MA679 Hw3

Jiahao Xu

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4.6 & 4.8 &4.9 in the next page graph!

4.10 (a)

```r
library(ISLR)
summary(Weekly)
```

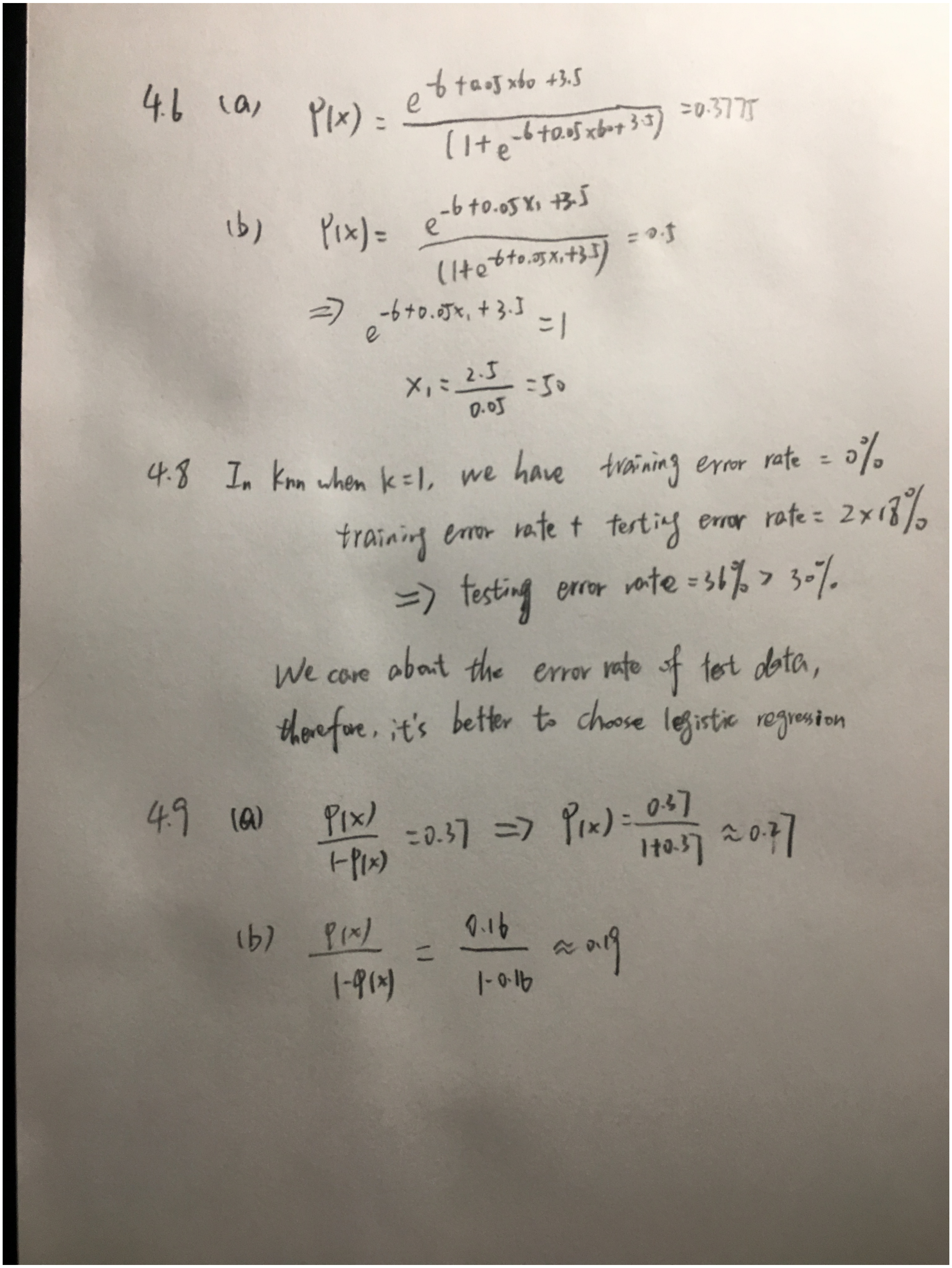
```
##       Year           Lag1               Lag2               Lag3
##  Min.   :1990   Min.   :-18.1950   Min.   :-18.1950   Min.   :-18.1950
##  1st Qu.:1995   1st Qu.: -1.1540   1st Qu.: -1.1540   1st Qu.: -1.1580
##  Median :2000   Median :  0.2410   Median :  0.2410   Median :  0.2410
##  Mean   :2000   Mean   :  0.1506   Mean   :  0.1511   Mean   :  0.1472
##  3rd Qu.:2005   3rd Qu.:  1.4050   3rd Qu.:  1.4090   3rd Qu.:  1.4090
##  Max.   :2010   Max.   : 12.0260   Max.   : 12.0260   Max.   : 12.0260
##       Lag4               Lag5              Volume
##  Min.   :-18.1950   Min.   :-18.1950   Min.   :0.08747
##  1st Qu.: -1.1580   1st Qu.: -1.1660   1st Qu.:0.33202
##  Median :  0.2380   Median :  0.2340   Median :1.00268
##  Mean   :  0.1458   Mean   :  0.1399   Mean   :1.57462
##  3rd Qu.:  1.4090   3rd Qu.:  1.4050   3rd Qu.:2.05373
##  Max.   : 12.0260   Max.   : 12.0260   Max.   :9.32821
##      Today          Direction
##  Min.   :-18.1950   Down:484
##  1st Qu.: -1.1540   Up  :605
##  Median :  0.2410
##  Mean   :  0.1499
##  3rd Qu.:  1.4050
##  Max.   : 12.0260
```

```r
# According to the summary, all the lags and today have the same min and max value.
```

