STAT 321

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STAT 321-001

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Exercise 3a

```
rm(list=ls())
r <- rep(0,4)
r[1] <- ceiling(6*runif(1))
r[2] <- ceiling(6*runif(1))
r[3] <- ceiling(6*runif(1))
r[4] <- ceiling(6*runif(1))
print(r[1])
```

```
## [1] 5
```

```
print(r[2])
```

```
## [1] 3
```

```
print(r[3])
```

```
## [1] 3
```

```
print(r[4])
```

```
## [1] 3
```

```
if (r[1] == 6 | r[2] == 6 | r[3] == 6 | r[4] == 6){
  cat("You won. Nice!")
} else {
  cat("You lost. Sad!")
}
```

```
## You lost. Sad!
```

Exercise 3b

```
rm(list=ls())
library(purrr)
sixes <- function(n = 4){
  i <- 1
  r <- rep(0,n)
  x <- rep(0,n)
  while (i <= n){
    r[i] <- ceiling(6*runif(1))
```

```
    print(r[i])
    i <- i + 1
  }
  has_element(r,6)
}
sixes()
```

```
## [1] 6
## [1] 3
## [1] 5
## [1] 2
```

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

Exercise 3c

Part 1

```
rm(list=ls())
sixes <- function(n = 4){
  i <- 1
  r <- rep(0,n)
  x <- rep(0,n)
  while (i <= n){
    r[i] <- ceiling(6*runif(1)) # Did not print rolls to prevent 33,300 rolls from being printed
    i <- i + 1
  }
  has_element(r,6)
}
sixesN <- function(n = 4,N = 3){ # Roll four dice three times by default
  cat("Proportion:", mean(replicate(N,sixes(n))))
}
sixesN()
```

```
## Proportion: 0.3333333
```

```
sixesN(4,100)
```

```
## Proportion: 0.53
```

```
sixesN(4,100)
```

```
## Proportion: 0.5
```

```
sixesN(4,100)
```

```
## Proportion: 0.63
```

```
sixesN(4,1000)
```

```
## Proportion: 0.546
```

```
sixesN(4,1000)
```

```
## Proportion: 0.509
```

```
sixesN(4,1000)
```

```
## Proportion: 0.541
```

```
sixesN(4,10000)
```

```
## Proportion: 0.5167
```

```
sixesN(4,10000)
```

```
## Proportion: 0.5242
```

```
sixesN(4,10000)
```

```
## Proportion: 0.511
```

```
# The variability decreases as N increases.
```

Part 2

```
rm(list=ls())
sixes <- function(n = 4){
  i <- 1
  r <- rep(0,n)
  x <- rep(0,n)
  while (i <= n){
    r[i] <- ceiling(6*runif(1)) # Did not print rolls to prevent 11,100 rolls from being printed
    i <- i + 1
  }
  has_element(r,6)
}
sixesN <- function(n = 4,N = 3){
  est <- mean(replicate(N,sixes(n))) # "Simulation estimate"
  cat("Estimate:", est, "\n")
  p <- 1 - (5/6)^n                   # "Theoretical probability"
  cat("Probability:", p, "\n")
  cat("Difference:", abs(p - est))
}
sixesN()
```

```
## Estimate: 0.6666667
## Probability: 0.5177469
## Difference: 0.1489198
```

```
sixesN(4,100)
```

```
## Estimate: 0.59
## Probability: 0.5177469
## Difference: 0.07225309
```

```
sixesN(4,1000)
```

```
## Estimate: 0.52
## Probability: 0.5177469
## Difference: 0.002253086
```

```
sixesN(4,10000)
```

```
## Estimate: 0.5115
## Probability: 0.5177469
## Difference: 0.006246914
```

```
# The accuracy increases as N increases.
```

Exercise 3d

```
rm(list=ls())
library(car)
library(plyr)
library(rio)
sixes <- function(n = 4){
  i <- 1
  r <- rep(0,n)
  x <- rep(0,n)
  while (i <= n){
    r[i] <- ceiling(6*runif(1))
    i <- i + 1
  }
  has_element(r,6)
}
sixesN <- function(n = 4,N = 3){
  Export(data.frame(replicate(N,sixes(n))),"sixes_sim.txt") # Creating .txt file without printing resul
}
sixesN(4,11103) # "N" not specified, so I chose 11,103 = 3 + 100 + 1,000 + 10,000

data <- read.table(file="/Users/newuser/Desktop/Notes/Undergraduate/STAT 321 - Modeling and Simulation/s
m <- count(data)/lengths(data) # Manually calculating the mean
m[2,2]
```

```
## [1] 0.5209403
```

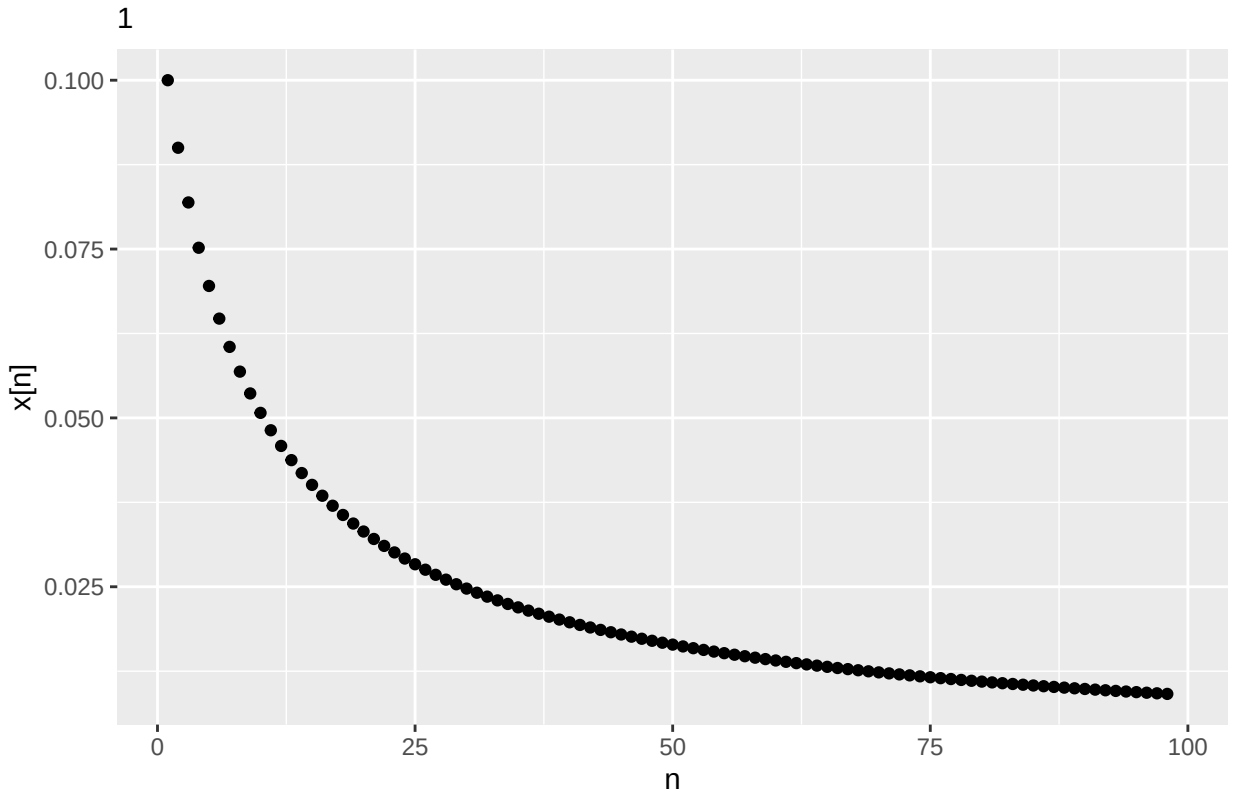
Exercise 5

```
rm(list=ls())
library(ggplot2)
library(gridExtra)
sys <- function(x1 = 0.1,r = 1,n = 99){
x <- rep(NA,n)
  for (i in 1:n){
    if (i == 1) {
      x[1] = x1
      print(x[i])
    } else if (i == n) {
      print(x[i])
      cat("\n") # Separate each run of the function
      } else {
        x[i] = r*x[i-1]*(1 - x[i-1])
        print(x[i])
      }
    }
return(ggplot(data.frame(X = c(1:n), Y = x),aes(X,Y))+geom_point()+ylab("x[n]")+xlab("n")+ggtitle("",su
}
sys()
```

