211100  4.3177300
## 13      int   50000 noDuplicates    7.92707e+00 0.01443500  0.2101600
## 14      int    5000     60sorted    1.33967e-02 0.00132197  0.0204084
## 15      int    5000       sorted    6.16390e-05 0.00101474  0.0166772
## 16      int  100000 20duplicates    3.16373e+01 0.02955740  0.4144030
## 17      int   50000     60sorted    1.26396e+00 0.01188120  0.2052760
## 18      int   10000 noDuplicates    3.23680e-01 0.00291363  0.0396229
## 19      int  500000 20duplicates    7.86741e+02 0.16625900  2.0826600
## 20      int  500000 40duplicates    7.76092e+02 0.15903700  2.0506100
## 21      int 1000000       sorted    1.22738e-02 0.19862100  4.0315300
## 22      int    5000 20duplicates    7.45130e-02 0.00128955  0.0180706
## 23      int  100000 noDuplicates    3.10339e+01 0.02829320  0.4001210
## 24      int   50000 40duplicates    7.75182e+00 0.01533210  0.2010430
## 25      int   10000 20duplicates    3.18130e-01 0.00289081  0.0402507
## 26      int  100000       sorted    1.48089e-03 0.02122200  0.3884380
## 27      int  100000     60sorted    5.00708e+00 0.02511440  0.4058680
## 28      int   10000       sorted    1.48140e-04 0.00184614  0.0396463
## 29      int    5000 40duplicates    8.49797e-02 0.00135574  0.0203961
## 30      int 1000000     60sorted    4.96103e+02 0.24900200  4.0825000
## 31   string   50000       sorted    5.34647e-03 0.07387960  0.2638780
## 32   string  500000 20duplicates    5.14512e+03 0.97943700  3.3090600
## 33   string   50000 20duplicates    5.10532e+01 0.07543130  0.2956520
## 34   string   10000 40duplicates    2.04046e+00 0.01292500  0.0572353
## 35   string   10000     60sorted    1.29043e+00 0.01346670  0.0556319
## 36   string  100000       sorted    1.10993e-02 0.16852600  0.5636770
## 37   string    5000 40duplicates    5.10891e-01 0.00649668  0.0261124
## 38   string  500000     60sorted    3.28954e+03 0.93865900  3.0265600
## 39   string   50000 noDuplicates    5.16270e+01 0.07948510  0.3091600
## 40   string  500000 40duplicates    5.14260e+03 1.01228000  3.2950600
## 41   string    5000 20duplicates    5.16617e-01 0.00653917  0.0287966
## 42   string  100000 noDuplicates    2.05698e+02 0.16876200  0.6321520
## 43   string    5000 noDuplicates    5.21201e-01 0.00642101  0.0253947
## 44   string  100000     60sorted    1.31478e+02 0.16656500  0.5803110
## 45   string 1000000 20duplicates    2.09586e+04 2.14006000  6.8582900
## 46   string   10000 noDuplicates    2.05775e+00 0.01611400  0.0544607
## 47   string 1000000 noDuplicates    2.34202e+04 3.70442000 11.4343000
## 48   string 1000000       sorted    1.46393e-01 2.64701000 11.9568000
## 49   string  500000 noDuplicates    7.01488e+03 1.00256000  3.3534600
## 50   string  100000 40duplicates    2.09063e+02 0.19067700  0.6149120
## 51   string    5000     60sorted    3.25228e-01 0.00628677  0.0261034
## 52   string 1000000     60sorted    1.41741e+04 2.04694000  6.3251100
## 53   string    5000       sorted    4.50962e-04 0.00536470  0.0235652
## 54   string  100000 20duplicates    2.05982e+02 0.17654600  0.6268760
## 55   string   10000 20duplicates    2.03632e+00 0.01560860  0.0614365
## 56   string   10000       sorted    9.79634e-04 0.01251130  0.0522329
## 57   string  500000       sorted    4.75168e-02 0.95233200  2.9277300
## 58   string   50000 40duplicates    5.13650e+01 0.07892800  0.3075030
## 59   string   50000     60sorted    3.32685e+01 0.07817330  0.2773730
## 60   string 1000000 40duplicates    2.09124e+04 2.06010000  6.7977200
##     shell_time  intro_time   tim_time      n2       nlogn
## 1  0.265615000  0.67225900 0.74547300 2.5e+11  6561181.69
## 2  0.592526000  1.45301000 1.58412000 1.0e+12 13815510.56
## 3  0.040778200  0.12452300 0.13062500 1.0e+10  1151292.55
## 4  0.002582330  0.00961603 0.01038150 1.0e+08    92103.40
## 5  0.005058930  0.05164430 0.05012550 2.5e+09   540988.91
## 6  0.018773600  0.06001270 0.06192480 2.5e+09   540988.91
## 7  0.001326450  0.00495500 0.00505642 2.5e+07    42585.97
## 8  0.065695800  0.64501200 0.59772900 2.5e+11  6561181.69
## 9  0.137265000  0.63992100 0.64383600 2.5e+11  6561181.69
## 10 0.001449060  0.00919040 0.00962555 1.0e+08    92103.40
## 11 0.591718000  1.43119000 1.55271000 1.0e+12 13815510.56
## 12 0.595075000  1.47730000 1.54371000 1.0e+12 13815510.56
## 13 0.019980500  0.06349480 0.06460700 2.5e+09   540988.91
## 14 0.000664547  0.00491135 0.00414646 2.5e+07    42585.97
## 15 0.000342053  0.00454191 0.00404962 2.5e+07    42585.97
## 16 0.041880100  0.12514300 0.13178000 1.0e+10  1151292.55
## 17 0.010177800  0.05137300 0.05354640 2.5e+09   540988.91
## 18 0.002805930  0.01047000 0.01082610 1.0e+08    92103.40
## 19 0.276191000  0.68597700 0.72346400 2.5e+11  6561181.69
## 20 0.255003000  0.68750300 0.71473900 2.5e+11  6561181.69
## 21 0.132546000  1.27628000 1.25504000 1.0e+12 13815510.56
## 22 0.001103840  0.00443419 0.00477446 2.5e+07    42585.97
## 23 0.046334700  0.11598900 0.14238000 1.0e+10  1151292.55
## 24 0.018745300  0.06389830 0.06737100 2.5e+09   540988.91
## 25 0.002934560  0.01055090 0.01119010 1.0e+08    92103.40
## 26 0.009435880  0.11134500 0.10641200 1.0e+10  1151292.55
## 27 0.023200100  0.11279400 0.10789600 1.0e+10  1151292.55
## 28 0.000886534  0.00933530 0.00950768 1.0e+08    92103.40
## 29 0.001372570  0.00518506 0.00556664 2.5e+07    42585.97
## 30 0.281297000  1.39514000 1.37132000 1.0e+12 13815510.56
## 31 0.057227000  0.13653300 0.12684100 2.5e+09   540988.91
## 32 2.222900000  2.05527000 2.28578000 2.5e+11  6561181.69
## 33 0.163702000  0.16297800 0.17953700 2.5e+09   540988.91
## 34 0.020406200  0.02682590 0.03173440 1.0e+08    92103.40
## 35 0.022979700  0.02751490 0.02605040 1.0e+08    92103.40
## 36 0.117571000  0.32720200 0.27328800 1.0e+10  1151292.55
## 37 0.008972860  0.01203780 0.01451480 2.5e+07    42585.97
## 38 2.107770000  1.96857000 1.88870000 2.5e+11  6561181.69
## 39 0.156538000  0.16552400 0.18918100 2.5e+09   540988.91
## 40 2.519060000  2.14414000 2.30078000 2.5e+11  6561181.69
## 41 0.008434710  0.01103280 0.01411310 2.5e+07    42585.97
## 42 0.366069000  0.34577400 0.39171200 1.0e+10  1151292.55
## 43 0.009774680  0.01259800 0.01449530 2.5e+07    42585.97
## 44 0.334957000  0.33161300 0.32746600 1.0e+10  1151292.55
## 45 5.664340000  4.66392000 4.83753000 1.0e+12 13815510.56
## 46 0.024775100  0.03463140 0.03478310 1.0e+08    92103.40
## 47 7.935090000  8.12423000 8.56265000 1.0e+12 13815510.56
## 48 1.873910000 10.17380000 6.05236000 1.0e+12 13815510.56
## 49 2.362380000  2.05452000 2.42759000 2.5e+11  6561181.69
## 50 0.361969000  0.35122200 0.40865600 1.0e+10  1151292.55
## 51 0.007896310  0.01158290 0.01143420 2.5e+07    42585.97
## 52 4.680090000  4.36611000 4.01885000 1.0e+12 13815510.56
## 53 0.004536150  0.01185560 0.01047710 2.5e+07    42585.97
## 54 0.358063000  0.38033100 0.44681100 1.0e+10  1151292.55
## 55 0.020422000  0.02618030 0.03146440 1.0e+08    92103.40
## 56 0.009215910  0.02485190 0.01878570 1.0e+08    92103.40
## 57 0.721358000  1.96970000 1.66419000 2.5e+11  6561181.69
## 58 0.161091000  0.16140900 0.20064300 2.5e+09   540988.91
## 59 0.151833000  0.16607700 0.16001200 2.5e+09   540988.91
## 60 5.346170000  4.32209000 4.94691000 1.0e+12 13815510.56
```

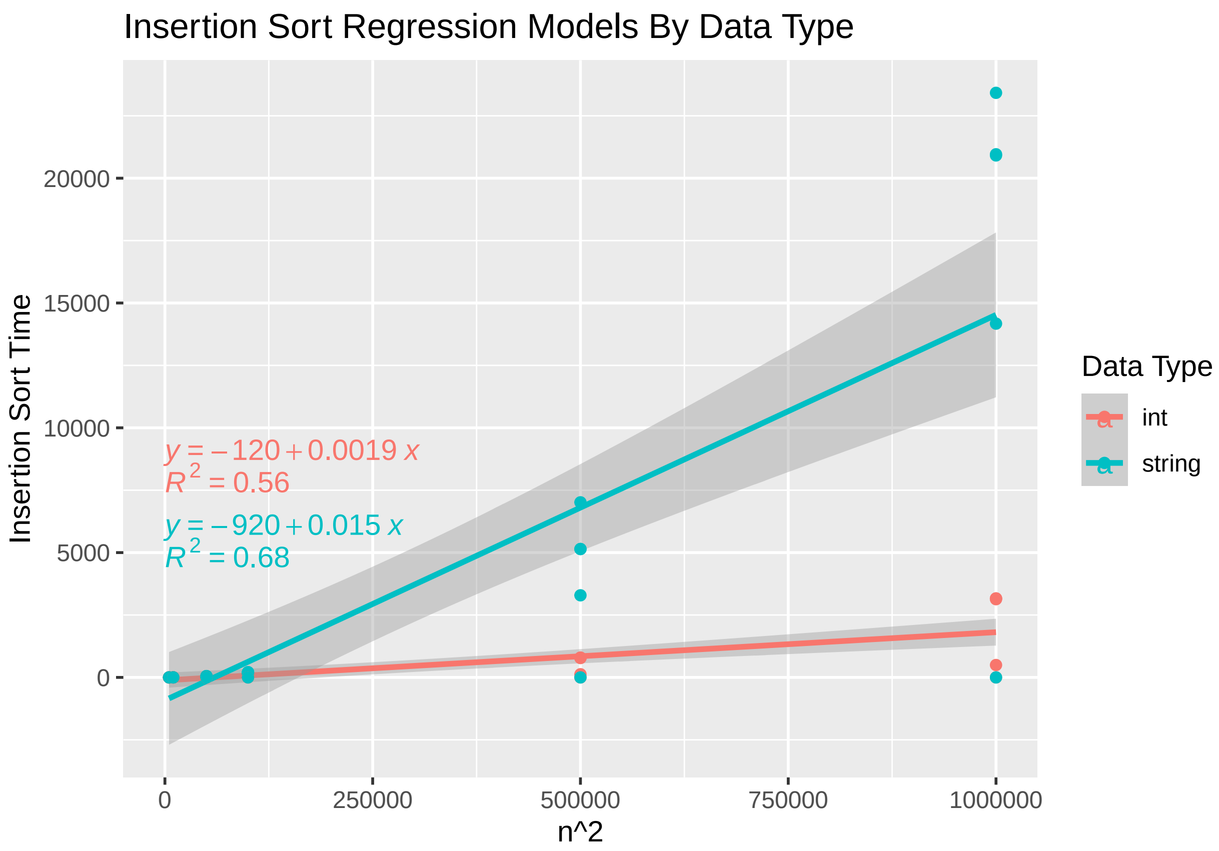
Insertion Sort