(b)

```r
mod1<-glm(Direction ~ Lag1 + Lag2 + Lag3 + Lag4 + Lag5 + Volume, data = Weekly, family = binomial)
summary(mod1)
```

```
##
## Call:
## glm(formula = Direction ~ Lag1 + Lag2 + Lag3 + Lag4 + Lag5 +
##     Volume, family = binomial, data = Weekly)
##
## Deviance Residuals:
```



4.6 (a) $p(x) = \frac{e^{-6+0.05\times 60+3.5}}{(1+e^{-6+0.05\times 60+3.5})} = 0.3775$

(b) $p(x) = \frac{e^{-6+0.05x_1+3.5}}{(1+e^{-6+0.05x_1+3.5})} = 0.5$

$\Rightarrow e^{-6+0.05x_1+3.5} = 1$

$x_1 = \frac{2.5}{0.05} = 50$

4.8 In knn when $k=1$, we have training error rate $= 0\%$

training error rate + testing error rate $= 2\times 18\%$

$\Rightarrow$ testing error rate $= 36\% > 30\%$.

We care about the error rate of test data, therefore, it's better to choose logistic regression

4.9 (a) $\frac{p(x)}{1-p(x)} = 0.37 \Rightarrow p(x) = \frac{0.37}{1+0.37} \approx 0.27$

(b) $\frac{p(x)}{1-p(x)} = \frac{0.16}{1-0.16} \approx 0.19$

Figure 1: lalala

```
##     Min       1Q   Median       3Q      Max
## -1.6949  -1.2565   0.9913   1.0849   1.4579
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.26686    0.08593   3.106   0.0019 **
## Lag1        -0.04127    0.02641  -1.563   0.1181
## Lag2         0.05844    0.02686   2.175   0.0296 *
## Lag3        -0.01606    0.02666  -0.602   0.5469
## Lag4        -0.02779    0.02646  -1.050   0.2937
## Lag5        -0.01447    0.02638  -0.549   0.5833
## Volume      -0.02274    0.03690  -0.616   0.5377
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 1496.2  on 1088  degrees of freedom
## Residual deviance: 1486.4  on 1082  degrees of freedom
## AIC: 1500.4
##
## Number of Fisher Scoring iterations: 4
```

```r
# From the model summary, we can see that only the intercept and Lag2 are significant.
```

(c)

```r
library(caret)
```

```
## Loading required package: lattice
## Loading required package: ggplot2
```

```r
pred<-predict(mod1, type = "response")
updown <- rep("Down", length(pred))
updown[pred > 0.5] <- "Up"
table(updown, Weekly$Direction)
```

```
##
## updown Down  Up
##   Down   54  48
##   Up    430 557
```

```r
# According to the confusion matrix, the accuracy of down is 54/(54+430)
# the accuary of up is 557/(48+557)
```

(d)

```r
library(dplyr)
```

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

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

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

```
train <- Weekly%>% filter(Year < 2009)
Weekly.20092010 <- Weekly[!train, ]
```

```
## Warning in Ops.factor(left): '!' not meaningful for factors
```

```
mod2 <- glm(Direction ~ Lag2, data = train, family = binomial)
summary(mod2)
```

```
##
## Call:
## glm(formula = Direction ~ Lag2, family = binomial, data = train)
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -1.536  -1.264   1.021   1.091   1.368
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.20326    0.06428   3.162  0.00157 **
## Lag2         0.05810    0.02870   2.024  0.04298 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 1354.7  on 984  degrees of freedom
## Residual deviance: 1350.5  on 983  degrees of freedom
## AIC: 1354.5
##
## Number of Fisher Scoring iterations: 4
```

```
pred2<-predict(mod2, Weekly.20092010,type = "response")
updown <- rep("Down", length(pred2))
updown[pred2 > 0.5] <- "Up"
table(updown, Weekly.20092010$Direction)
```

```
##
## updown Down Up
##   Down    0  0
```

(e)

```
library(MASS)
```

```
##
## Attaching package: 'MASS'
```

```
## The following object is masked from 'package:dplyr':
##
##     select
```

```r
train <- Weekly%>% filter(Year < 2009)
Weekly.20092010 <- Weekly[!train, ]
mod3 <- lda(Direction ~ Lag2, data = train, family = binomial)
mod3
```

```
## Call:
## lda(Direction ~ Lag2, data = train, family = binomial)
##
## Prior probabilities of groups:
##      Down        Up
## 0.4477157 0.5522843
##
## Group means:
##             Lag2
## Down -0.03568254
## Up    0.26036581
##
## Coefficients of linear discriminants:
##            LD1
## Lag2 0.4414162
```

```r
pred3<-predict(mod3, Weekly.20092010)
table(pred3$class, Weekly.20092010$Direction)
```

```
##
##        Down Up
##   Down    0  0
##   Up      0  0
```