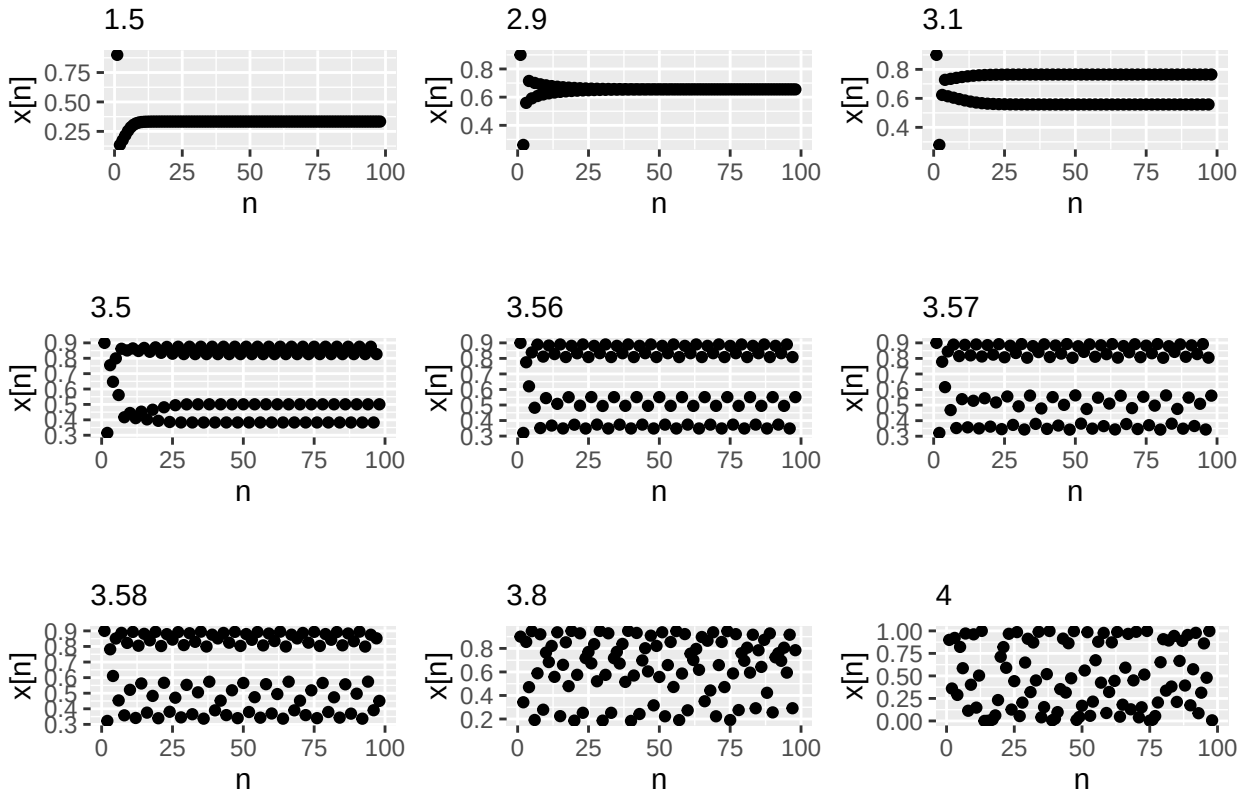
```
## [1] 0.1
```

```
## [1] 0.09
## [1] 0.0819
## [1] 0.07519239
## [1] 0.06953849
## [1] 0.06470289
## [1] 0.06051643
## [1] 0.05685419
## [1] 0.05362179
## [1] 0.05074649
## [1] 0.04817129
## [1] 0.04585081
## [1] 0.04374852
## [1] 0.04183458
## [1] 0.04008445
## [1] 0.03847769
## [1] 0.03699716
## [1] 0.03562837
## [1] 0.03435899
## [1] 0.03317845
## [1] 0.03207764
## [1] 0.03104866
## [1] 0.03008464
## [1] 0.02917956
## [1] 0.02832811
## [1] 0.02752563
## [1] 0.02676797
## [1] 0.02605144
## [1] 0.02537277
## [1] 0.02472899
## [1] 0.02411747
## [1] 0.02353581
## [1] 0.02298188
## [1] 0.02245371
## [1] 0.02194954
## [1] 0.02146776
## [1] 0.0210069
## [1] 0.02056561
## [1] 0.02014266
## [1] 0.01973694
## [1] 0.01934739
## [1] 0.01897307
## [1] 0.01861309
## [1] 0.01826664
## [1] 0.01793297
## [1] 0.01761138
## [1] 0.01730122
## [1] 0.01700189
## [1] 0.01671282
## [1] 0.01643351
## [1] 0.01616345
## [1] 0.01590219
## [1] 0.01564931
## [1] 0.01540441
## [1] 0.01516711
```

```
## [1] 0.01493707
## [1] 0.01471395
## [1] 0.01449745
## [1] 0.01428728
## [1] 0.01408315
## [1] 0.01388482
## [1] 0.01369203
## [1] 0.01350456
## [1] 0.01332218
## [1] 0.0131447
## [1] 0.01297192
## [1] 0.01280365
## [1] 0.01263972
## [1] 0.01247995
## [1] 0.0123242
## [1] 0.01217232
## [1] 0.01202415
## [1] 0.01187957
## [1] 0.01173845
## [1] 0.01160066
## [1] 0.01146608
## [1] 0.01133461
## [1] 0.01120614
## [1] 0.01108056
## [1] 0.01095778
## [1] 0.01083771
## [1] 0.01072025
## [1] 0.01060533
## [1] 0.01049286
## [1] 0.01038276
## [1] 0.01027495
## [1] 0.01016938
## [1] 0.01006596
## [1] 0.009964639
## [1] 0.009865345
## [1] 0.00976802
## [1] 0.009672606
## [1] 0.009579047
## [1] 0.009487289
## [1] 0.00939728
## [1] 0.009308971
## [1] 0.009222314
## [1] 0.009137263
## [1] NA
```




```
grid.arrange(sys(0.9,1.5),sys(0.9,2.9),sys(0.9,3.1),sys(0.9,3.5),sys(0.9,3.56),sys(0.9,3.57),sys(0.9,3.5
```




```
## [1] 0.9
## [1] 0.135
```

```
## [1] 0.1751625
## [1] 0.2167209
## [1] 0.2546294
## [1] 0.2846899
## [1] 0.3054624
## [1] 0.3182327
## [1] 0.3254409
## [1] 0.3292937
## [1] 0.331289
## [1] 0.3323049
## [1] 0.3328175
## [1] 0.333075
## [1] 0.3332041
## [1] 0.3332687
## [1] 0.333301
## [1] 0.3333172
## [1] 0.3333252
## [1] 0.3333293
## [1] 0.3333313
## [1] 0.3333323
## [1] 0.3333328
## [1] 0.3333331
## [1] 0.3333332
## [1] 0.3333333
## [1] 0.3333333
## [1] 0.3333333
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## [1] 0.3333333
```

```
## [1] 0.3333333
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## [1] 0.3333333
## [1] 0.3333333
## [1] 0.3333333
## [1] 0.3333333
## [1] 0.3333333
## [1] 0.3333333
## [1] NA
##
## [1] 0.9
## [1] 0.261
## [1] 0.5593491
## [1] 0.7147853
## [1] 0.5912151
## [1] 0.7008714
## [1] 0.6079869
## [1] 0.6911826
## [1] 0.6190027
## [1] 0.6839312
```

```
## [1] 0.626891
## [1] 0.6783062
## [1] 0.6328001
## [1] 0.673856
## [1] 0.6373448
## [1] 0.6702955
## [1] 0.6408983
## [1] 0.6674282
## [1] 0.6437066
## [1] 0.6651104
## [1] 0.6459418
## [1] 0.6632329
## [1] 0.6477296
## [1] 0.6617103
## [1] 0.6491644
## [1] 0.660475
## [1] 0.6503186
## [1] 0.6594726
## [1] 0.6512487
## [1] 0.6586591
## [1] 0.6519991
## [1] 0.6579992
## [1] 0.6526051
## [1] 0.6574638
## [1] 0.6530949
## [1] 0.6570297
## [1] 0.6534909
## [1] 0.6566776
## [1] 0.6538112
## [1] 0.6563921
## [1] 0.6540703
## [1] 0.6561608
## [1] 0.6542801
## [1] 0.6559732
## [1] 0.6544498
## [1] 0.6558212
## [1] 0.6545873
## [1] 0.6556981
## [1] 0.6546985
## [1] 0.6555983
## [1] 0.6547886
## [1] 0.6555174
## [1] 0.6548616
## [1] 0.6554519
## [1] 0.6549207
## [1] 0.6553988
## [1] 0.6549685
## [1] 0.6553558
## [1] 0.6550073
## [1] 0.655321
## [1] 0.6550387
## [1] 0.6552927
## [1] 0.6550641
## [1] 0.6552699
```

```