```r
insertionTimes = aggregate(insertion_time ~ var_type + size + n2 + format, data = data, FUN = mean)
insertionTimes2 = aggregate(insertion_time ~ var_type + size + n2, data = data, FUN = mean)
ggplot(insertionTimes2, aes(x = size, y = insertion_time, color = var_type)) +
  geom_line() +
  labs(title = "Mean Insertion Sort Time By Data Set Size and Data Type", x = "n", y = "Insertion Sort 
  guides(color = guide_legend(title = "Data Type"))
```

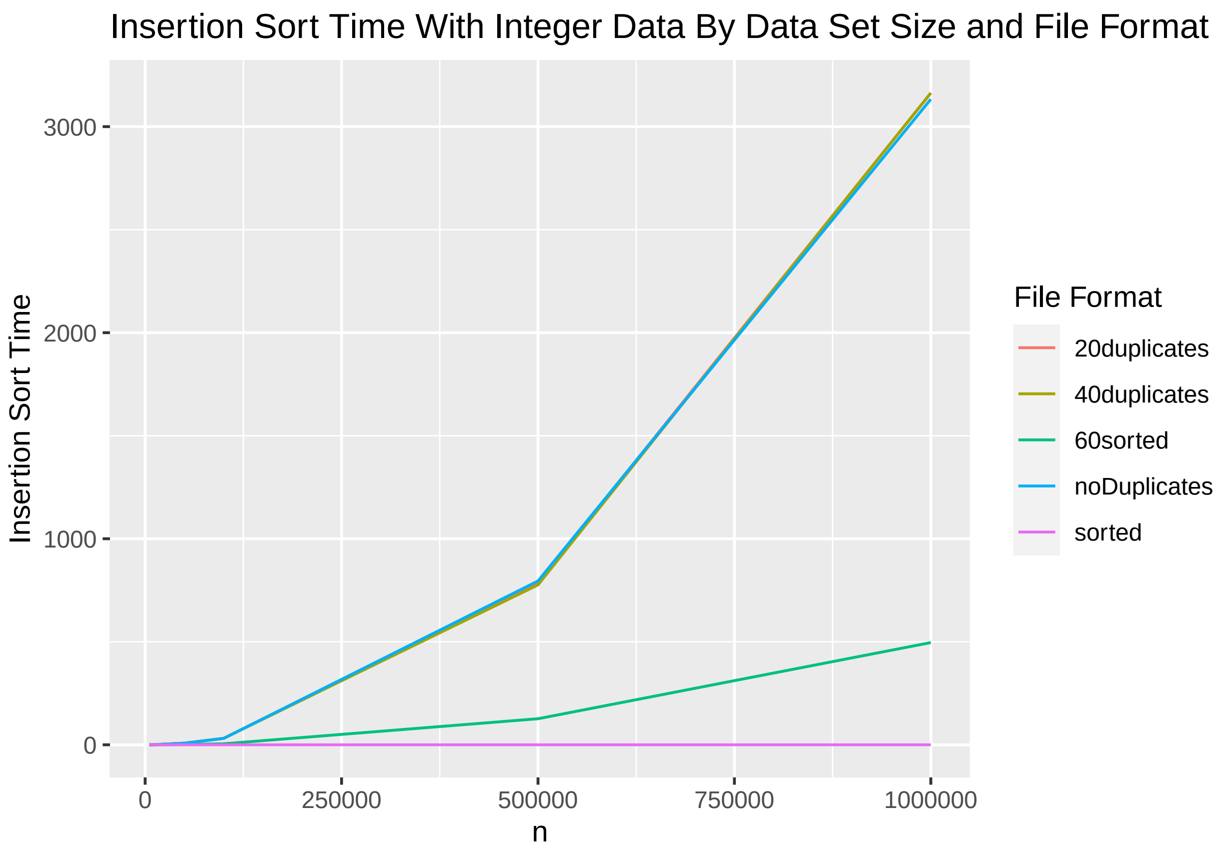


```
ggplot(insertionTimes, aes(x = size, y = insertion_time, color = var_type)) +
  labs(title = "Insertion Sort Regression Models By Data Type", x = "n^2", y = "Insertion Sort Time") +
  geom_smooth(method="lm") +
  geom_point() +
  stat_regline_equation(label.x=0, label.y=c(9000, 6000)) +
  stat_cor(aes(label=..rr.label..), label.x=0, label.y=c(8000, 5000)) +
  guides(color = guide_legend(title = "Data Type"))
```

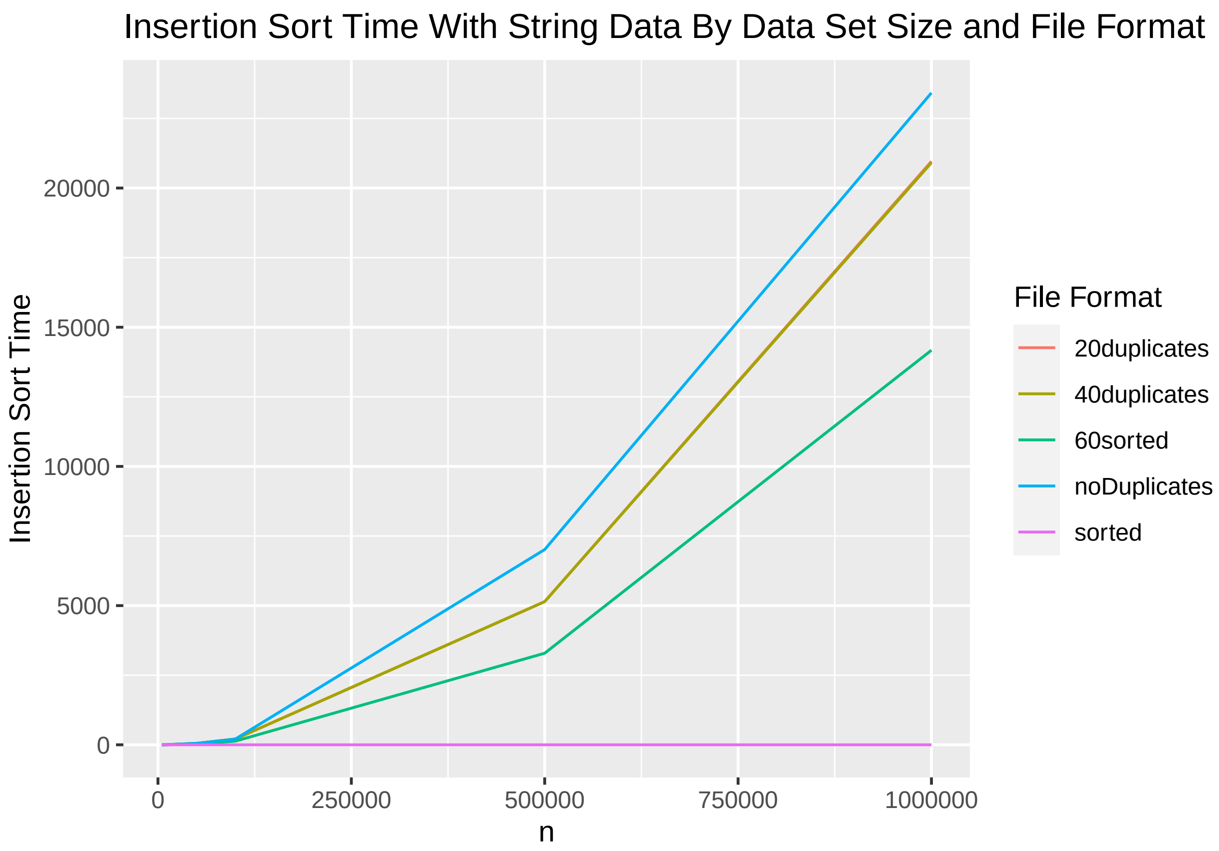
```
## ‘geom_smooth()‘ using formula ’y ~ x’
```



```
insertionInts = subset(insertionTimes, var_type == "int")
ggplot(insertionInts, aes(x = size, y = insertion_time, color = format)) +
  geom_line() +
  labs(title = "Insertion Sort Time With Integer Data By Data Set Size and File Format", x = "n", y = "
  guides(color = guide_legend(title = "File Format"))
```

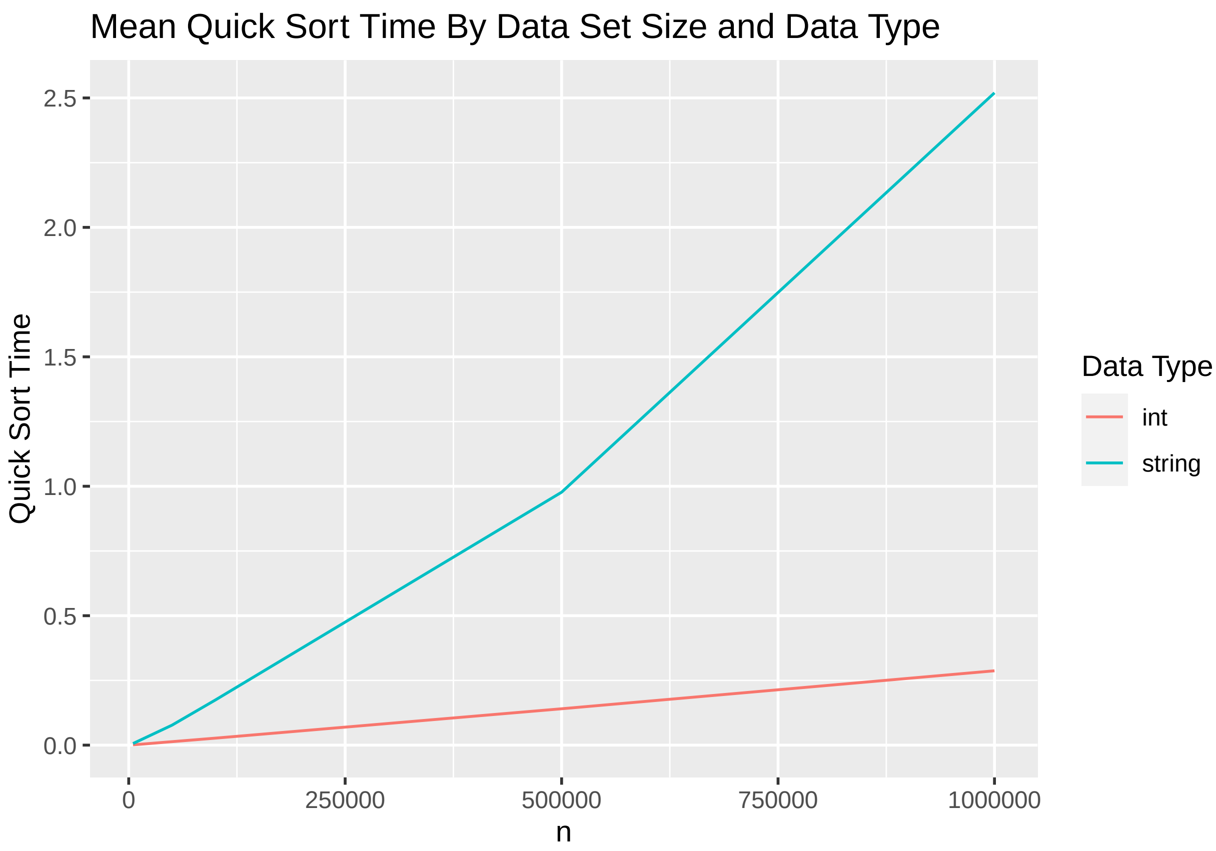


```
insertionStrings = subset(insertionTimes, var_type == "string")
ggplot(insertionStrings, aes(x = size, y = insertion_time, color = format)) +
  geom_line() +
  labs(title = "Insertion Sort Time With String Data By Data Set Size and File Format", x = "n", y = "In
  guides(color = guide_legend(title = "File Format"))
```



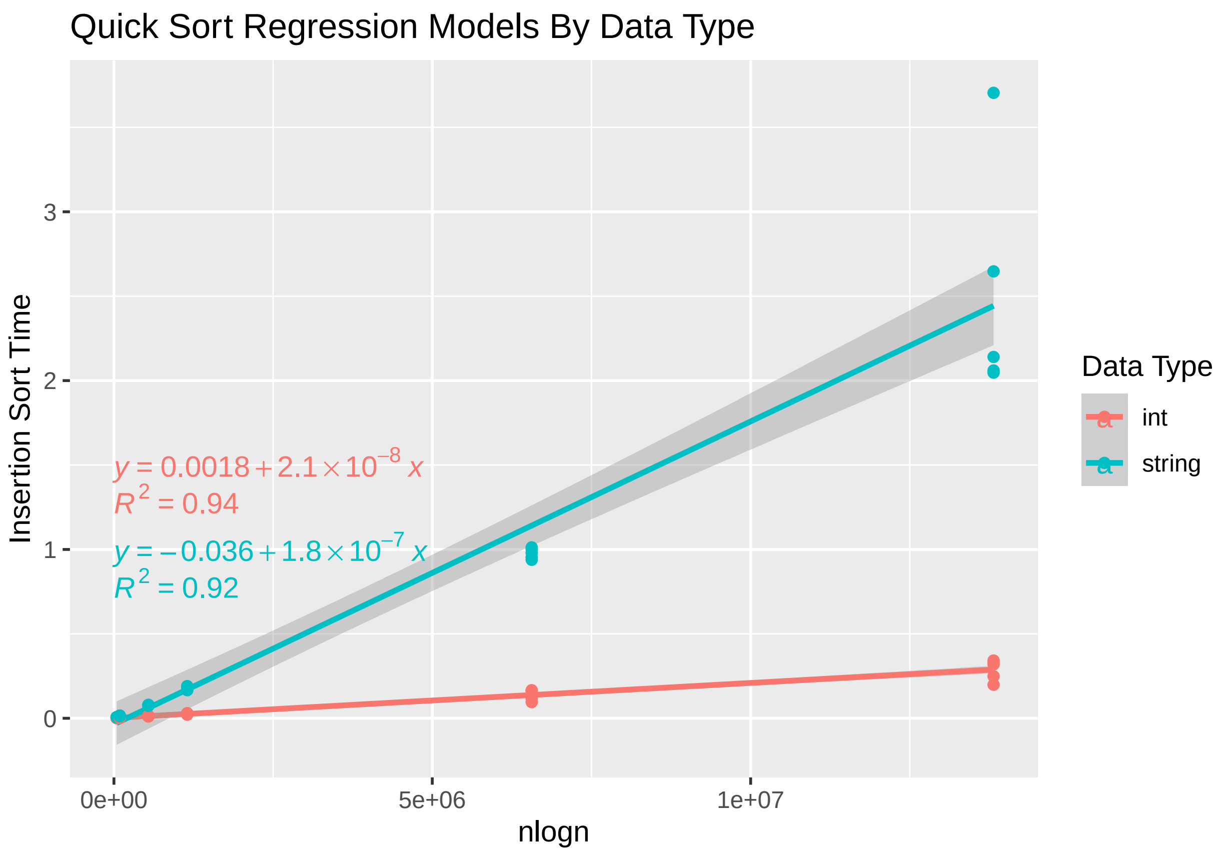
Quick Sort