(f)

```r
library(MASS)
train <- Weekly%>% filter(Year < 2009)
Weekly.20092010 <- Weekly[!train, ]
mod3 <- qda(Direction ~ Lag2, data = train, family = binomial)
mod3
```

```
## Call:
## qda(Direction ~ Lag2, data = train, family = binomial)
##
## Prior probabilities of groups:
##      Down        Up
## 0.4477157 0.5522843
##
## Group means:
##             Lag2
## Down -0.03568254
## Up    0.26036581
```

```r
pred3<-predict(mod3, Weekly.20092010)
table(pred3$class, Weekly.20092010$Direction)
```

```
##
##         Down Up
##   Down     0  0
##   Up       0  0
```

(g)

```r
library(class)
train.X <- na.omit(as.matrix(Weekly%>% filter(Year < 2009)))
test.X <- na.omit(as.matrix(Weekly%>% filter(Year >= 2009)))
train<-Weekly%>% filter(Year < 2009)
train.Direction <-na.omit(train$Direction)
set.seed(1)
###pred.knn <- knn(train.X, test.X, train.Direction, k = 1)
###table(pred.knn, Weekly.20092010$Direction)
```

4.11 (a)

```r
data(Auto)
mpg<-Auto$mpg
mpg
```

```
##   [1] 18.0 15.0 18.0 16.0 17.0 15.0 14.0 14.0 14.0 15.0 15.0 14.0 15.0 14.0
##  [15] 24.0 22.0 18.0 21.0 27.0 26.0 25.0 24.0 25.0 26.0 21.0 10.0 10.0 11.0
##  [29]  9.0 27.0 28.0 25.0 19.0 16.0 17.0 19.0 18.0 14.0 14.0 14.0 14.0 12.0
##  [43] 13.0 13.0 18.0 22.0 19.0 18.0 23.0 28.0 30.0 30.0 31.0 35.0 27.0 26.0
##  [57] 24.0 25.0 23.0 20.0 21.0 13.0 14.0 15.0 14.0 17.0 11.0 13.0 12.0 13.0
##  [71] 19.0 15.0 13.0 13.0 14.0 18.0 22.0 21.0 26.0 22.0 28.0 23.0 28.0 27.0
##  [85] 13.0 14.0 13.0 14.0 15.0 12.0 13.0 13.0 14.0 13.0 12.0 13.0 18.0 16.0
##  [99] 18.0 18.0 23.0 26.0 11.0 12.0 13.0 12.0 18.0 20.0 21.0 22.0 18.0 19.0
## [113] 21.0 26.0 15.0 16.0 29.0 24.0 20.0 19.0 15.0 24.0 20.0 11.0 20.0 19.0
## [127] 15.0 31.0 26.0 32.0 25.0 16.0 16.0 18.0 16.0 13.0 14.0 14.0 14.0 29.0
## [141] 26.0 26.0 31.0 32.0 28.0 24.0 26.0 24.0 26.0 31.0 19.0 18.0 15.0 15.0
## [155] 16.0 15.0 16.0 14.0 17.0 16.0 15.0 18.0 21.0 20.0 13.0 29.0 23.0 20.0
## [169] 23.0 24.0 25.0 24.0 18.0 29.0 19.0 23.0 23.0 22.0 25.0 33.0 28.0 25.0
## [183] 25.0 26.0 27.0 17.5 16.0 15.5 14.5 22.0 22.0 24.0 22.5 29.0 24.5 29.0
## [197] 33.0 20.0 18.0 18.5 17.5 29.5 32.0 28.0 26.5 20.0 13.0 19.0 19.0 16.5
## [211] 16.5 13.0 13.0 13.0 31.5 30.0 36.0 25.5 33.5 17.5 17.0 15.5 15.0 17.5
## [225] 20.5 19.0 18.5 16.0 15.5 15.5 16.0 29.0 24.5 26.0 25.5 30.5 33.5 30.0
## [239] 30.5 22.0 21.5 21.5 43.1 36.1 32.8 39.4 36.1 19.9 19.4 20.2 19.2 20.5
## [253] 20.2 25.1 20.5 19.4 20.6 20.8 18.6 18.1 19.2 17.7 18.1 17.5 30.0 27.5
## [267] 27.2 30.9 21.1 23.2 23.8 23.9 20.3 17.0 21.6 16.2 31.5 29.5 21.5 19.8
## [281] 22.3 20.2 20.6 17.0 17.6 16.5 18.2 16.9 15.5 19.2 18.5 31.9 34.1 35.7
## [295] 27.4 25.4 23.0 27.2 23.9 34.2 34.5 31.8 37.3 28.4 28.8 26.8 33.5 41.5
## [309] 38.1 32.1 37.2 28.0 26.4 24.3 19.1 34.3 29.8 31.3 37.0 32.2 46.6 27.9
## [323] 40.8 44.3 43.4 36.4 30.0 44.6 33.8 29.8 32.7 23.7 35.0 32.4 27.2 26.6
## [337] 25.8 23.5 30.0 39.1 39.0 35.1 32.3 37.0 37.7 34.1 34.7 34.4 29.9 33.0
```

```
## [351] 33.7 32.4 32.9 31.6 28.1 30.7 25.4 24.2 22.4 26.6 20.2 17.6 28.0 27.0
## [365] 34.0 31.0 29.0 27.0 24.0 36.0 37.0 31.0 38.0 36.0 36.0 36.0 34.0 38.0
## [379] 32.0 38.0 25.0 38.0 26.0 22.0 32.0 36.0 27.0 27.0 44.0 32.0 28.0 31.0
```

```r
mpg01 <- rep(0, length(mpg))
mpg01[mpg > median(mpg)] <- 1
mpg01<-data.frame(Auto,mpg01)
mpg01
```

```
##      mpg cylinders displacement horsepower weight acceleration year origin
## 1   18.0         8        307.0        130   3504         12.0   70      1
## 2   15.0         8        350.0        165   3693         11.5   70      1
## 3   18.0         8        318.0        150   3436         11.0   70      1
## 4   16.0         8        304.0        150   3433         12.0   70      1
## 5   17.0         8        302.0        140   3449         10.5   70      1
## 6   15.0         8        429.0        198   4341         10.0   70      1
## 7   14.0         8        454.0        220   4354          9.0   70      1
## 8   14.0         8        440.0        215   4312          8.5   70      1
## 9   14.0         8        455.0        225   4425         10.0   70      1
## 10  15.0         8        390.0        190   3850          8.5   70      1
## 11  15.0         8        383.0        170   3563         10.0   70      1
## 12  14.0         8        340.0        160   3609          8.0   70      1
## 13  15.0         8        400.0        150   3761          9.5   70      1
## 14  14.0         8        455.0        225   3086         10.0   70      1
## 15  24.0         4        113.0         95   2372         15.0   70      3
## 16  22.0         6        198.0         95   2833         15.5   70      1
## 17  18.0         6        199.0         97   2774         15.5   70      1
## 18  21.0         6        200.0         85   2587         16.0   70      1
## 19  27.0         4         97.0         88   2130         14.5   70      3
## 20  26.0         4         97.0         46   1835         20.5   70      2
## 21  25.0         4        110.0         87   2672         17.5   70      2
## 22  24.0         4        107.0         90   2430         14.5   70      2
## 23  25.0         4        104.0         95   2375         17.5   70      2
## 24  26.0         4        121.0        113   2234         12.5   70      2
## 25  21.0         6        199.0         90   2648         15.0   70      1
## 26  10.0         8        360.0        215   4615         14.0   70      1
## 27  10.0         8        307.0        200   4376         15.0   