## [1] 0.6550847
## [1] 0.6552514
## [1] 0.6551013
## [1] 0.6552364
## [1] 0.6551148
## [1] 0.6552242
## [1] 0.6551258
## [1] 0.6552144
## [1] 0.6551346
## [1] 0.6552064
## [1] 0.6551418
## [1] 0.6551999
## [1] 0.6551476
## [1] 0.6551947
## [1] 0.6551523
## [1] 0.6551905
## [1] 0.6551562
## [1] 0.655187
## [1] 0.6551592
## [1] 0.6551843
## [1] 0.6551617
## [1] 0.655182
## [1] 0.6551638
## [1] 0.6551802
## [1] 0.6551654
## [1] 0.6551787
## [1] 0.6551667
## [1] 0.6551775
## [1] 0.6551678
## [1] 0.6551765
## [1] 0.6551687
## [1] 0.6551758
## [1] 0.6551694
## [1] 0.6551751
## [1] NA
##
## [1] 0.9
## [1] 0.279
## [1] 0.6235929
## [1] 0.7276469
## [1] 0.6143484
## [1] 0.7344658
## [1] 0.60458
## [1] 0.7410954
## [1] 0.5948064
## [1] 0.7471364
## [1] 0.5856631
## [1] 0.7522517
## [1] 0.5777442
## [1] 0.7562631
## [1] 0.5714206
## [1] 0.7591872
## [1] 0.5667482
## [1] 0.7611885
```

```
## [1] 0.5635197
## [1] 0.7624923
## [1] 0.5614032
## [1] 0.7633119
## [1] 0.5600672
## [1] 0.763815
## [1] 0.5592451
## [1] 0.764119
## [1] 0.5587475
## [1] 0.7643011
## [1] 0.5584493
## [1] 0.7644094
## [1] 0.5582718
## [1] 0.7644736
## [1] 0.5581665
## [1] 0.7645117
## [1] 0.5581041
## [1] 0.7645341
## [1] 0.5580673
## [1] 0.7645474
## [1] 0.5580455
## [1] 0.7645552
## [1] 0.5580326
## [1] 0.7645599
## [1] 0.558025
## [1] 0.7645626
## [1] 0.5580206
## [1] 0.7645642
## [1] 0.5580179
## [1] 0.7645652
## [1] 0.5580164
## [1] 0.7645657
## [1] 0.5580154
## [1] 0.764566
## [1] 0.5580149
## [1] 0.7645662
## [1] 0.5580146
## [1] 0.7645664
## [1] 0.5580144
## [1] 0.7645664
## [1] 0.5580143
## [1] 0.7645665
## [1] 0.5580142
## [1] 0.7645665
## [1] 0.5580142
## [1] 0.7645665
## [1] 0.5580142
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
```

```
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] 0.5580141
## [1] 0.7645665
## [1] NA
##
## [1] 0.9
## [1] 0.315
## [1] 0.7552125
## [1] 0.647033
## [1] 0.7993345
## [1] 0.561396
## [1] 0.8618069
## [1] 0.4168353
## [1] 0.8507927
## [1] 0.4443057
## [1] 0.8641435
## [1] 0.4108983
## [1] 0.8472131
## [1] 0.4530507
## [1] 0.8672852
## [1] 0.4028556
## [1] 0.8419704
## [1] 0.465697
## [1] 0.8708816
## [1] 0.3935641
## [1] 0.8353499
## [1] 0.4813916
## [1] 0.8737881
## [1] 0.3859887
## [1] 0.829505
## [1] 0.4949926
```

```
## [1] 0.8749122
## [1] 0.3830428
## [1] 0.8271236
## [1] 0.5004656
## [1] 0.8749992
## [1] 0.3828145
## [1] 0.8269364
## [1] 0.500894
## [1] 0.8749972
## [1] 0.3828198
## [1] 0.8269408
## [1] 0.5008839
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
```

```
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] 0.8749973
## [1] 0.3828197
## [1] 0.8269407
## [1] 0.5008842
## [1] NA
##
## [1] 0.9
## [1] 0.3204
## [1] 0.7751681
## [1] 0.6204458
## [1] 0.8383544
## [1] 0.4824381
## [1] 0.888902
## [1] 0.3515686
## [1] 0.8115665
## [1] 0.5444177
## [1] 0.8829764
## [1] 0.3678516
## [1] 0.827831
## [1] 0.5073954
## [1] 0.8898053
## [1] 0.3490645
## [1] 0.8088978
## [1] 0.5503125
## [1] 0.8809884
## [1] 0.3732583
## [1] 0.8328141
## [1] 0.4956759
## [1] 0.8899334
## [1] 0.3487088
## [1] 0.8085151
## [1] 0.5511537
## [1] 0.8806846
## [1] 0.3740822
## [1] 0.8335551
## [1] 0.4939178
## [1] 0.8898683
## [1] 0.3488896
## [1] 0.8087097
## [1] 0.550726
```

```
## [1] 0.8808397
## [1] 0.3736616
## [1] 0.8331775
## [1] 0.4948142
## [1] 0.8899043
## [1] 0.3487898
## [1] 0.8086023
## [1] 0.5509621
## [1] 0.8807542
## [1] 0.3738934
## [1] 0.8333857
## [1] 0.4943201
## [1] 0.8898851
## [1] 0.3488429
## [1] 0.8086594
## [1] 0.5508365
## [1] 0.8807997
## [1] 0.37377
## [1] 0.8332749
## [1] 0.494583
## [1] 0.8898955
## [1] 0.348814
## [1] 0.8086284
## [1] 0.5509047
## [1] 0.880775
## [1] 0.373837
## [1] 0.8333351
## [1] 0.4944402
## [1] 0.88989
## [1] 0.3488295
## [1] 0.8086451
## [1] 0.5508681
## [1] 0.8807883
## [1] 0.373801
## [1] 0.8333028
## [1] 0.4945169
## [1] 0.889893
## [1] 0.3488212
## [1] 0.808636
## [1] 0.5508879
## [1] 0.8807811
## [1] 0.3738205
## [1] 0.8333203
## [1] 0.4944754
## [1] 0.8898913
## [1] 0.3488257
## [1] 0.8086409
## [1] 0.5508772
## [1] 0.880785
## [1] 0.37381
## [1] 0.8333109
## [1] 0.4944978
## [1] 0.8898922
## [1] 0.3488232
```

```