```
quickTimes = aggregate(quick_time ~ var_type + size + nlogn + format, data = data, FUN = mean)
quickTimes2 = aggregate(quick_time ~ var_type + size + nlogn, data = data, FUN = mean)
ggplot(quickTimes2, aes(x = size, y = quick_time, color = var_type)) +
  geom_line() +
  labs(title = "Mean Quick Sort Time By Data Set Size and Data Type", x = "n", y = "Quick Sort Time") +
  guides(color = guide_legend(title = "Data Type"))
```

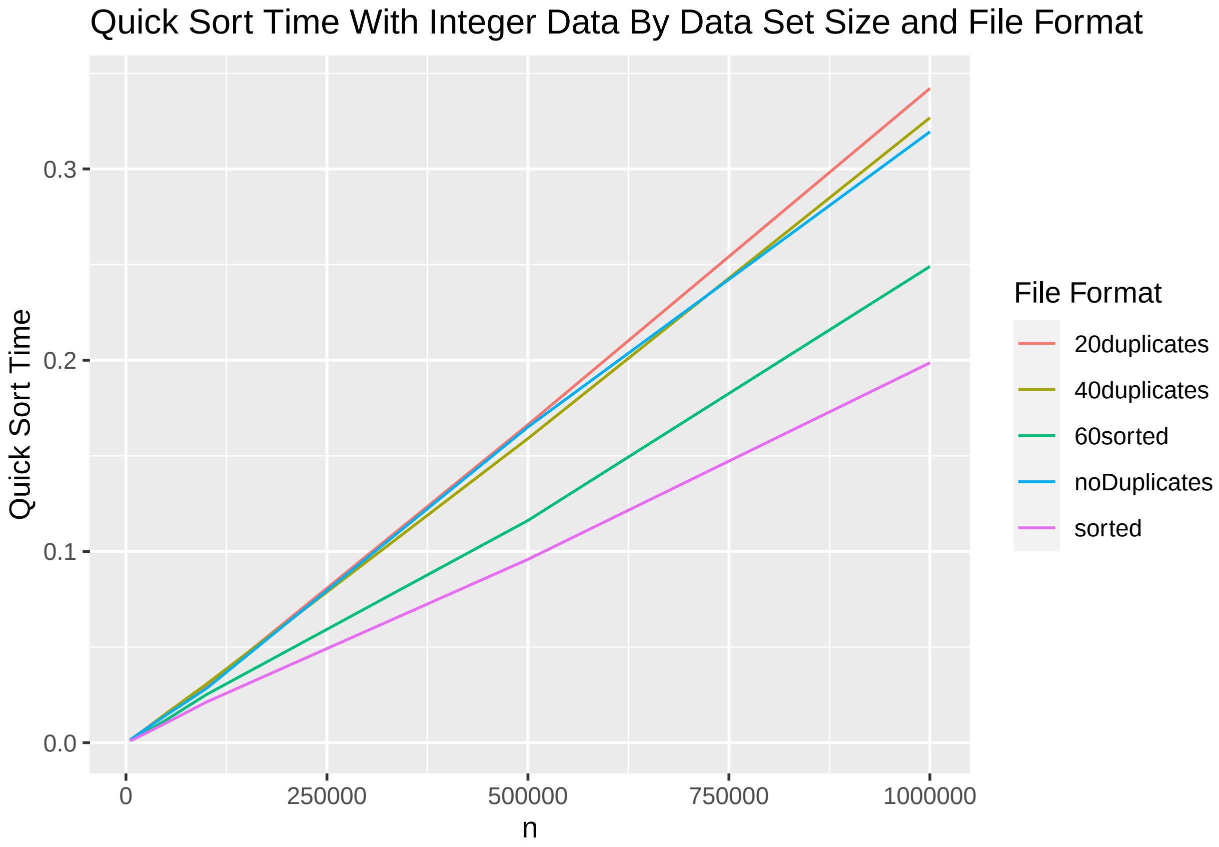


```
ggplot(quickTimes, aes(x = nlogn, y = quick_time, color = var_type)) +
  labs(title = "Quick Sort Regression Models By Data Type", x = "nlogn", y = "Insertion Sort Time") +
  geom_smooth(method="lm") +
  geom_point() +
  stat_regline_equation(label.x=0, label.y=c(1.5, 1)) +
  stat_cor(aes(label=..rr.label..), label.x=0, label.y=c(1.3, 0.8)) +
  guides(color = guide_legend(title = "Data Type"))
```

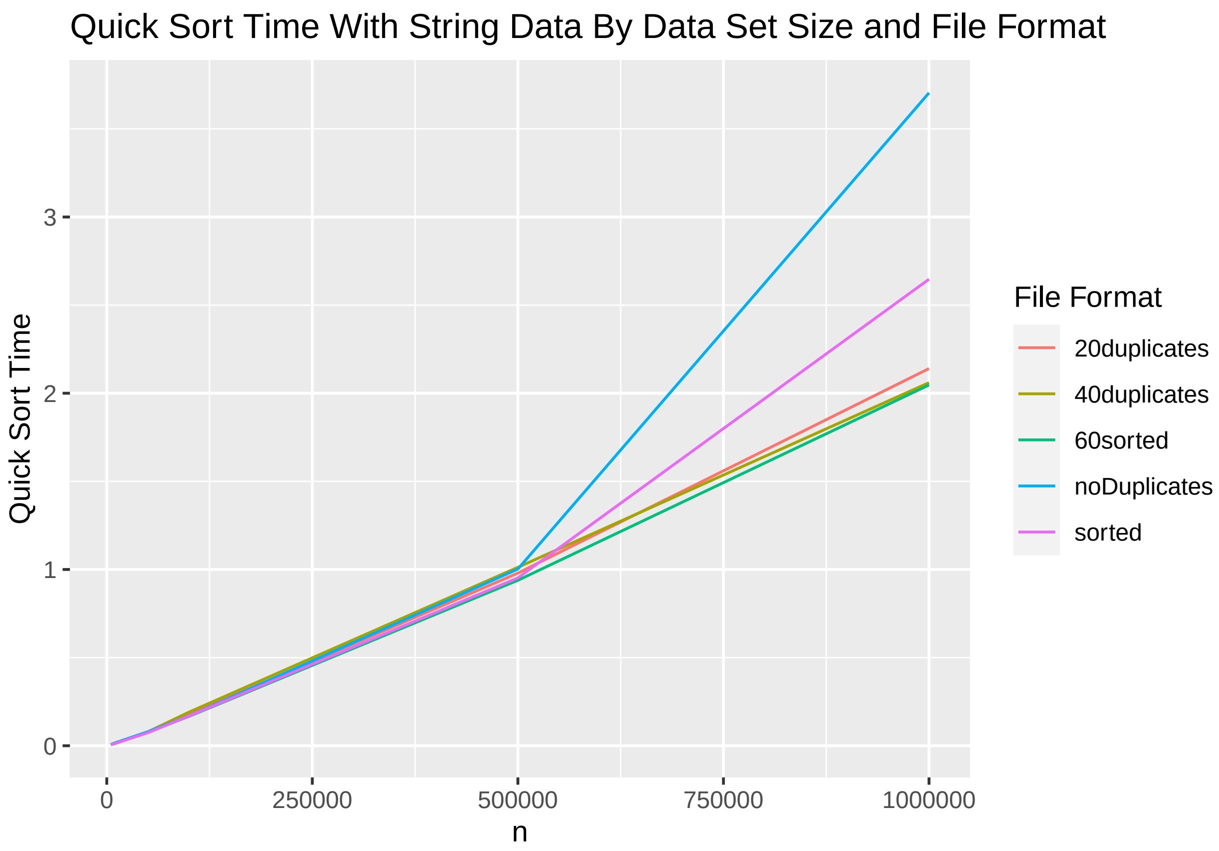
```
## ‘geom_smooth()‘ using formula ’y ~ x’
```



```
quickInts = subset(quickTimes, var_type == "int")
ggplot(quickInts, aes(x = size, y = quick_time, color = format)) +
  geom_line() +
  labs(title = "Quick Sort Time With Integer Data By Data Set Size and File Format", x = "n", y = "Quicl
  guides(color = guide_legend(title = "File Format"))
```

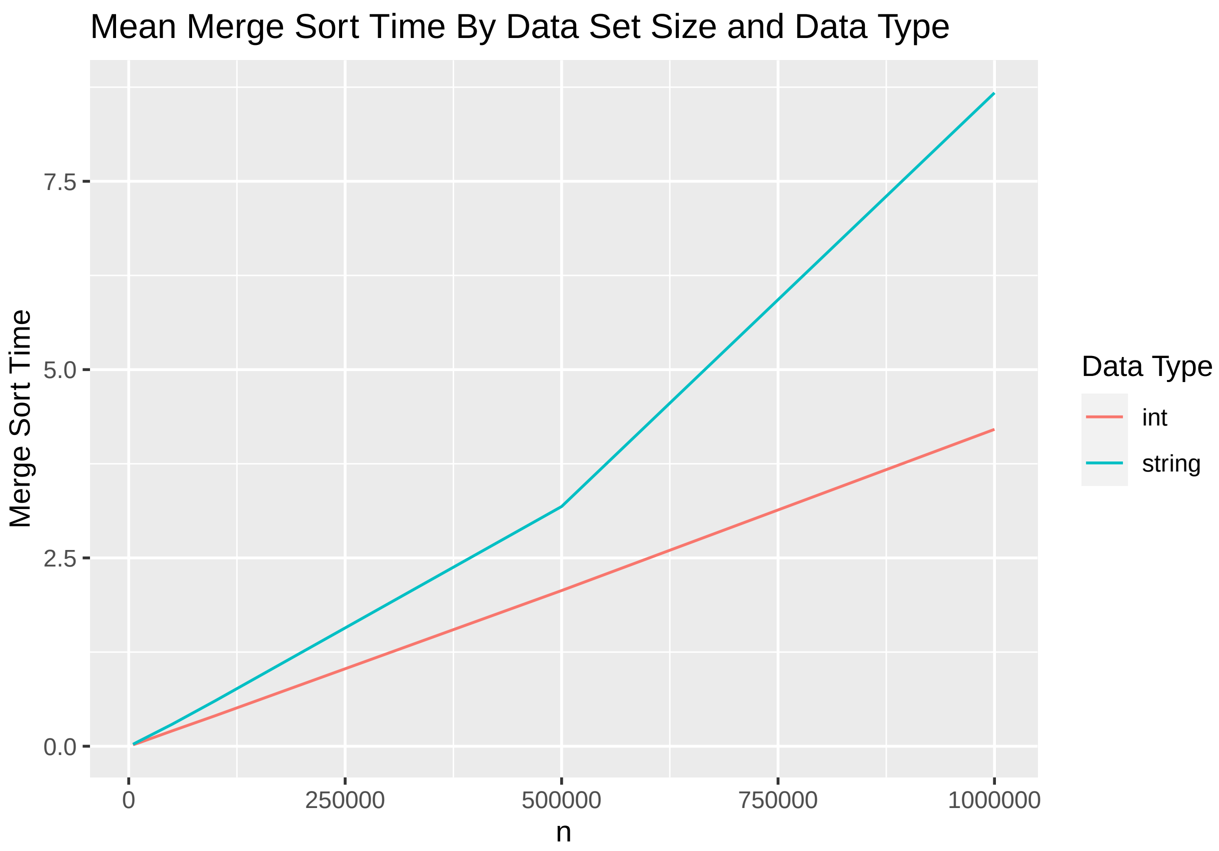


```
quickStrings = subset(quickTimes, var_type == "string")
ggplot(quickStrings, aes(x = size, y = quick_time, color = format)) +
  geom_line() +
  labs(title = "Quick Sort Time With String Data By Data Set Size and File Format", x = "n", y = "Quick
  guides(color = guide_legend(title = "File Format"))
```



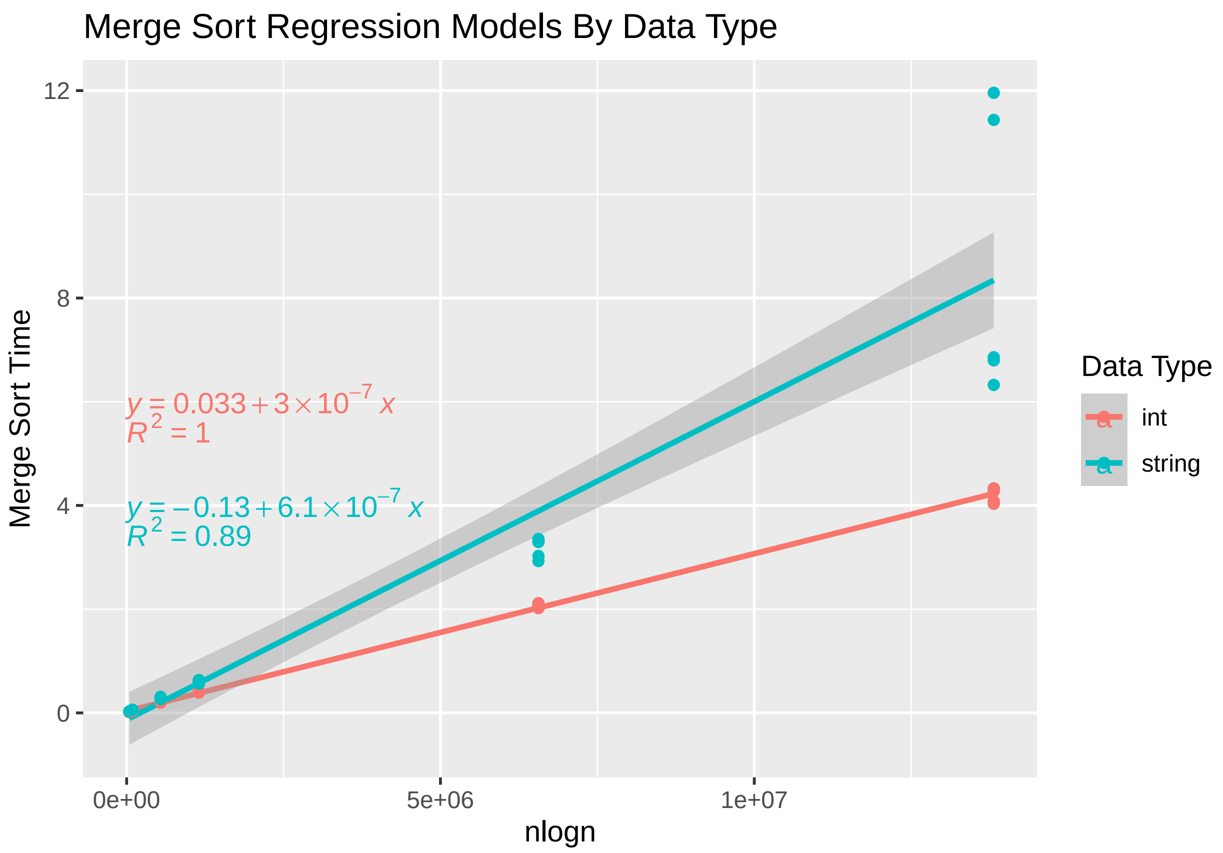
Merge Sort