70      1
## 28  11.0         8        318.0        210   4382         13.5   70      1
## 29   9.0         8        304.0        193   4732         18.5   70      1
## 30  27.0         4         97.0         88   2130         14.5   71      3
## 31  28.0         4        140.0         90   2264         15.5   71      1
## 32  25.0         4        113.0         95   2228         14.0   71      3
## 34  19.0         6        232.0        100   2634         13.0   71      1
## 35  16.0         6        225.0        105   3439         15.5   71      1
## 36  17.0         6        250.0        100   3329         15.5   71      1
## 37  19.0         6        250.0         88   3302         15.5   71      1
## 38  18.0         6        232.0        100   3288         15.5   71      1
## 39  14.0         8        350.0        165   4209         12.0   71      1
## 40  14.0         8        400.0        175   4464         11.5   71      1
## 41  14.0         8        351.0        153   4154         13.5   71      1
## 42  14.0         8        318.0        150   4096         13.0   71      1
## 43  12.0         8        383.0        180   4955         11.5   71      1
## 44  13.0         8        400.0        170   4746         12.0   71      1
## 45  13.0         8        400.0        175   5140         12.0   71      1
## 46  18.0         6        258.0        110   2962         13.5   71      1
```

```
## 47  22.0          4        140.0         72  2408          19.0  71       1
## 48  19.0          6        250.0        100  3282          15.0  71       1
## 49  18.0          6        250.0         88  3139          14.5  71       1
## 50  23.0          4        122.0         86  2220          14.0  71       1
## 51  28.0          4        116.0         90  2123          14.0  71       2
## 52  30.0          4         79.0         70  2074          19.5  71       2
## 53  30.0          4         88.0         76  2065          14.5  71       2
## 54  31.0          4         71.0         65  1773          19.0  71       3
## 55  35.0          4         72.0         69  1613          18.0  71       3
## 56  27.0          4         97.0         60  1834          19.0  71       2
## 57  26.0          4         91.0         70  1955          20.5  71       1
## 58  24.0          4        113.0         95  2278          15.5  72       3
## 59  25.0          4         97.5         80  2126          17.0  72       1
## 60  23.0          4         97.0         54  2254          23.5  72       2
## 61  20.0          4        140.0         90  2408          19.5  72       1
## 62  21.0          4        122.0         86  2226          16.5  72       1
## 63  13.0          8        350.0        165  4274          12.0  72       1
## 64  14.0          8        400.0        175  4385          12.0  72       1
## 65  15.0          8        318.0        150  4135          13.5  72       1
## 66  14.0          8        351.0        153  4129          13.0  72       1
## 67  17.0          8        304.0        150  3672          11.5  72       1
## 68  11.0          8        429.0        208  4633          11.0  72       1
## 69  13.0          8        350.0        155  4502          13.5  72       1
## 70  12.0          8        350.0        160  4456          13.5  72       1
## 71  13.0          8        400.0        190  4422          12.5  72       1
## 72  19.0          3         70.0         97  2330          13.5  72       3
## 73  15.0          8        304.0        150  3892          12.5  72       1
## 74  13.0          8        307.0        130  4098          14.0  72       1
## 75  13.0          8        302.0        140  4294          16.0  72       1
## 76  14.0          8        318.0        150  4077          14.0  72       1
## 77  18.0          4        121.0        112  2933          14.5  72       2
## 78  22.0          4        121.0         76  2511          18.0  72       2
## 79  21.0          4        120.0         87  2979          19.5  72       2
## 80  26.0          4         96.0         69  2189          18.0  72       2
## 81  22.0          4        122.0         86  2395          16.0  72       1
## 82  28.0          4         97.0         92  2288          17.0  72       3
## 83  23.0          4        120.0         97  2506          14.5  72       3
## 84  28.0          4         98.0         80  2164          15.0  72       1
## 85  27.0          4         97.0         88  2100          16.5  72       3
## 86  13.0          8        350.0        175  4100          13.0  73       1
## 87  14.0          8        304.0        150  3672          11.5  73       1
## 88  13.0          8        350.0        145  3988          13.0  73       1
## 89  14.0          8        302.0        137  4042          14.5  73       1
## 90  15.0          8        318.0        150  3777          12.5  73       1
## 91  12.0          8        429.0        198  4952          11.5  73       1
## 92  13.0          8        400.0        150  4464          12.0  73       1
## 93  13.0          8        351.0        158  4363          13.0  73       1
## 94  14.0          8        318.0        150  4237          14.5  73       1
## 95  13.0          8        440.0        215  4735          11.0  73       1
## 96  12.0          8        455.0        225  4951          11.0  73       1
## 97  13.0          8        360.0        175  3821          11.0  73       1
## 98  18.0          6        225.0        105  3121          16.5  73       1
## 99  16.0          6        250.0        100  3278          18.0  73       1
## 100 18.0          6        232.0        100  2945          16.0  73       1
```