## [1] 0.8086383
## [1] 0.550883
## [1] 0.8807829
## [1] 0.3738157
## [1] 0.8333159
## [1] 0.4944857
## [1] 0.8898918
## [1] 0.3488245
## [1] 0.8086397
## [1] 0.5508799
## [1] NA
##
## [1] 0.9
## [1] 0.3213
## [1] 0.7784967
## [1] 0.6156093
## [1] 0.8447851
## [1] 0.4681098
## [1] 0.8888694
## [1] 0.3526468
## [1] 0.8149847
## [1] 0.5383012
## [1] 0.8872629
## [1] 0.357098
## [1] 0.8195971
## [1] 0.5278519
## [1] 0.8897306
## [1] 0.3502528
## [1] 0.8124455
## [1] 0.5439888
## [1] 0.885592
## [1] 0.3617081
## [1] 0.824225
## [1] 0.5172149
## [1] 0.891442
## [1] 0.3454801
## [1] 0.8072613
## [1] 0.5554581
## [1] 0.8815201
## [1] 0.3728594
## [1] 0.8347919
## [1] 0.4923543
## [1] 0.8922913
## [1] 0.3431039
## [1] 0.8046195
## [1] 0.5612289
## [1] 0.8791161
## [1] 0.3793873
## [1] 0.8405657
## [1] 0.4784336
## [1] 0.8908396
## [1] 0.3471627
## [1] 0.8091075
## [1] 0.5513957
```

```
## [1] 0.8830698
## [1] 0.3686294
## [1] 0.8308881
## [1] 0.5016316
## [1] 0.8924905
## [1] 0.3425458
## [1] 0.8039932
## [1] 0.5625896
## [1] 0.8785147
## [1] 0.3810141
## [1] 0.8419572
## [1] 0.4750429
## [1] 0.8902764
## [1] 0.348733
## [1] 0.8108124
## [1] 0.5476226
## [1] 0.8844036
## [1] 0.364975
## [1] 0.8274127
## [1] 0.5097994
## [1] 0.8921572
## [1] 0.3434795
## [1] 0.8050398
## [1] 0.5603142
## [1] 0.8795131
## [1] 0.3783123
## [1] 0.8396358
## [1] 0.4806916
## [1] 0.8911691
## [1] 0.3462428
## [1] 0.8081006
## [1] 0.5536142
## [1] 0.8822381
## [1] 0.3709017
## [1] 0.8330011
## [1] 0.4966237
## [1] 0.8924593
## [1] 0.3426332
## [1] 0.8040914
## [1] 0.5623764
## [1] 0.8786098
## [1] 0.380757
## [1] 0.8417385
## [1] 0.4755768
## [1] 0.8903705
## [1] 0.3484708
## [1] 0.8105288
## [1] 0.5482514
## [1] 0.8841883
## [1] 0.3655656
## [1] 0.8279808
## [1] 0.50847
## [1] 0.8922439
## [1] 0.3432367
```

```
## [1] 0.8047682
## [1] 0.5609053
## [1] NA
##
## [1] 0.9
## [1] 0.3222
## [1] 0.781826
## [1] 0.6106552
## [1] 0.8511644
## [1] 0.4535272
## [1] 0.8872682
## [1] 0.3580836
## [1] 0.8228979
## [1] 0.5217384
## [1] 0.8933082
## [1] 0.3412049
## [1] 0.8047271
## [1] 0.5625662
## [1] 0.880986
## [1] 0.3753619
## [1] 0.8393859
## [1] 0.4826456
## [1] 0.8939218
## [1] 0.3394757
## [1] 0.8027504
## [1] 0.5668651
## [1] 0.878994
## [1] 0.3807814
## [1] 0.8441172
## [1] 0.4710684
## [1] 0.8920034
## [1] 0.3448733
## [1] 0.8088498
## [1] 0.5535102
## [1] 0.8847492
## [1] 0.3650455
## [1] 0.8297985
## [1] 0.505614
## [1] 0.8948872
## [1] 0.3367496
## [1] 0.7995905
## [1] 0.573679
## [1] 0.8755656
## [1] 0.3900427
## [1] 0.8517156
## [1] 0.4521401
## [1] 0.8867998
## [1] 0.3593817
## [1] 0.8242108
## [1] 0.5186966
## [1] 0.8937486
## [1] 0.3399642
## [1] 0.803311
## [1] 0.5656487
```

```
## [1] 0.8795711
## [1] 0.3792143
## [1] 0.8427708
## [1] 0.4743794
## [1] 0.89265
## [1] 0.3430569
## [1] 0.8068205
## [1] 0.5579829
## [1] 0.882964
## [1] 0.3699522
## [1] 0.8344535
## [1] 0.4945443
## [1] 0.8948934
## [1] 0.3367318
## [1] 0.7995697
## [1] 0.5737235
## [1] 0.8755421
## [1] 0.3901058
## [1] 0.8517653
## [1] 0.452015
## [1] 0.8867568
## [1] 0.3595006
## [1] 0.8243305
## [1] 0.5184189
## [1] 0.8937855
## [1] 0.3398602
## [1] 0.8031917
## [1] 0.5659077
## [1] 0.8794491
## [1] 0.3795458
## [1] 0.843057
## [1] 0.4736766
## [1] 0.8925193
## [1] 0.3434243
## [1] 0.8072328
## [1] 0.5570766
## [1] 0.8833373
## [1] 0.368928
## [1] 0.833496
## [1] 0.4968338
## [1] 0.8949641
## [1] 0.336532
## [1] 0.799336
## [1] 0.5742247
## [1] 0.8752767
## [1] 0.3908193
## [1] 0.8523249
## [1] 0.4506044
## [1] NA
##
## [1] 0.9
## [1] 0.342
## [1] 0.8551368
## [1] 0.4707358
```

```
## [1] 0.9467457
## [1] 0.1915894
## [1] 0.5885551
## [1] 0.9202004
## [1] 0.2790401
## [1] 0.7644716
## [1] 0.6842081
## [1] 0.8210561
## [1] 0.5583074
## [1] 0.9370809
## [1] 0.224049
## [1] 0.660634
## [1] 0.8519475
## [1] 0.4793052
## [1] 0.9483726
## [1] 0.1860558
## [1] 0.5754683
## [1] 0.9283572
## [1] 0.2527383
## [1] 0.7176742
## [1] 0.7699482
## [1] 0.6730863
## [1] 0.8361563
## [1] 0.5205959
## [1] 0.9483881
## [1] 0.1860029
## [1] 0.5753422
## [1] 0.9284295
## [1] 0.252503
## [1] 0.7172319
## [1] 0.7706792
## [1] 0.6715845
## [1] 0.8381232
## [1] 0.5155562
## [1] 0.9490804
## [1] 0.1836418
## [1] 0.5696864
## [1] 0.9315465
## [1] 0.242317
## [1] 0.697678
## [1] 0.801509
## [1] 0.6045508
## [1] 0.9084627
## [1] 0.3160014
## [1] 0.8213491
## [1] 0.5575921
## [1] 0.937396
## [1] 0.223002
## [1] 0.6584341
## [1] 0.8546148
## [1] 0.4721437
## [1] 0.9470513
## [1] 0.1905515
## [1] 0.5861182
```