```
mergeTimes = aggregate(merge_time ~ var_type + size + nlogn + format, data = data, FUN = mean)
mergeTimes2 = aggregate(merge_time ~ var_type + size + nlogn, data = data, FUN = mean)
ggplot(mergeTimes2, aes(x = size, y = merge_time, color = var_type)) +
  geom_line() +
  labs(title = "Mean Merge Sort Time By Data Set Size and Data Type", x = "n", y = "Merge Sort Time") +
  guides(color = guide_legend(title = "Data Type"))
```

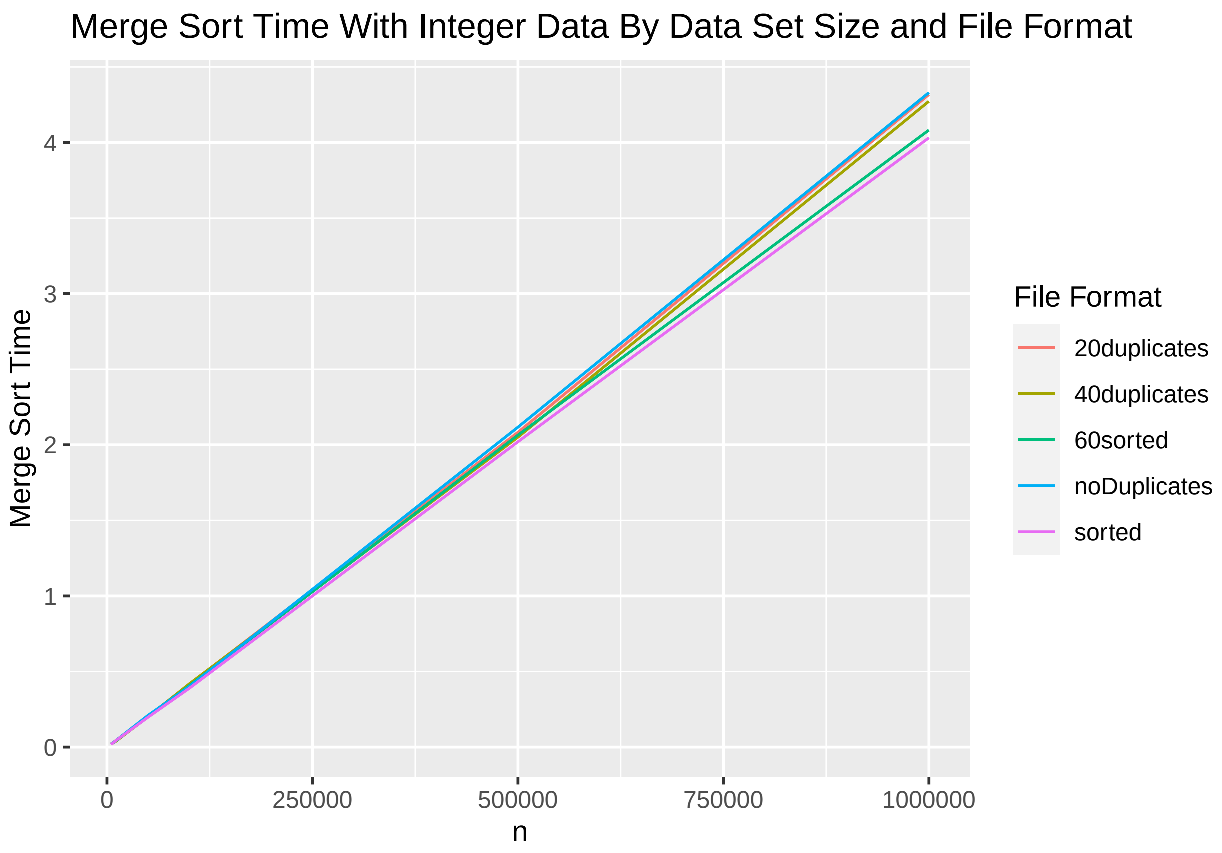


```
ggplot(mergeTimes, aes(x = nlogn, y = merge_time, color = var_type)) +
  labs(title = "Merge Sort Regression Models By Data Type", x = "nlogn", y = "Merge Sort Time") +
  geom_smooth(method="lm") +
  geom_point() +
  stat_regline_equation(label.x=0, label.y=c(6, 4)) +
  stat_cor(aes(label=..rr.label..), label.x=0, label.y=c(5.5, 3.5)) +
  guides(color = guide_legend(title = "Data Type"))
```

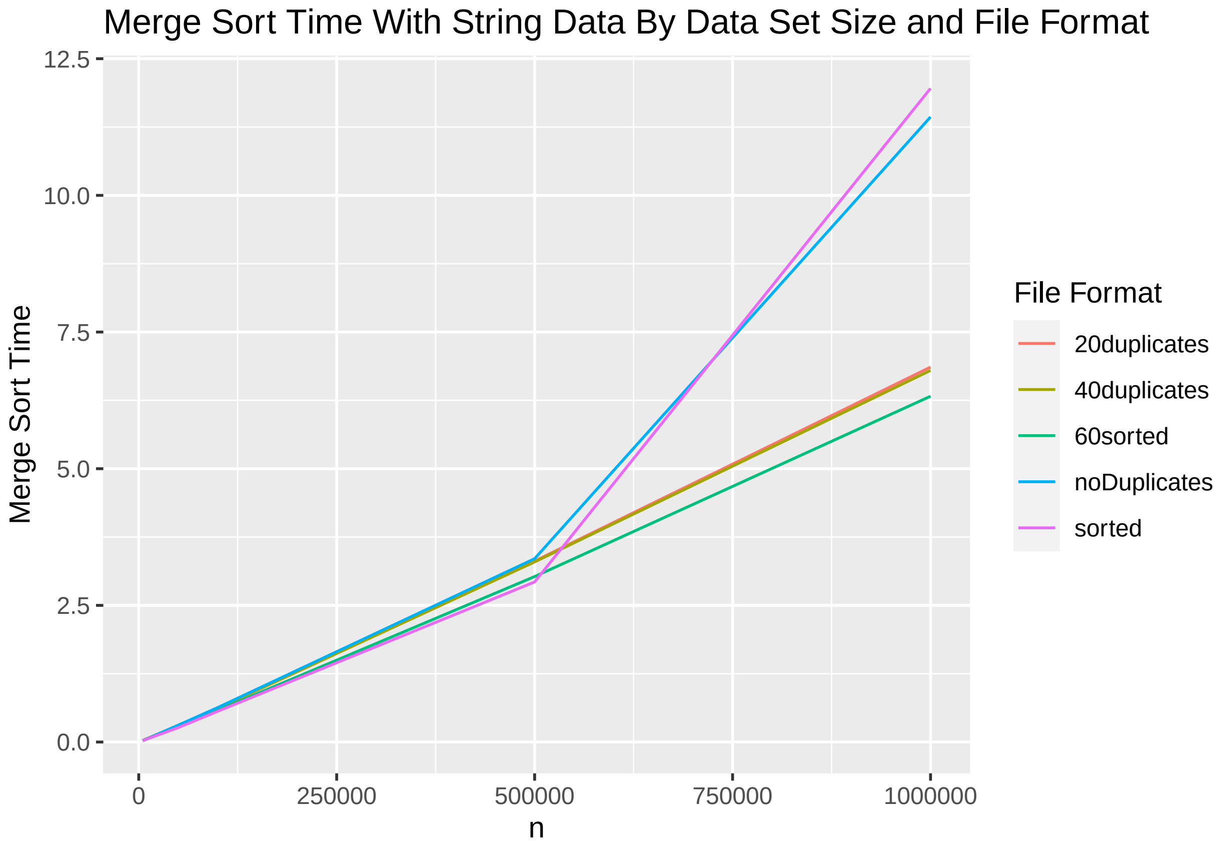
```
## `geom_smooth()` using formula 'y ~ x'
```



```
mergeInts = subset(mergeTimes, var_type == "int")
ggplot(mergeInts, aes(x = size, y = merge_time, color = format)) +
  geom_line() +
  labs(title = "Merge Sort Time With Integer Data By Data Set Size and File Format", x = "n", y = "Merg
  guides(color = guide_legend(title = "File Format"))
```

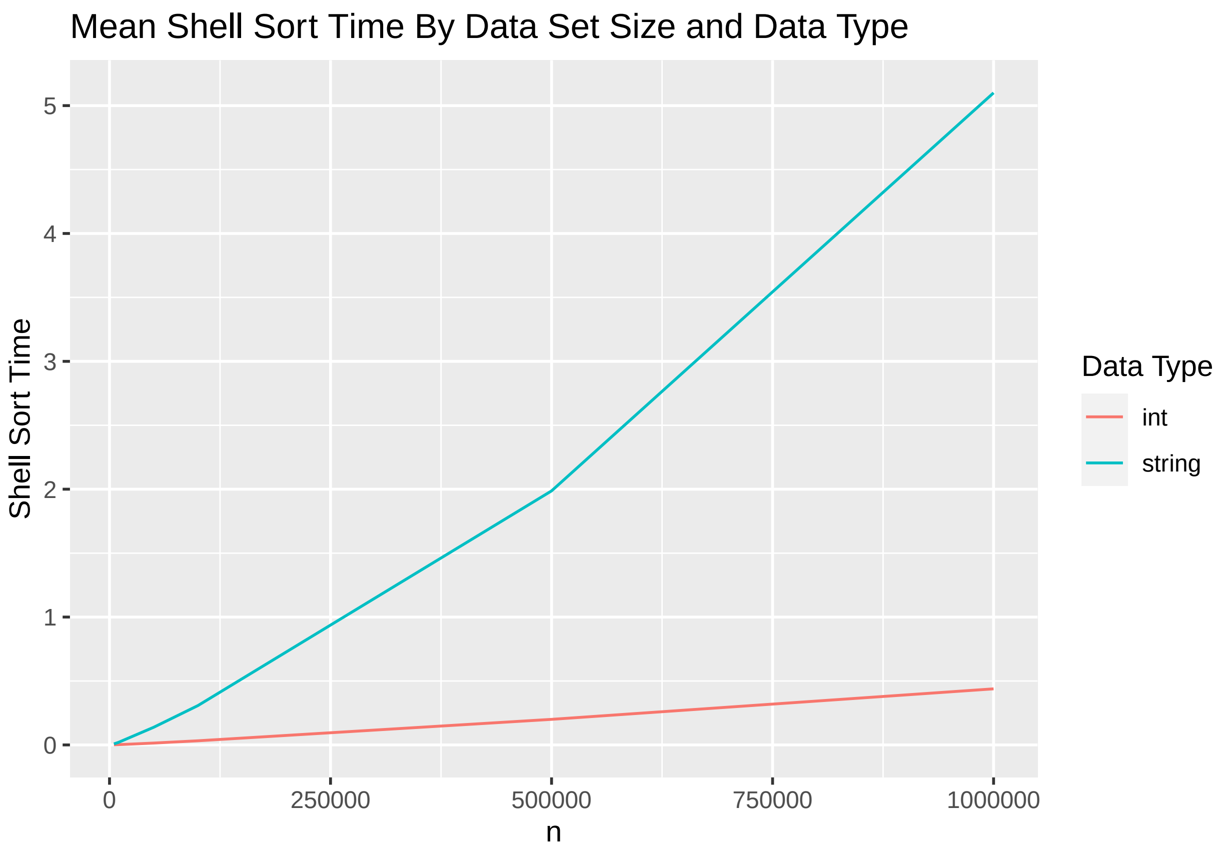


```
mergeStrings = subset(mergeTimes, var_type == "string")
ggplot(mergeStrings, aes(x = size, y = merge_time, color = format)) +
  geom_line() +
  labs(title = "Merge Sort Time With String Data By Data Set Size and File Format", x = "n", y = "Merge
  guides(color = guide_legend(title = "File Format"))
```



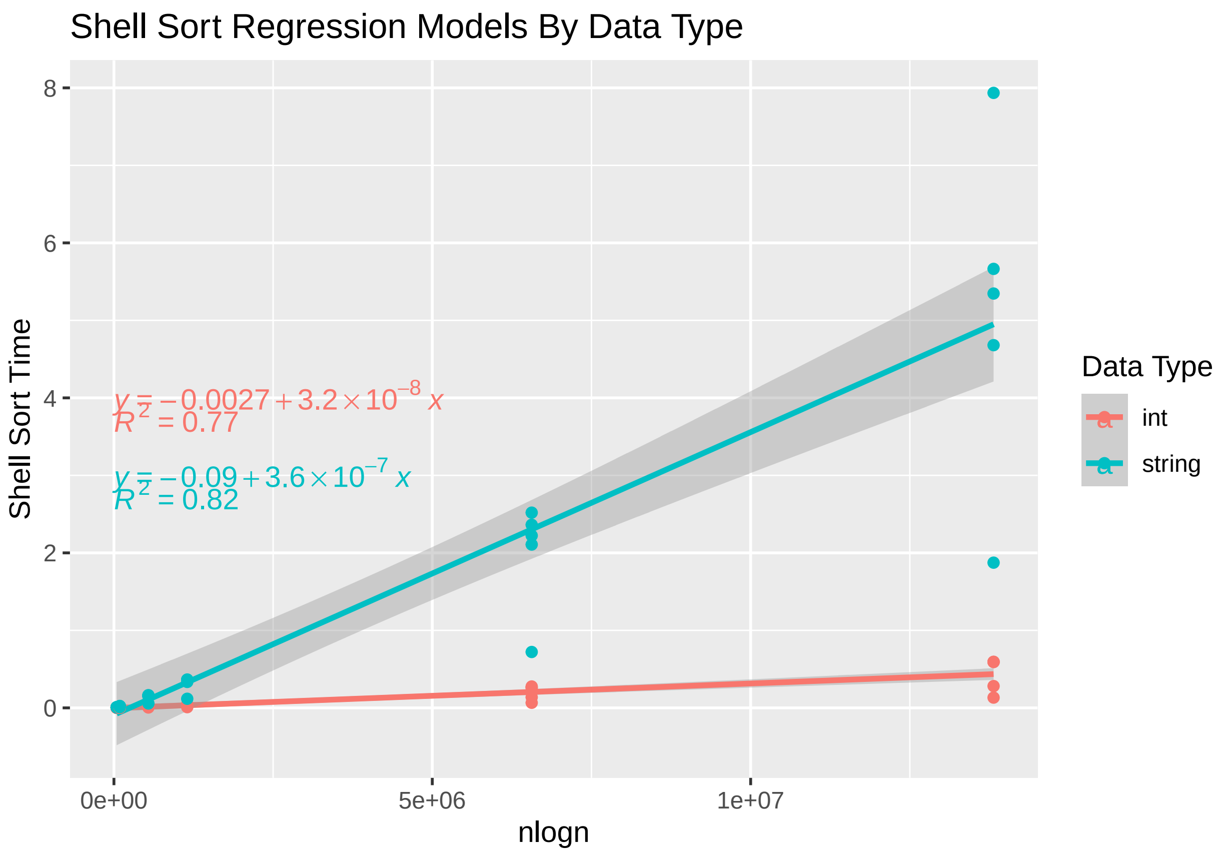
Shell Sort