```
## 101 18.0         6         250.0         88   3021         16.5   73       1
## 102 23.0         6         198.0         95   2904         16.0   73       1
## 103 26.0         4          97.0         46   1950         21.0   73       2
## 104 11.0         8         400.0        150   4997         14.0   73       1
## 105 12.0         8         400.0        167   4906         12.5   73       1
## 106 13.0         8         360.0        170   4654         13.0   73       1
## 107 12.0         8         350.0        180   4499         12.5   73       1
## 108 18.0         6         232.0        100   2789         15.0   73       1
## 109 20.0         4          97.0         88   2279         19.0   73       3
## 110 21.0         4         140.0         72   2401         19.5   73       1
## 111 22.0         4         108.0         94   2379         16.5   73       3
## 112 18.0         3          70.0         90   2124         13.5   73       3
## 113 19.0         4         122.0         85   2310         18.5   73       1
## 114 21.0         6         155.0        107   2472         14.0   73       1
## 115 26.0         4          98.0         90   2265         15.5   73       2
## 116 15.0         8         350.0        145   4082         13.0   73       1
## 117 16.0         8         400.0        230   4278          9.5   73       1
## 118 29.0         4          68.0         49   1867         19.5   73       2
## 119 24.0         4         116.0         75   2158         15.5   73       2
## 120 20.0         4         114.0         91   2582         14.0   73       2
## 121 19.0         4         121.0        112   2868         15.5   73       2
## 122 15.0         8         318.0        150   3399         11.0   73       1
## 123 24.0         4         121.0        110   2660         14.0   73       2
## 124 20.0         6         156.0        122   2807         13.5   73       3
## 125 11.0         8         350.0        180   3664         11.0   73       1
## 126 20.0         6         198.0         95   3102         16.5   74       1
## 128 19.0         6         232.0        100   2901         16.0   74       1
## 129 15.0         6         250.0        100   3336         17.0   74       1
## 130 31.0         4          79.0         67   1950         19.0   74       3
## 131 26.0         4         122.0         80   2451         16.5   74       1
## 132 32.0         4          71.0         65   1836         21.0   74       3
## 133 25.0         4         140.0         75   2542         17.0   74       1
## 134 16.0         6         250.0        100   3781         17.0   74       1
## 135 16.0         6         258.0        110   3632         18.0   74       1
## 136 18.0         6         225.0        105   3613         16.5   74       1
## 137 16.0         8         302.0        140   4141         14.0   74       1
## 138 13.0         8         350.0        150   4699         14.5   74       1
## 139 14.0         8         318.0        150   4457         13.5   74       1
## 140 14.0         8         302.0        140   4638         16.0   74       1
## 141 14.0         8         304.0        150   4257         15.5   74       1
## 142 29.0         4          98.0         83   2219         16.5   74       2
## 143 26.0         4          79.0         67   1963         15.5   74       2
## 144 26.0         4          97.0         78   2300         14.5   74       2
## 145 31.0         4          76.0         52   1649         16.5   74       3
## 146 32.0         4          83.0         61   2003         19.0   74       3
## 147 28.0         4          90.0         75   2125         14.5   74       1
## 148 24.0         4          90.0         75   2108         15.5   74       2
## 149 26.0         4         116.0         75   2246         14.0   74       2
## 150 24.0         4         120.0         97   2489         15.0   74       3
## 151 26.0         4         108.0         93   2391         15.5   74       3
## 152 31.0         4          79.0         67   2000         16.0   74       2
## 153 19.0         6         225.0         95   3264         16.0   75       1
## 154 18.0         6         250.0        105   3459         16.0   75       1
## 155 15.0         6         250.0         72   3432         21.0   75       1
```

```
## 156 15.0         6        250.0        72  3158         19.5   75      1
## 157 16.0         8        400.0       170  4668         11.5   75      1
## 158 15.0         8        350.0       145  4440         14.0   75      1
## 159 16.0         8        318.0       150  4498         14.5   75      1
## 160 14.0         8        351.0       148  4657         13.5   75      1
## 161 17.0         6        231.0       110  3907         21.0   75      1
## 162 16.0         6        250.0       105  3897         18.5   75      1
## 163 15.0         6        258.0       110  3730         19.0   75      1
## 164 18.0         6        225.0        95  3785         19.0   75      1
## 165 21.0         6        231.0       110  3039         15.0   75      1
## 166 20.0         8        262.0       110  3221         13.5   75      1
## 167 13.0         8        302.0       129  3169         12.0   75      1
## 168 29.0         4         