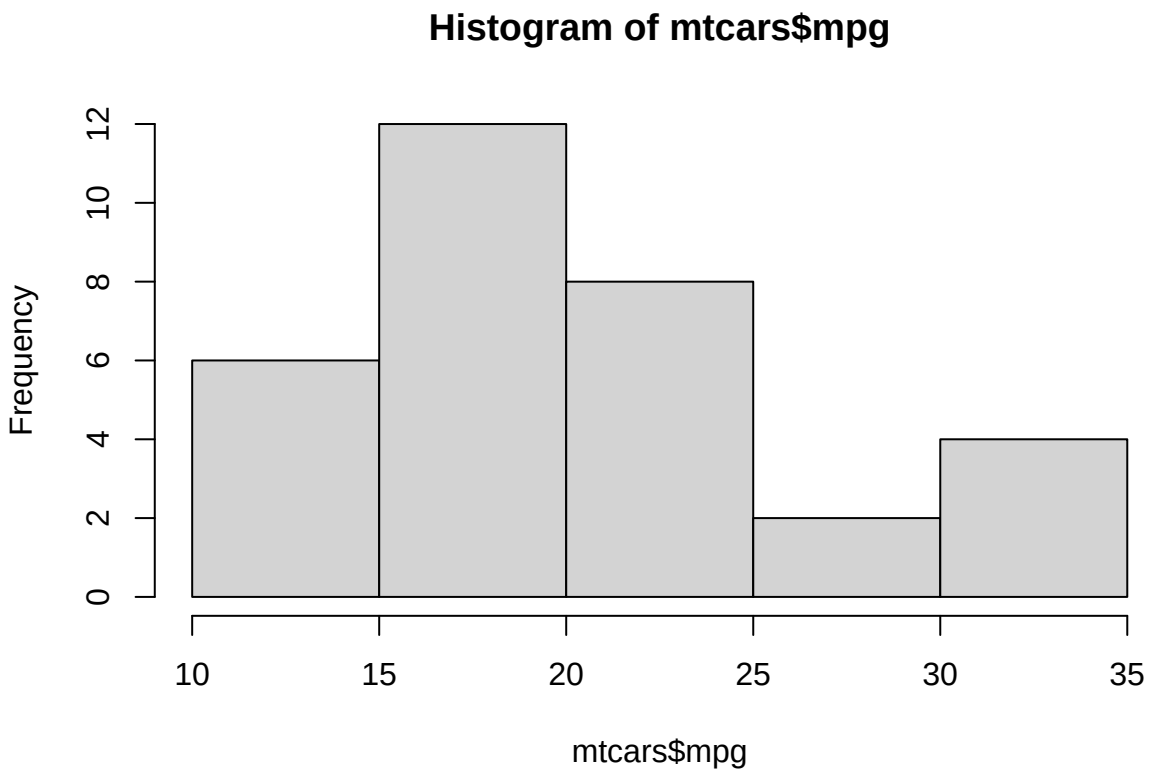
```
## [1] 0.9218179
## [1] 0.2738647
## [1] 0.7556788
## [1] 0.7015878
## [1] 0.795577
## [1] 0.6180101
## [1] 0.8970797
## [1] 0.3508452
## [1] 0.8654608
## [1] 0.442466
## [1] 0.9374214
## [1] 0.2229176
## [1] 0.6582562
## [1] 0.8548289
## [1] 0.4715666
## [1] 0.9469279
## [1] 0.1909709
## [1] 0.5871038
## [1] 0.9211691
## [1] 0.2759429
## [1] 0.759234
## [1] 0.6946315
## [1] 0.8060506
## [1] 0.5940654
## [1] 0.9163764
## [1] 0.2911965
## [1] 0.7843242
## [1] 0.6428071
## [1] 0.8725033
## [1] 0.4227169
## [1] 0.9273038
## [1] 0.2561635
## [1] 0.7240663
## [1] 0.7592183
## [1] 0.6946622
## [1] 0.8060051
## [1] 0.5941712
## [1] 0.9163008
## [1] 0.291436
## [1] 0.784704
## [1] NA
##
## [1] 0.9
## [1] 0.36
## [1] 0.9216
## [1] 0.2890138
## [1] 0.8219392
## [1] 0.5854205
## [1] 0.9708133
## [1] 0.1133392
## [1] 0.4019738
## [1] 0.9615635
## [1] 0.1478366
## [1] 0.5039236
```

```
## [1] 0.9999384
## [1] 0.0002463048
## [1] 0.0009849765
## [1] 0.003936025
## [1] 0.01568213
## [1] 0.06174481
## [1] 0.2317295
## [1] 0.7121239
## [1] 0.8200139
## [1] 0.5903645
## [1] 0.967337
## [1] 0.1263844
## [1] 0.4416454
## [1] 0.986379
## [1] 0.05374198
## [1] 0.2034151
## [1] 0.6481497
## [1] 0.9122067
## [1] 0.3203425
## [1] 0.8708927
## [1] 0.4497544
## [1] 0.9899015
## [1] 0.03998595
## [1] 0.1535483
## [1] 0.5198849
## [1] 0.9984184
## [1] 0.006316538
## [1] 0.02510656
## [1] 0.09790488
## [1] 0.353278
## [1] 0.9138907
## [1] 0.314778
## [1] 0.8627713
## [1] 0.4735879
## [1] 0.9972096
## [1] 0.01113042
## [1] 0.04402615
## [1] 0.1683514
## [1] 0.5600368
## [1] 0.9855823
## [1] 0.05683913
## [1] 0.2144338
## [1] 0.6738077
## [1] 0.8791635
## [1] 0.4249402
## [1] 0.9774641
## [1] 0.08811206
## [1] 0.3213933
## [1] 0.8723986
## [1] 0.4452772
## [1] 0.9880217
## [1] 0.04733943
## [1] 0.1803936
## [1] 0.5914071
```