```
shellTimes = aggregate(shell_time ~ var_type + size + nlogn + format, data = data, FUN = mean)
shellTimes2 = aggregate(shell_time ~ var_type + size + nlogn, data = data, FUN = mean)
ggplot(shellTimes2, aes(x = size, y = shell_time, color = var_type)) +
  geom_line() +
  labs(title = "Mean Shell Sort Time By Data Set Size and Data Type", x = "n", y = "Shell Sort Time") +
  guides(color = guide_legend(title = "Data Type"))
```

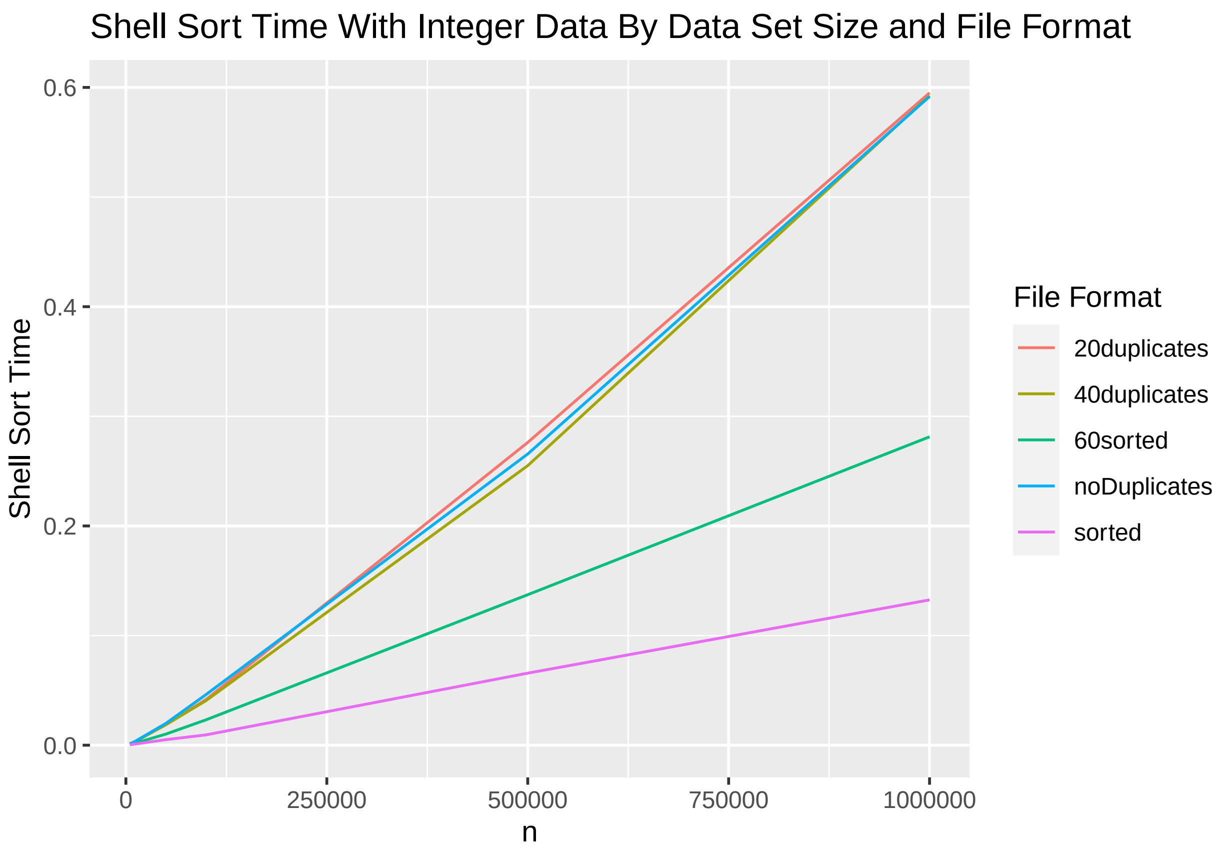


```
ggplot(shellTimes, aes(x = nlogn, y = shell_time, color = var_type)) +
  labs(title = "Shell Sort Regression Models By Data Type", x = "nlogn", y = "Shell Sort Time") +
  geom_smooth(method="lm") +
  geom_point() +
  stat_regline_equation(label.x=0, label.y=c(4, 3)) +
  stat_cor(aes(label=..rr.label..), label.x=0, label.y=c(3.75, 2.75)) +
  guides(color = guide_legend(title = "Data Type"))
```

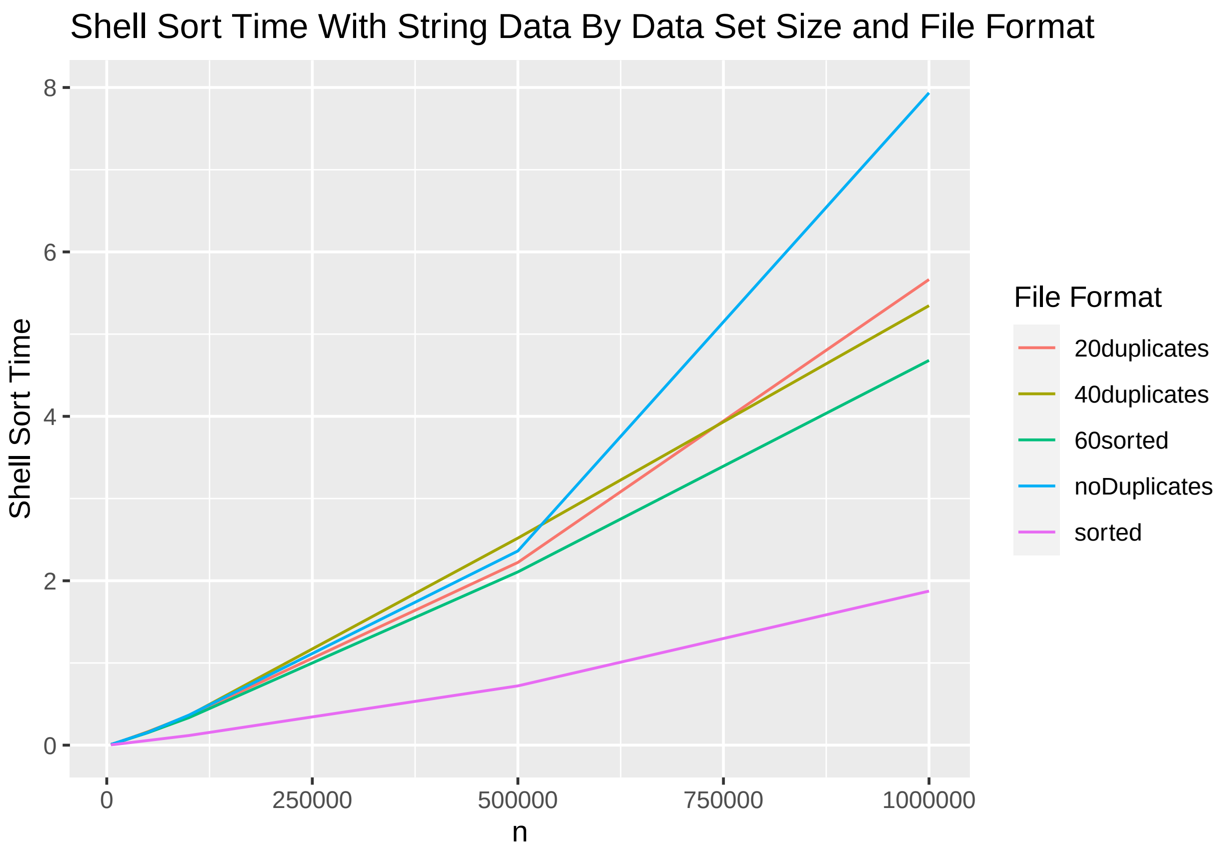
```
## ‘geom_smooth()‘ using formula ’y ~ x’
```



```
shellInts = subset(shellTimes, var_type == "int")
ggplot(shellInts, aes(x = size, y = shell_time, color = format)) +
  geom_line() +
  labs(title = "Shell Sort Time With Integer Data By Data Set Size and File Format", x = "n", y = "Shel
  guides(color = guide_legend(title = "File Format"))
```

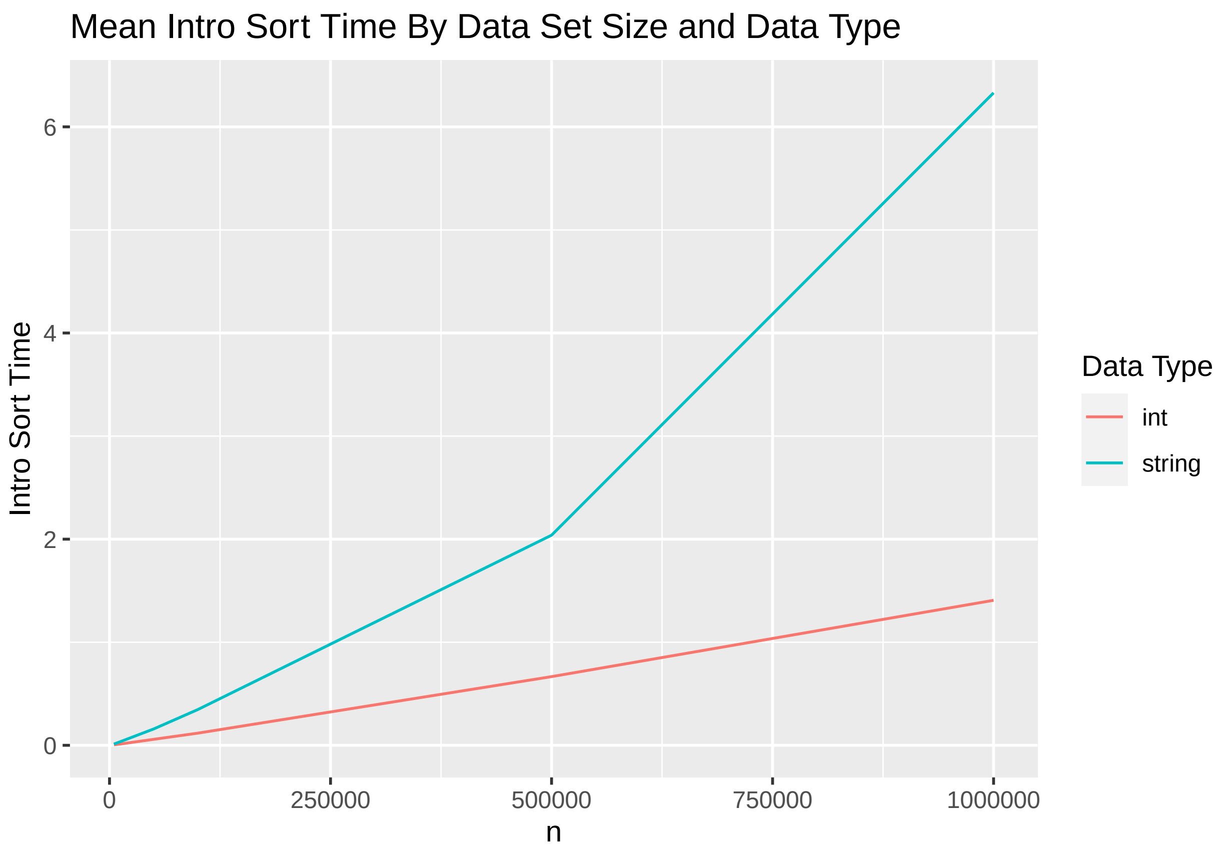