97.0        75  2171         16.0   75      3
## 169 23.0         4        140.0        83  2639         17.0   75      1
## 170 20.0         6        232.0       100  2914         16.0   75      1
## 171 23.0         4        140.0        78  2592         18.5   75      1
## 172 24.0         4        134.0        96  2702         13.5   75      3
## 173 25.0         4         90.0        71  2223         16.5   75      2
## 174 24.0         4        119.0        97  2545         17.0   75      3
## 175 18.0         6        171.0        97  2984         14.5   75      1
## 176 29.0         4         90.0        70  1937         14.0   75      2
## 177 19.0         6        232.0        90  3211         17.0   75      1
## 178 23.0         4        115.0        95  2694         15.0   75      2
## 179 23.0         4        120.0        88  2957         17.0   75      2
## 180 22.0         4        121.0        98  2945         14.5   75      2
## 181 25.0         4        121.0       115  2671         13.5   75      2
## 182 33.0         4         91.0        53  1795         17.5   75      3
## 183 28.0         4        107.0        86  2464         15.5   76      2
## 184 25.0         4        116.0        81  2220         16.9   76      2
## 185 25.0         4        140.0        92  2572         14.9   76      1
## 186 26.0         4         98.0        79  2255         17.7   76      1
## 187 27.0         4        101.0        83  2202         15.3   76      2
## 188 17.5         8        305.0       140  4215         13.0   76      1
## 189 16.0         8        318.0       150  4190         13.0   76      1
## 190 15.5         8        304.0       120  3962         13.9   76      1
## 191 14.5         8        351.0       152  4215         12.8   76      1
## 192 22.0         6        225.0       100  3233         15.4   76      1
## 193 22.0         6        250.0       105  3353         14.5   76      1
## 194 24.0         6        200.0        81  3012         17.6   76      1
## 195 22.5         6        232.0        90  3085         17.6   76      1
## 196 29.0         4         85.0        52  2035         22.2   76      1
## 197 24.5         4         98.0        60  2164         22.1   76      1
## 198 29.0         4         90.0        70  1937         14.2   76      2
## 199 33.0         4         91.0        53  1795         17.4   76      3
## 200 20.0         6        225.0       100  3651         17.7   76      1
## 201 18.0         6        250.0        78  3574         21.0   76      1
## 202 18.5         6        250.0       110  3645         16.2   76      1
## 203 17.5         6        258.0        95  3193         17.8   76      1
## 204 29.5         4         97.0        71  1825         12.2   76      2
## 205 32.0         4         85.0        70  1990         17.0   76      3
## 206 28.0         4         97.0        75  2155         16.4   76      3
## 207 26.5         4        140.0        72  2565         13.6   76      1
## 208 20.0         4        130.0       102  3150         15.7   76      2
## 209 13.0         8        318.0       150  3940         13.2   76      1
```

```
## 210 19.0          4         120.0          88   3270          21.9   76       2
## 211 19.0          6         156.0         108   2930          15.5   76       3
## 212 16.5          6         168.0         120   3820          16.7   76       2
## 213 16.5          8         350.0         180   4380          12.1   76       1
## 214 13.0          8         350.0         145   4055          12.0   76       1
## 215 13.0          8         302.0         130   3870          15.0   76       1
## 216 13.0          8         318.0         150   3755          14.0   76       1
## 217 31.5          4          98.0          68   2045          18.5   77       3
## 218 30.0          4         111.0          80   2155          14.8   77       1
## 219 36.0          4          79.0          58   1825          18.6   77       2
## 220 25.5          4         122.0          96   2300          15.5   77       1
## 221 33.5          4          85.0          70   1945          16.8   77       3
## 222 17.5          8         305.0         145   3880          12.5   77       1
## 223 17.0          8         260.0         110   4060          19.0   77       1
## 224 15.5          8         318.0         145   4140          13.7   77       1
## 225 15.0          8         302.0         130   4295          14.9   77       1
## 226 17.5          6         250.0         110   3520          16.4   77       1
## 227 20.5          6         231.0         105   3425          16.9   77       1
## 228 19.0          6         225.0         100   3630          17.7   77       1
## 229 18.5          6         250.0          98   3525          19.0   77       1
## 230 16.0          8         400.0         180   4220          11.1   77       1
## 231 15.5          8         350.0         170   4165          11.4   77       1
## 232 15.5          8         400.0         190   4325          12.2   77       1
## 233 16.0          8         351.0         149   4335          14.5   77       1
## 234 29.0          4          97.0          78   1940          14.5   77       2
## 235 24.5          4         151.0          88   2740          16.0   77       1
## 236 26.0          4          97.0          75   2265          18.2   77       3
## 237 25.5          4         140.0          89   2755          15.8   