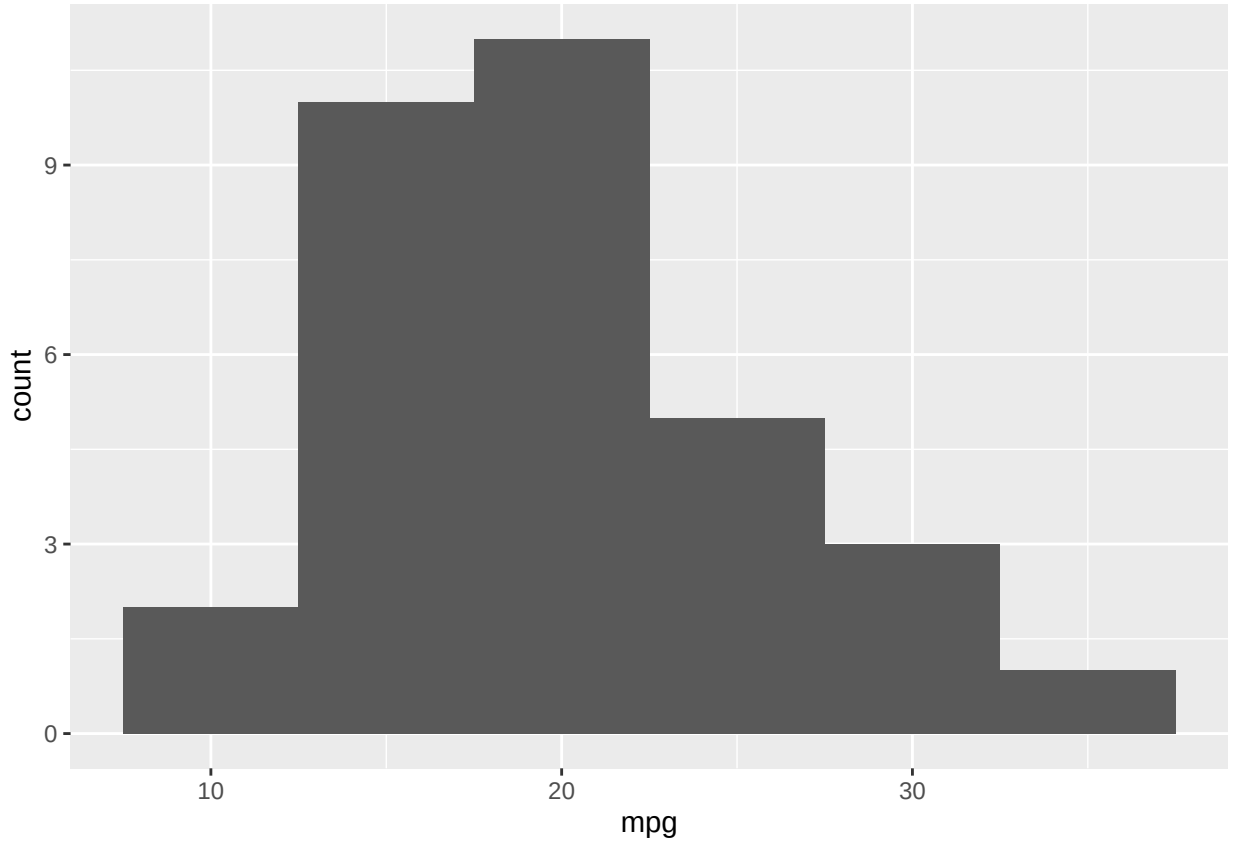
```
## [1] 0.966579
## [1] 0.1292163
## [1] 0.4500778
## [1] 0.9900311
## [1] 0.03947803
## [1] 0.151678
## [1] 0.5146873
## [1] 0.9991371
## [1] 0.003448475
## [1] 0.01374633
## [1] 0.05422948
## [1] 0.2051546
## [1] 0.6522647
## [1] 0.9072618
## [1] 0.3365512
## [1] 0.893138
## [1] 0.3817701
## [1] 0.9440867
## [1] 0.2111479
## [1] 0.6662578
## [1] 0.8894334
## [1] 0.3933666
## [1] 0.9545172
## [1] 0.1736563
## [1] 0.5739993
## [1] 0.9780964
## [1] 0.08569521
## [1] 0.3134062
## [1] 0.860731
## [1] 0.4794926
## [1] 0.9983178
## [1] 0.006717517
## [1] NA
```