```
shellStrings = subset(shellTimes, var_type == "string")
ggplot(shellStrings, aes(x = size, y = shell_time, color = format)) +
  geom_line() +
  labs(title = "Shell Sort Time With String Data By Data Set Size and File Format", x = "n", y = "Shell
  guides(color = guide_legend(title = "File Format"))
```



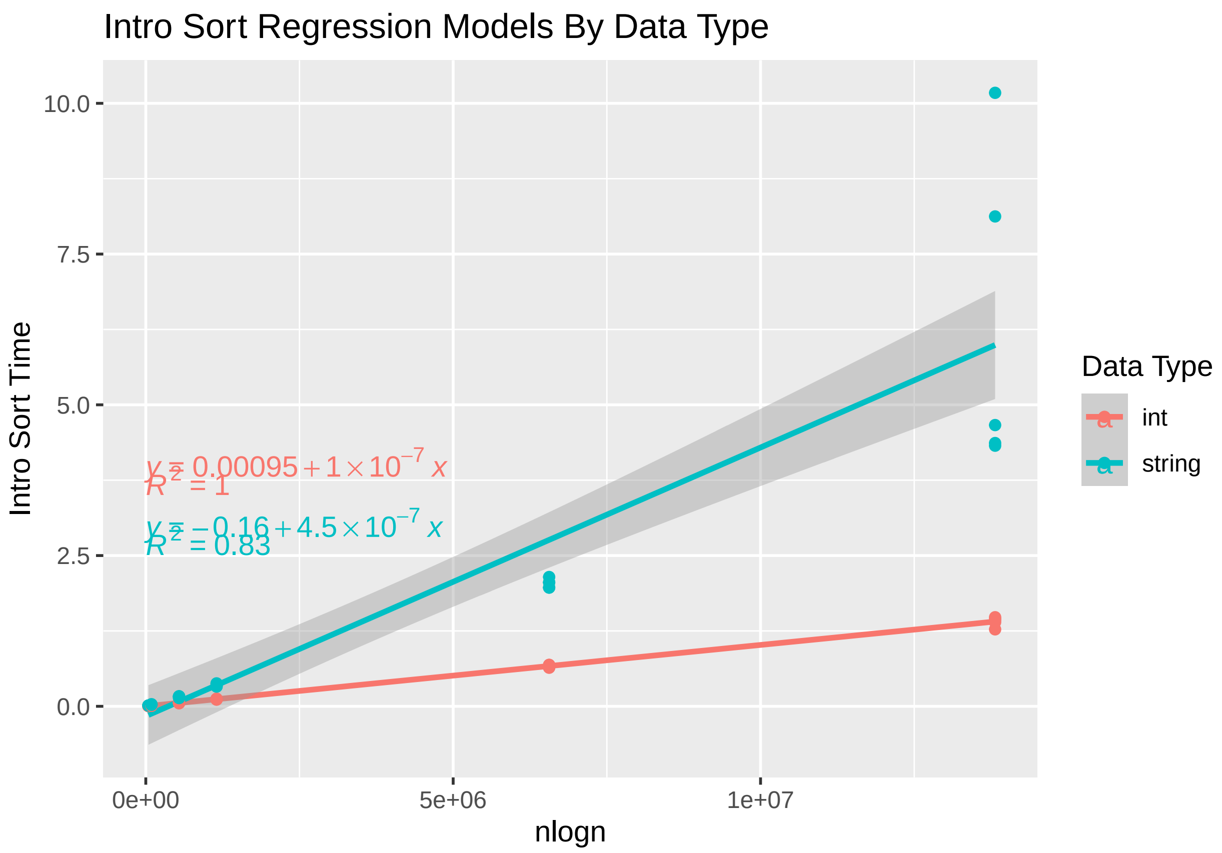
Intro Sort

```
introTimes = aggregate(intro_time ~ var_type + size + nlogn + format, data = data, FUN = mean)
introTimes2 = aggregate(intro_time ~ var_type + size + nlogn, data = data, FUN = mean)
ggplot(introTimes2, aes(x = size, y = intro_time, color = var_type)) +
  geom_line() +
  labs(title = "Mean Intro Sort Time By Data Set Size and Data Type", x = "n", y = "Intro Sort Time") +
  guides(color = guide_legend(title = "Data Type"))
```

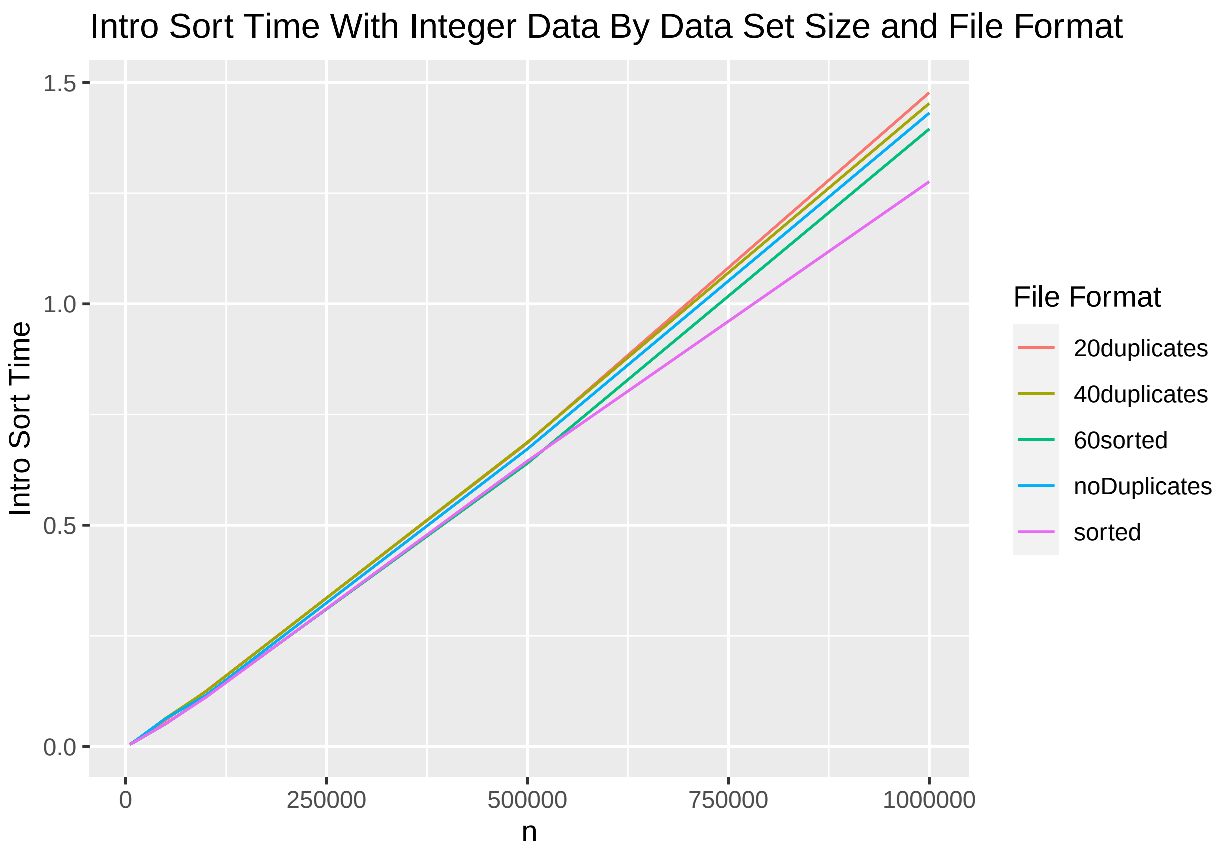


```
ggplot(introTimes, aes(x = nlogn, y = intro_time, color = var_type)) +
  labs(title = "Intro Sort Regression Models By Data Type", x = "nlogn", y = "Intro Sort Time") +
  geom_smooth(method="lm") +
  geom_point() +
  stat_regline_equation(label.x=0, label.y=c(4, 3)) +
  stat_cor(aes(label=..rr.label..), label.x=0, label.y=c(3.75, 2.75)) +
  guides(color = guide_legend(title = "Data Type"))
```

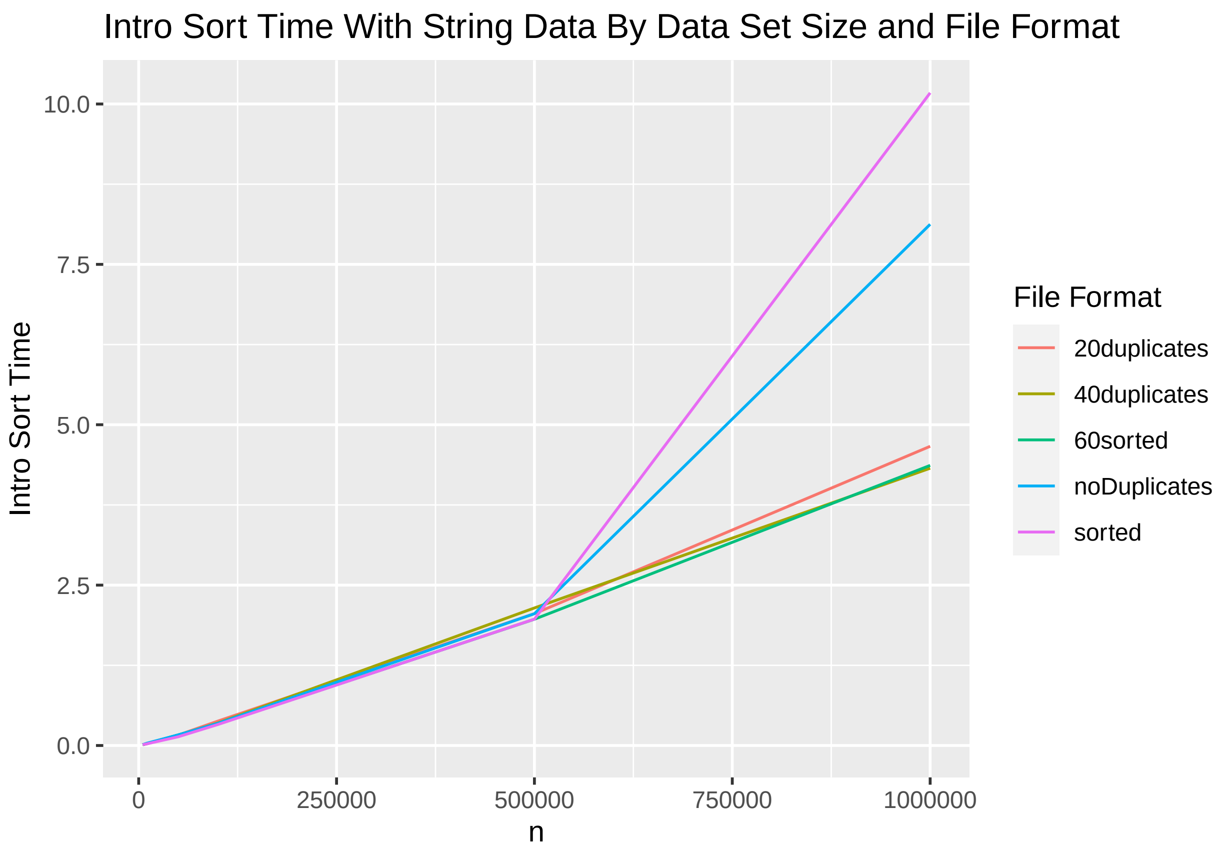
```
## ‘geom_smooth()‘ using formula ’y ~ x’
```



```
introInts = subset(introTimes, var_type == "int")
ggplot(introInts, aes(x = size, y = intro_time, color = format)) +
  geom_line() +
  labs(title = "Intro Sort Time With Integer Data By Data Set Size and File Format", x = "n", y = "Intr
  guides(color = guide_legend(title = "File Format"))
```

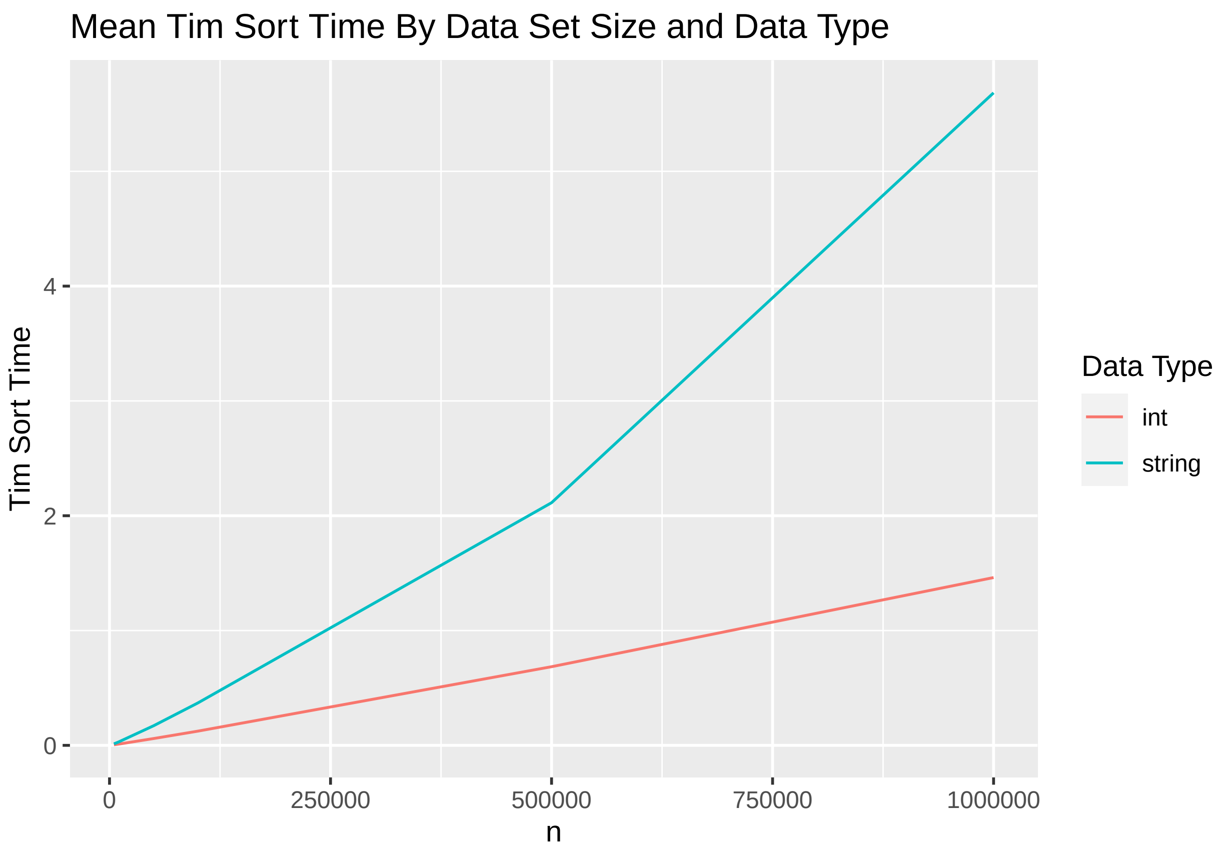