77       1
## 238 30.5          4          98.0          63   2051          17.0   77       1
## 239 33.5          4          98.0          83   2075          15.9   77       1
## 240 30.0          4          97.0          67   1985          16.4   77       3
## 241 30.5          4          97.0          78   2190          14.1   77       2
## 242 22.0          6         146.0          97   2815          14.5   77       3
## 243 21.5          4         121.0         110   2600          12.8   77       2
## 244 21.5          3          80.0         110   2720          13.5   77       3
## 245 43.1          4          90.0          48   1985          21.5   78       2
## 246 36.1          4          98.0          66   1800          14.4   78       1
## 247 32.8          4          78.0          52   1985          19.4   78       3
## 248 39.4          4          85.0          70   2070          18.6   78       3
## 249 36.1          4          91.0          60   1800          16.4   78       3
## 250 19.9          8         260.0         110   3365          15.5   78       1
## 251 19.4          8         318.0         140   3735          13.2   78       1
## 252 20.2          8         302.0         139   3570          12.8   78       1
## 253 19.2          6         231.0         105   3535          19.2   78       1
## 254 20.5          6         200.0          95   3155          18.2   78       1
## 255 20.2          6         200.0          85   2965          15.8   78       1
## 256 25.1          4         140.0          88   2720          15.4   78       1
## 257 20.5          6         225.0         100   3430          17.2   78       1
## 258 19.4          6         232.0          90   3210          17.2   78       1
## 259 20.6          6         231.0         105   3380          15.8   78       1
## 260 20.8          6         200.0          85   3070          16.7   78       1
## 261 18.6          6         225.0         110   3620          18.7   78       1
## 262 18.1          6         258.0         120   3410          15.1   78       1
## 263 19.2          8         305.0         145   3425          13.2   78       1
```

```
## 264 17.7          6         231.0        165   3445          13.4   78       1
## 265 18.1          8         302.0        139   3205          11.2   78       1
## 266 17.5          8         318.0        140   4080          13.7   78       1
## 267 30.0          4          98.0         68   2155          16.5   78       1
## 268 27.5          4         134.0         95   2560          14.2   78       3
## 269 27.2          4         119.0         97   2300          14.7   78       3
## 270 30.9          4         105.0         75   2230          14.5   78       1
## 271 21.1          4         134.0         95   2515          14.8   78       3
## 272 23.2          4         156.0        105   2745          16.7   78       1
## 273 23.8          4         151.0         85   2855          17.6   78       1
## 274 23.9          4         119.0         97   2405          14.9   78       3
## 275 20.3          5         131.0        103   2830          15.9   78       2
## 276 17.0          6         163.0        125   3140          13.6   78       2
## 277 21.6          4         121.0        115   2795          15.7   78       2
## 278 16.2          6         163.0        133   3410          15.8   78       2
## 279 31.5          4          89.0         71   1990          14.9   78       2
## 280 29.5          4          98.0         68   2135          16.6   78       3
## 281 21.5          6         231.0        115   3245          15.4   79       1
## 282 19.8          6         200.0         85   2990          18.2   79       1
## 283 22.3          4         140.0         88   2890          17.3   79       1
## 284 20.2          6         232.0         90   3265          18.2   79       1
## 285 20.6          6         225.0        110   3360          16.6   79       1
## 286 17.0          8         305.0        130   3840          15.4   79       1
## 287 17.6          8         302.0        129   3725          13.4   79       1
## 288 16.5          8         351.0        138   3955          13.2   79       1
## 289 18.2          8         318.0        135   3830          15.2   79       1
## 290 16.9          8         350.0        155   4360          14.9   79       1
## 291 15.5          8         351.0        142   4054          14.3   79       1
## 292 19.2          8         267.0        125   3605          15.0   79       1
## 293 18.5          8         360.0        150   3940          13.0   79       1
## 294 31.9          4          89.0         71   1925          14.0   79       2
## 295 34.1          4          86.0         65   1975          15.2   79       3
## 296 35.7          4          98.0         80   1915          14.4   79       1
## 297 27.4          4         121.0         80   2670          15.0   79       1
## 298 25.4          5         183.0         77   3530          20.1   79       2
## 299 23.0          8         350.0        125   3900          17.4   79       1
## 300 27.2          4         141.0         71   3190          24.8   79       2
## 301 23.9          8         260.0         90   3420          22.2   79       1
## 302 34.2          4         105.0         70   2200          13.2   79       1
## 303 34.5          4         105.0         70   2150          14.9   79       1
## 304 31.8          4          