Problem 3

```
rm(list=ls())
hist(mtcars$mpg)
```

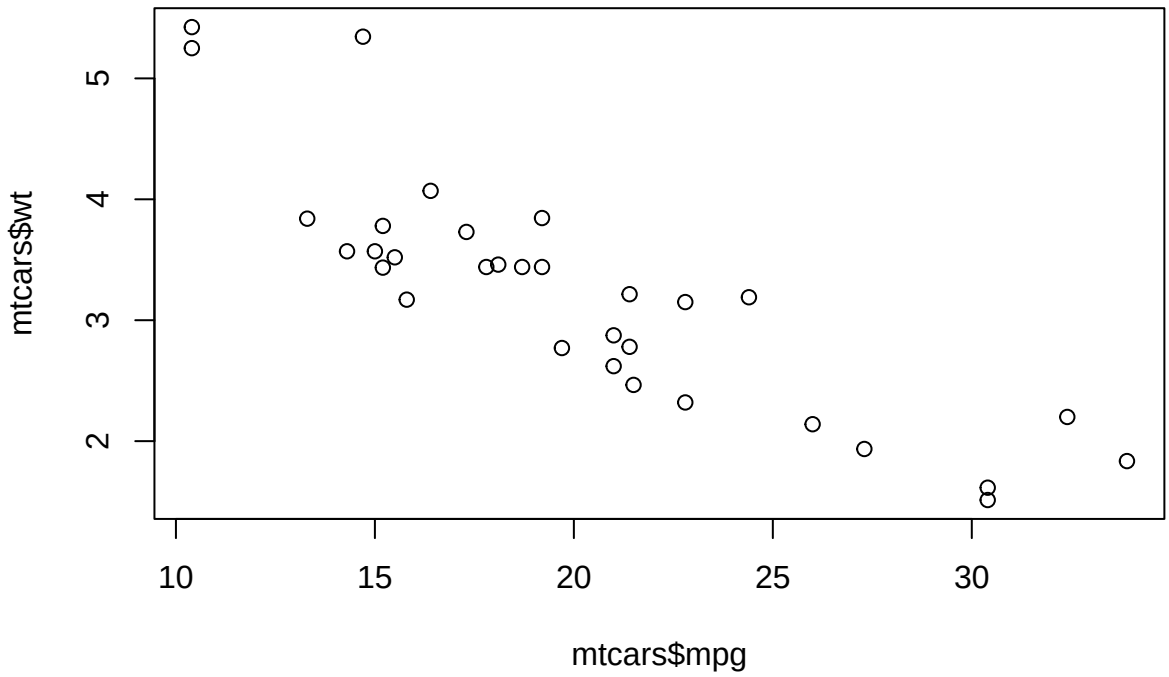



```
library(ggplot2)
ggplot(data=mtcars, aes(mpg))+geom_histogram(binwidth=5) # Arbitrary bin width chosen
```