```
introStrings = subset(introTimes, var_type == "string")
ggplot(introStrings, aes(x = size, y = intro_time, color = format)) +
  geom_line() +
  labs(title = "Intro Sort Time With String Data By Data Set Size and File Format", x = "n", y = "Intro
  guides(color = guide_legend(title = "File Format"))
```



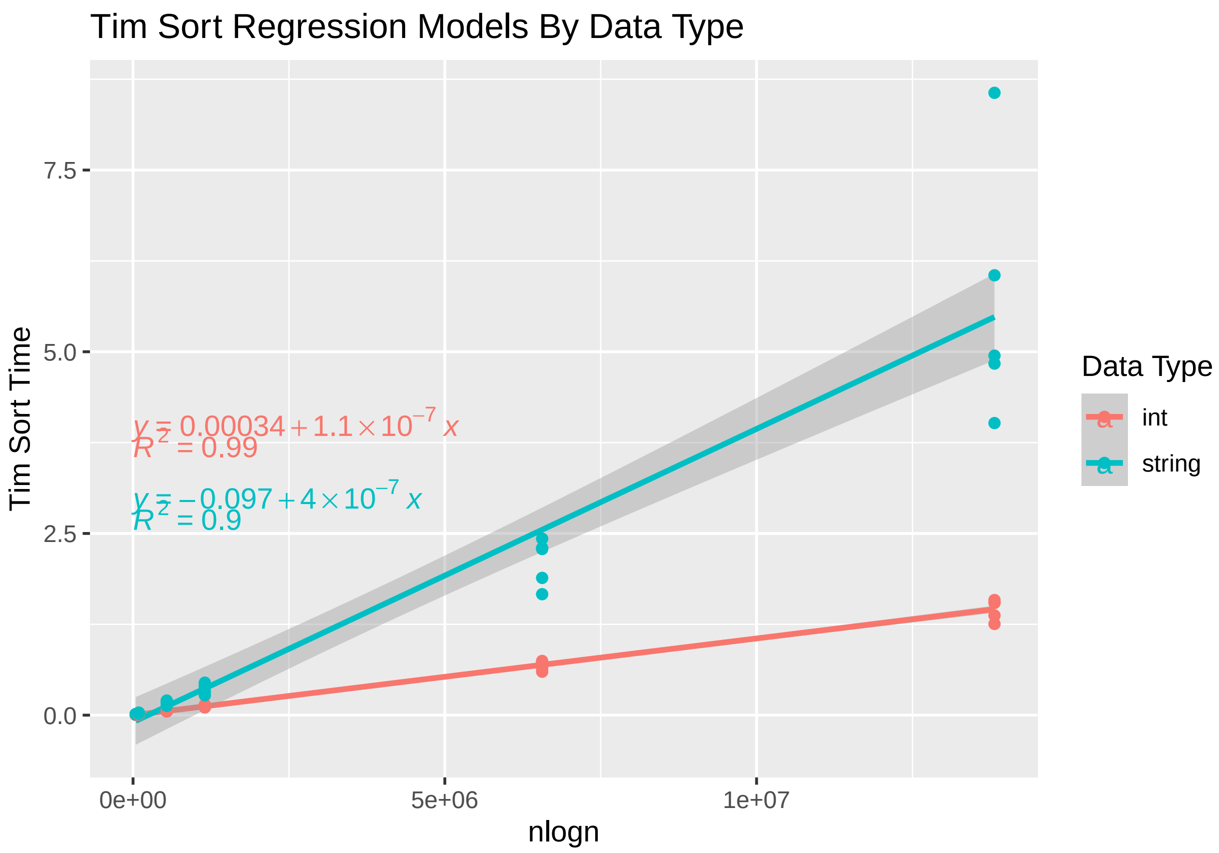
Tim Sort

```
timTimes = aggregate(tim_time ~ var_type + size + nlogn + format, data = data, FUN = mean)
timTimes2 = aggregate(tim_time ~ var_type + size + nlogn, data = data, FUN = mean)
ggplot(timTimes2, aes(x = size, y = tim_time, color = var_type)) +
  geom_line() +
  labs(title = "Mean Tim Sort Time By Data Set Size and Data Type", x = "n", y = "Tim Sort Time") +
  guides(color = guide_legend(title = "Data Type"))
```

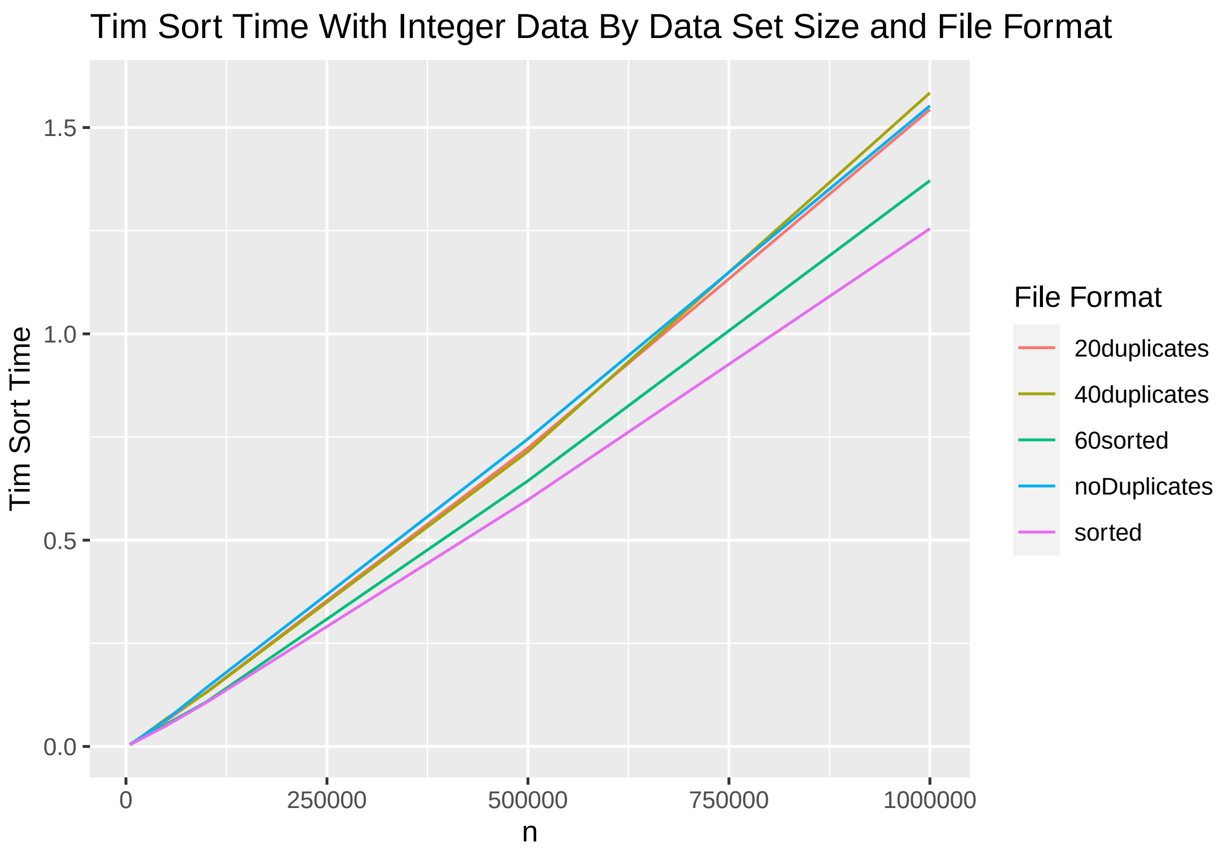


```
ggplot(timTimes, aes(x = nlogn, y = tim_time, color = var_type)) +
  labs(title = "Tim Sort Regression Models By Data Type", x = "nlogn", y = "Tim Sort Time") +
  geom_smooth(method="lm") +
  geom_point() +
  stat_regline_equation(label.x=0, label.y=c(4, 3)) +
  stat_cor(aes(label=..rr.label..), label.x=0, label.y=c(3.75, 2.75)) +
  guides(color = guide_legend(title = "Data Type"))
```

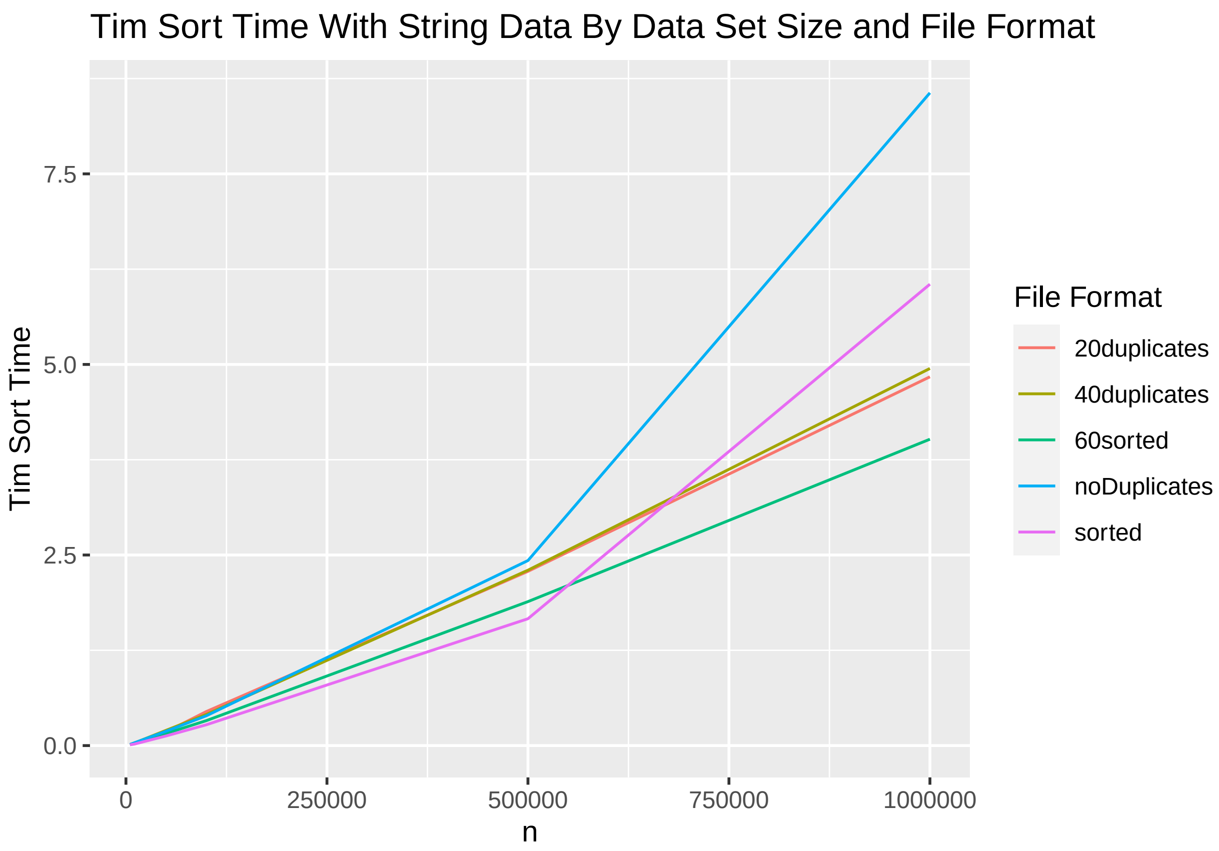
```
## ‘geom_smooth()‘ using formula ’y ~ x’
```



```r
timInts = subset(timTimes, var_type == "int")
ggplot(timInts, aes(x = size, y = tim_time, color = format)) +
  geom_line() +
  labs(title = "Tim Sort Time With Integer Data By Data Set Size and File Format", x = "n", y = "Tim So
  guides(color = guide_legend(title = "File Format"))
```



```r
timStrings = subset(timTimes, var_type == "string")
ggplot(timStrings, aes(x = size, y = tim_time, color = format)) +
  geom_line() +
  labs(title = "Tim Sort Time With String Data By Data Set Size and File Format", x = "n", y = "Tim Sor
  guides(color = guide_legend(title = "File Format"))
```

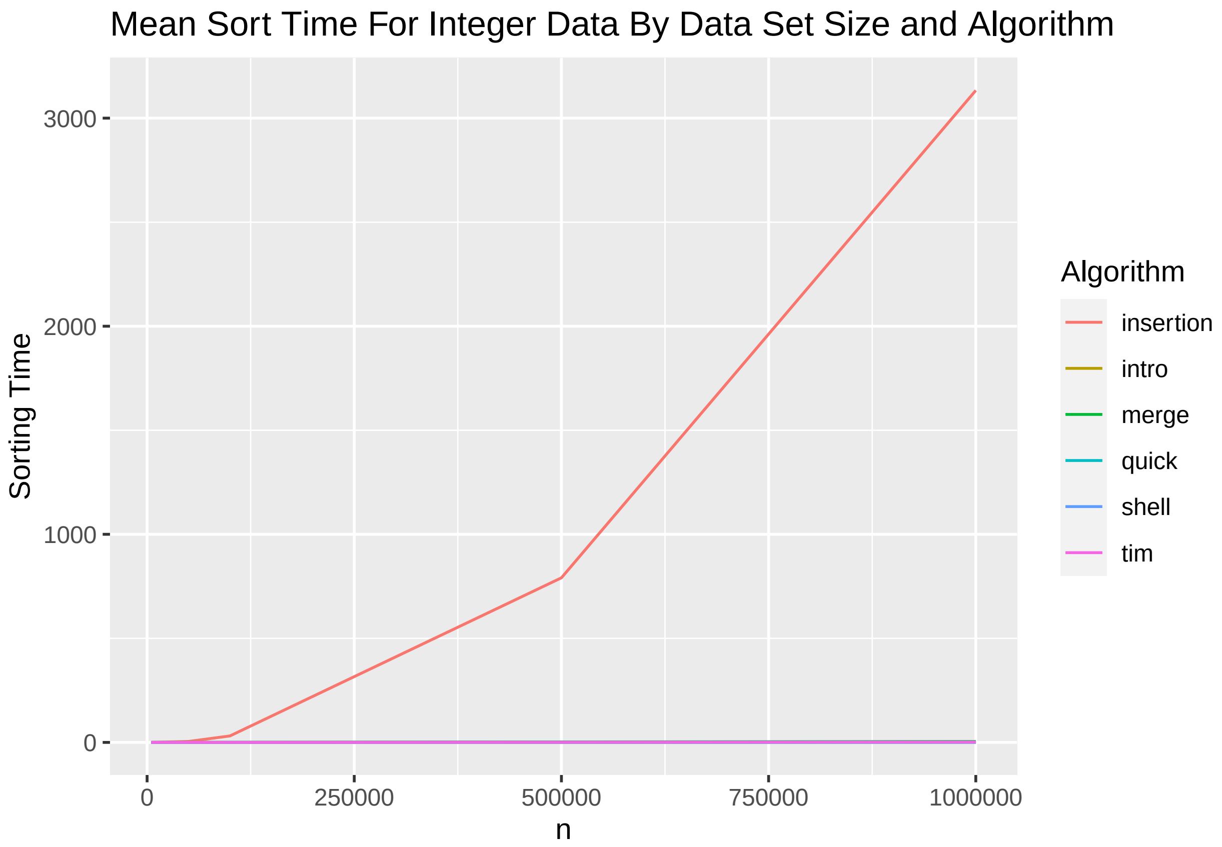


Algorithm Comparison

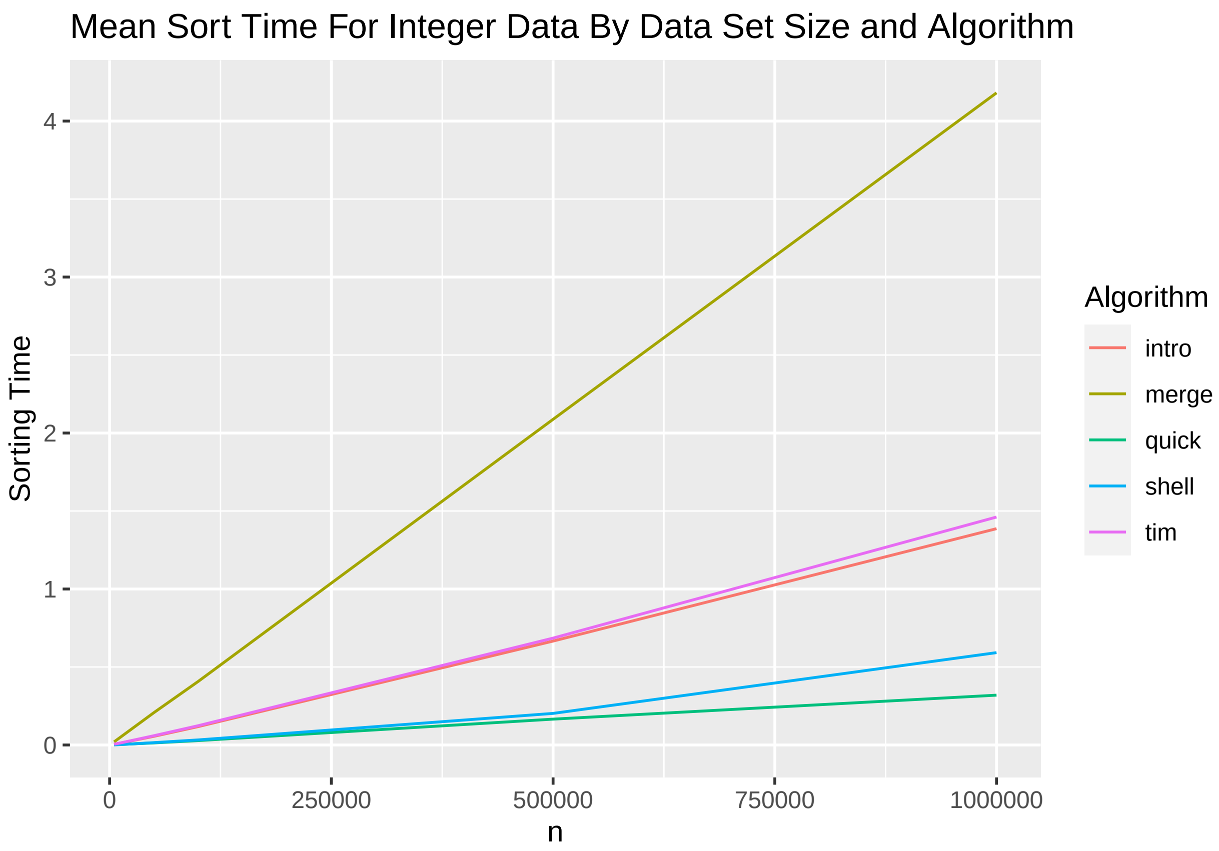
```
data2 = matrix(ncol = 5, nrow = 360)
for (i in 1:6) {
  for (j in 1:60) {
    data2[i * j, 1] = data[j, 1]
    data2[i * j, 2] = data[j, 2]
    data2[i * j, 3] = data[j, 3]
    data2[i * j, 4] = data[j, 3 + i]
    if (i == 1) {
      data2[i * j, 5] = "insertion"
    } else if (i == 2) {
      data2[i * j, 5] = "quick"
    } else if (i == 3) {
      data2[i * j, 5] = "merge"
    } else if (i == 4) {
      data2[i * j, 5] = "shell"
    } else if (i == 5) {
      data2[i * j, 5] = "intro"
    } else {
      data2[i * j, 5] = "tim"
    }
  }
}
```

```r
data2 = data.frame(data2)
colnames(data2) = c("var_type", "size", "format", "time", "algorithm")
data2 = transform(data2, time = as.numeric(time))
data2 = transform(data2, size = as.numeric(size))
```

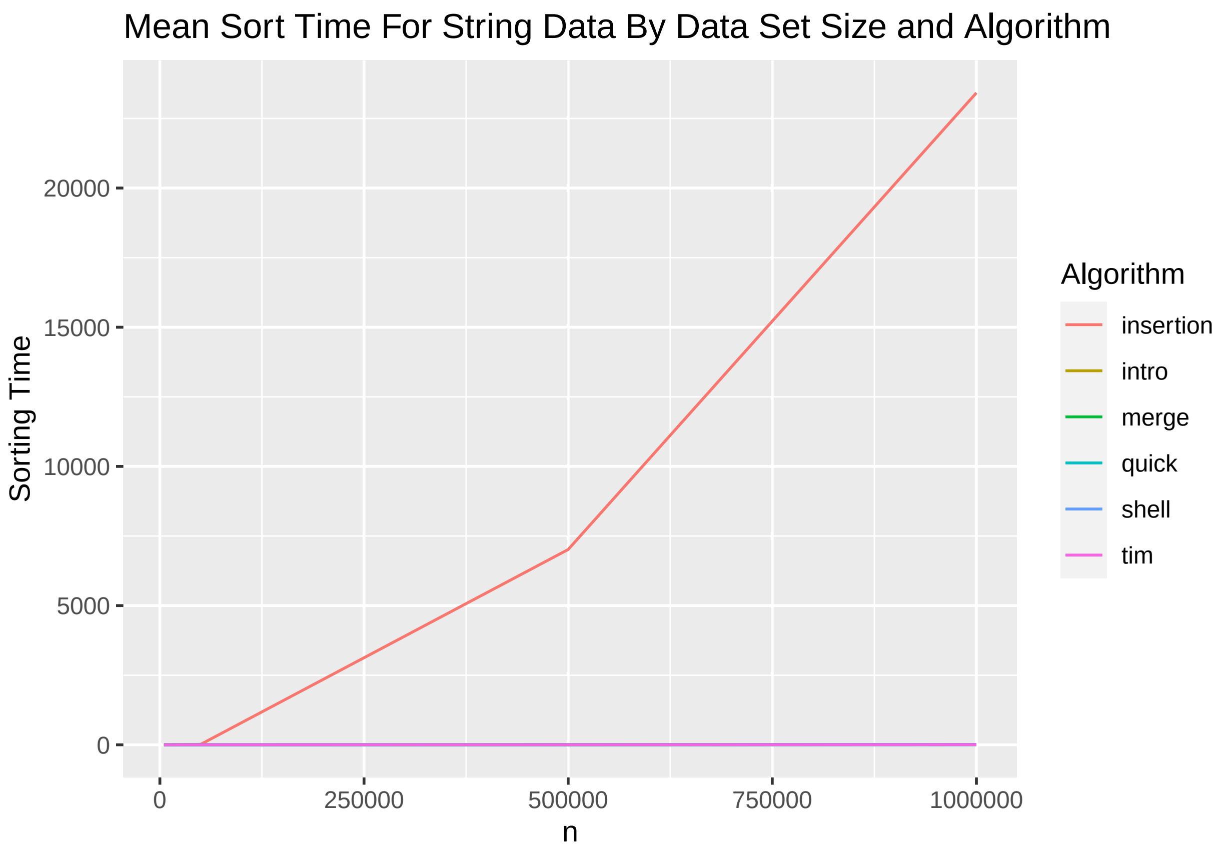
```r
integerData = subset(data2, var_type == "int")
integerTimes = aggregate(time ~ algorithm + size, data = integerData, FUN = mean)
ggplot(integerTimes, aes(x = size, y = time, color = algorithm)) +
  geom_line() +
  labs(title = "Mean Sort Time For Integer Data By Data Set Size and Algorithm", x = "n", y = "Sorting
  guides(color = guide_legend(title = "Algorithm"))
```



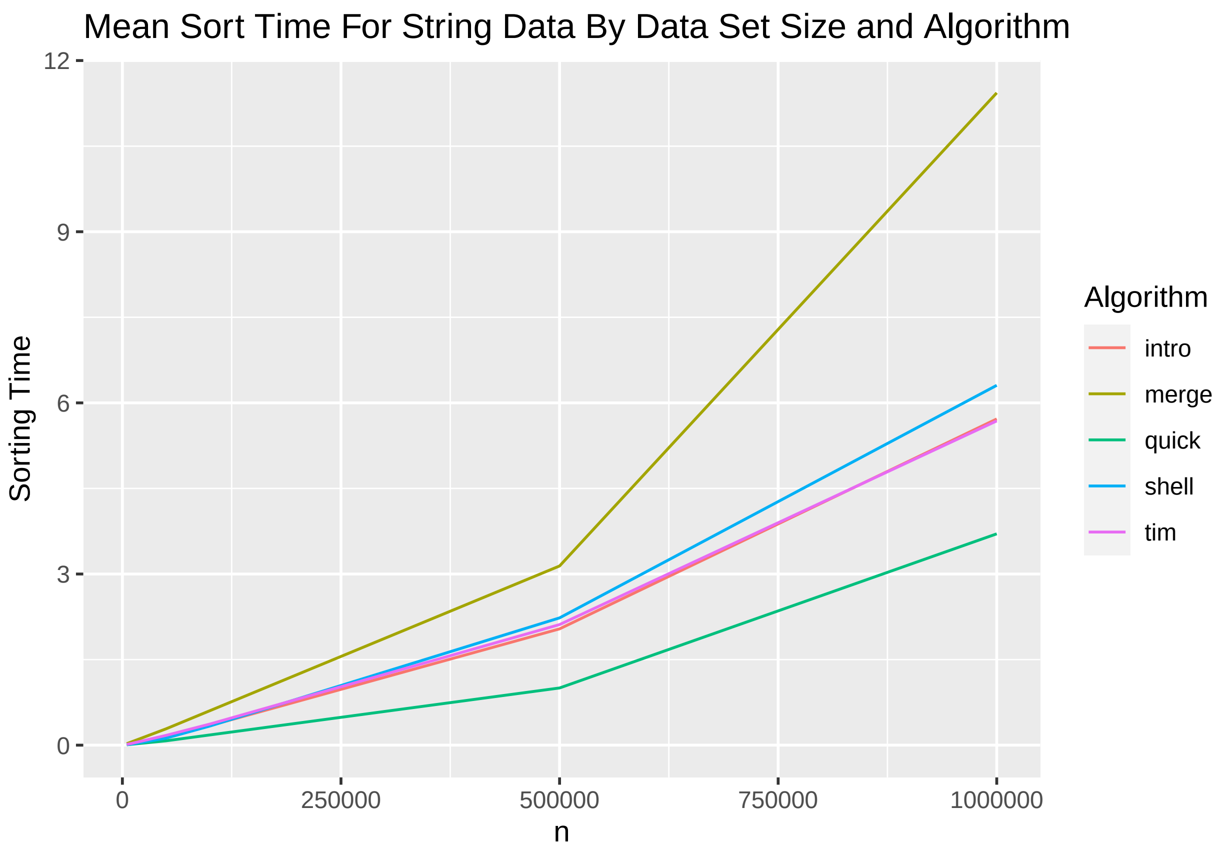
```r
integerTimes2 = subset(integerTimes, algorithm != "insertion")
ggplot(integerTimes2, aes(x = size, y = time, color = algorithm)) +
  geom_line() +
  labs(title = "Mean Sort Time For Integer Data By Data Set Size and Algorithm", x = "n", y = "Sorting
  guides(color = guide_legend(title = "Algorithm"))
```



```
stringData = subset(data2, var_type == "string")
stringTimes = aggregate(time ~ algorithm + size, data = stringData, FUN = mean)
ggplot(stringTimes, aes(x = size, y = time, color = algorithm)) +
  geom_line() +
  labs(title = "Mean Sort Time For String Data By Data Set Size and Algorithm", x = "n", y = "Sorting Ti
  guides(color = guide_legend(title = "Algorithm"))
```



```
stringTimes2 = subset(stringTimes, algorithm != "insertion")
ggplot(stringTimes2, aes(x = size, y = time, color = algorithm)) +
  geom_line() +
  labs(title = "Mean Sort Time For String Data By Data Set Size and Algorithm", x = "n", y = "Sorting Ti
  guides(color = guide_legend(title = "Algorithm"))
```


Mean Sort Time For String Data By Data Set Size and Algorithm
12
9
6
3
0
Sorting Time
0
250000
500000
750000
1000000
n
Algorithm
intro
merge
quick
shell
tim