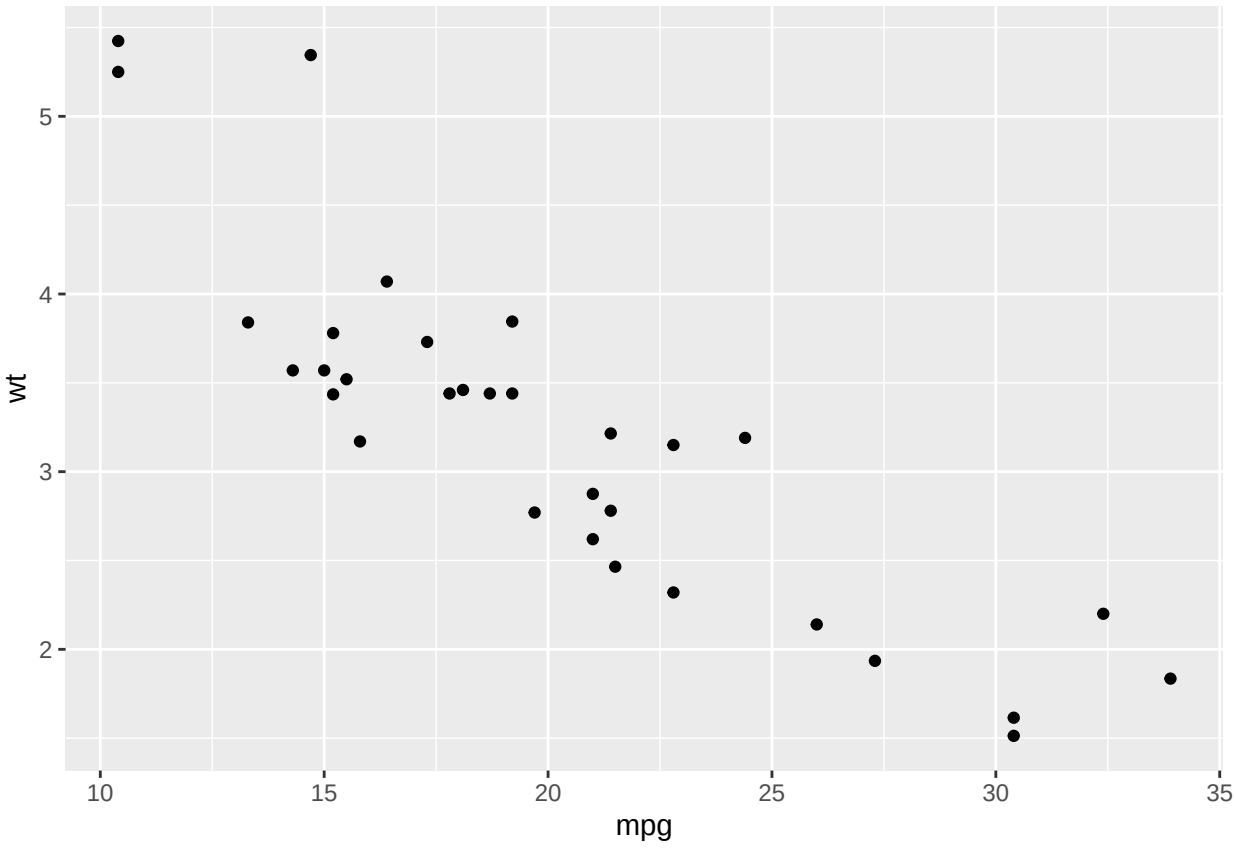


Problem 4

```
rm(list=ls())
plot(mtcars$mpg,mtcars$wt)
```

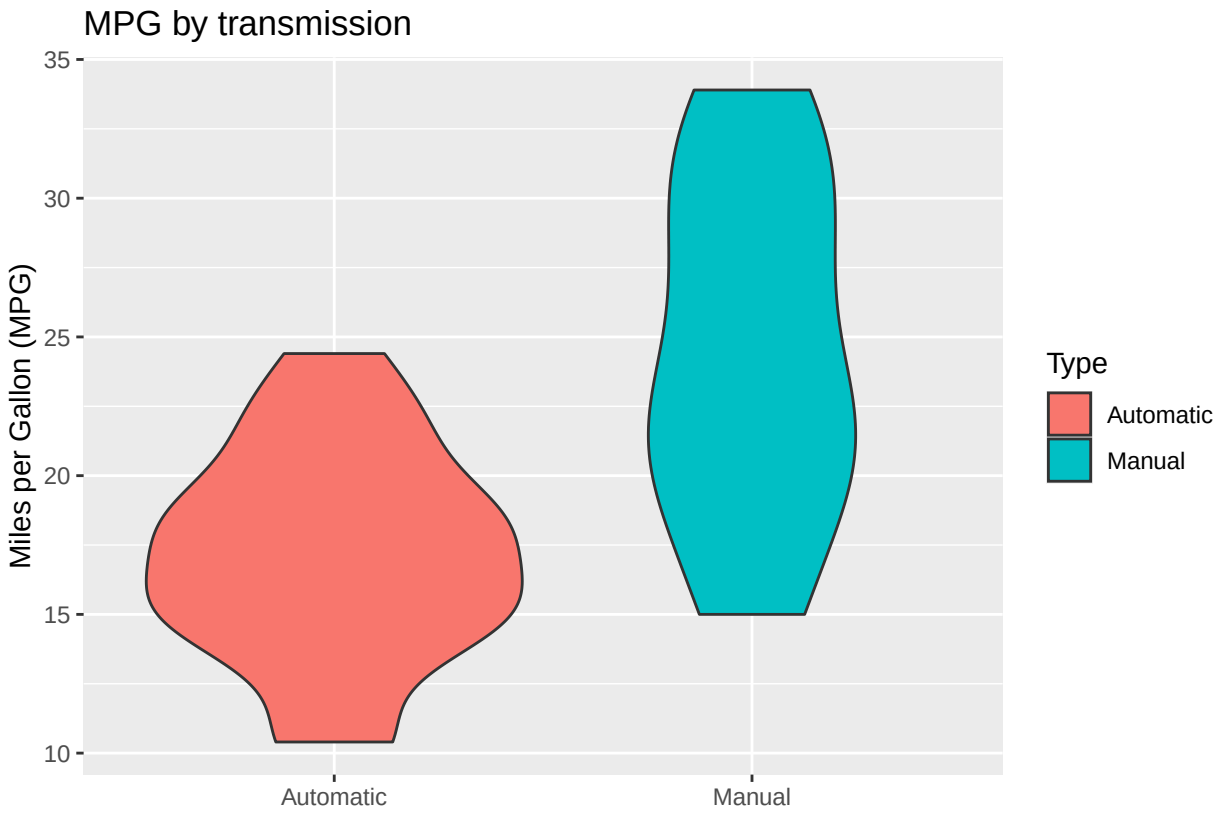



```
library(ggplot2)
ggplot(data=mtcars,aes(mpg,wt))+geom_point()
```

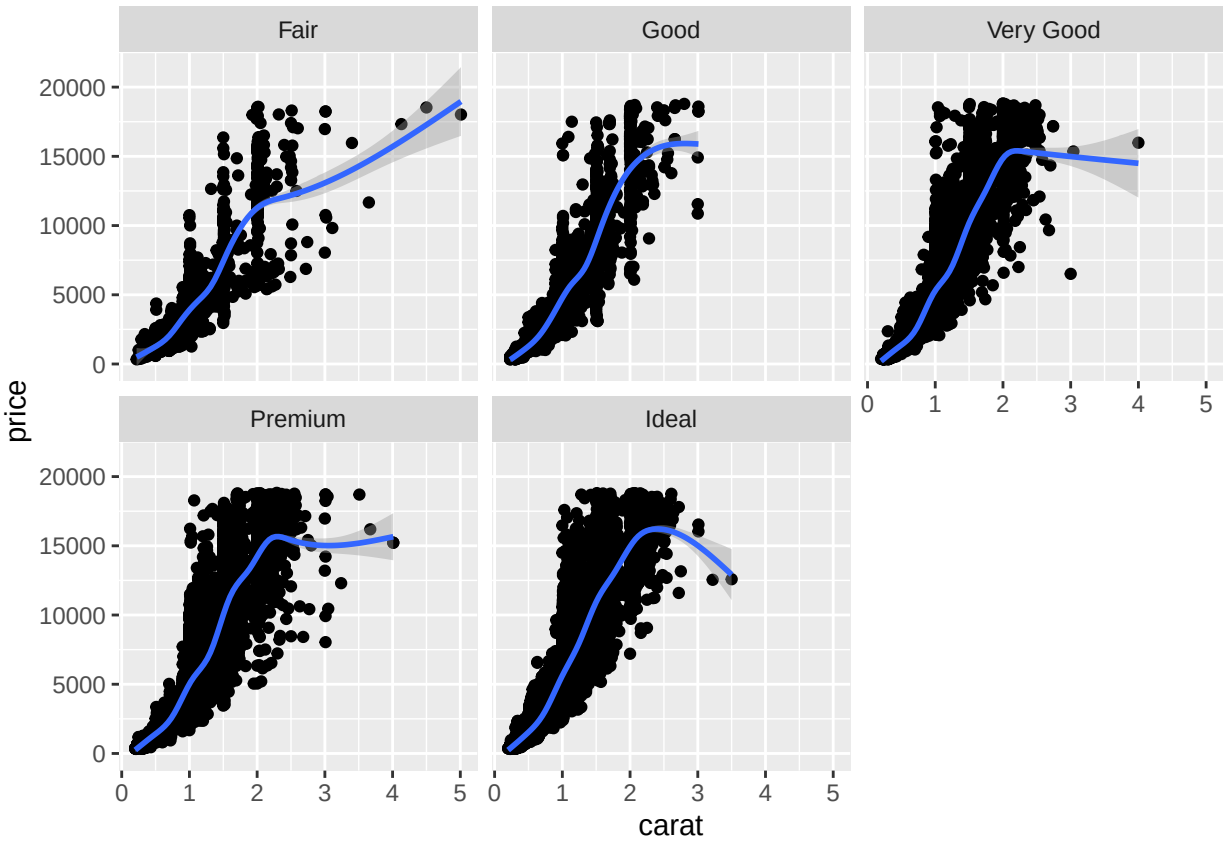


Problem 5

```
rm(list=ls())
ggplot(data=mtcars,aes(factor(am),mpg))+geom_violin(aes(fill=factor(am)))+ylab("Miles per Gallon (MPG)"
```




```
library(dplyr)
ggplot(data=diamonds,aes(carat,price))+geom_point()+geom_smooth()+facet_wrap(~cut)
```


Fair
Good
Very Good
Premium
Ideal
price
carat
20000
15000
10000
5000
0
0
1
2
3
4
5