85.0         65   2020          19.2   79       3
## 305 37.3          4          91.0         69   2130          14.7   79       2
## 306 28.4          4         151.0         90   2670          16.0   79       1
## 307 28.8          6         173.0        115   2595          11.3   79       1
## 308 26.8          6         173.0        115   2700          12.9   79       1
## 309 33.5          4         151.0         90   2556          13.2   79       1
## 310 41.5          4          98.0         76   2144          14.7   80       2
## 311 38.1          4          89.0         60   1968          18.8   80       3
## 312 32.1          4          98.0         70   2120          15.5   80       1
## 313 37.2          4          86.0         65   2019          16.4   80       3
## 314 28.0          4         151.0         90   2678          16.5   80       1
## 315 26.4          4         140.0         88   2870          18.1   80       1
## 316 24.3          4         151.0         90   3003          20.1   80       1
## 317 19.1          6         225.0         90   3381          18.7   80       1
```

```
## 318 34.3         4        97.0         78   2188          15.8   80       2
## 319 29.8         4       134.0         90   2711          15.5   80       3
## 320 31.3         4       120.0         75   2542          17.5   80       3
## 321 37.0         4       119.0         92   2434          15.0   80       3
## 322 32.2         4       108.0         75   2265          15.2   80       3
## 323 46.6         4        86.0         65   2110          17.9   80       3
## 324 27.9         4       156.0        105   2800          14.4   80       1
## 325 40.8         4        85.0         65   2110          19.2   80       3
## 326 44.3         4        90.0         48   2085          21.7   80       2
## 327 43.4         4        90.0         48   2335          23.7   80       2
## 328 36.4         5       121.0         67   2950          19.9   80       2
## 329 30.0         4       146.0         67   3250          21.8   80       2
## 330 44.6         4        91.0         67   1850          13.8   80       3
## 332 33.8         4        97.0         67   2145          18.0   80       3
## 333 29.8         4        89.0         62   1845          15.3   80       2
## 334 32.7         6       168.0        132   2910          11.4   80       3
## 335 23.7         3        70.0        100   2420          12.5   80       3
## 336 35.0         4       122.0         88   2500          15.1   80       2
## 338 32.4         4       107.0         72   2290          17.0   80       3
## 339 27.2         4       135.0         84   2490          15.7   81       1
## 340 26.6         4       151.0         84   2635          16.4   81       1
## 341 25.8         4       156.0         92   2620          14.4   81       1
## 342 23.5         6       173.0        110   2725          12.6   81       1
## 343 30.0         4       135.0         84   2385          12.9   81       1
## 344 39.1         4        79.0         58   1755          16.9   81       3
## 345 39.0         4        86.0         64   1875          16.4   81       1
## 346 35.1         4        81.0         60   1760          16.1   81       3
## 347 32.3         4        97.0         67   2065          17.8   81       3
## 348 37.0         4        85.0         65   1975          19.4   81       3
## 349 37.7         4        89.0         62   2050          17.3   81       3
## 350 34.1         4        91.0         68   1985          16.0   81       3
## 351 34.7         4       105.0         63   2215          14.9   81       1
## 352 34.4         4        98.0         65   2045          16.2   81       1
## 353 29.9         4        98.0         65   2380          20.7   81       1
## 354 33.0         4       105.0         74   2190          14.2   81       2
## 356 33.7         4       107.0         75   2210          14.4   81       3
## 357 32.4         4       108.0         75   2350          16.8   81       3
## 358 32.9         4       119.0        100   2615          14.8   81       3
## 359 31.6         4       120.0         74   2635          18.3   81       3
## 360 28.1         4       141.0         80   3230          20.4   81       2
## 361 30.7         6       145.0         76   3160          19.6   81       2
## 362 25.4         6       168.0        116   2900          12.6   81       3
## 363 24.2         6       146.0        120   2930          13.8   81       3
## 364 22.4         6       231.0        110   3415          15.8   81       1
## 365 26.6         8       350.0        105   3725          19.0   81       1
## 366 20.2         6       200.0         88   3060          17.1   81       1
## 367 17.6         6       225.0         85   3465          16.6   81       1
## 368 28.0         4       112.0         88   2605          19.6   82       1
## 369 27.0         4       112.0         88   2640          18.6   82       1
## 370 34.0         4       112.0         88   2395          18.0   82       1
## 371 31.0         4       112.0         85   2575          16.2   82       1
## 372 29.0         4       135.0         84   2525          16.0   82       1
## 373 27.0         4       151.0         90   2735          18.0   82       1
## 374 24.0         4       140.0         92   2865          16.4   82       1
```

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## 375 36.0         4        105.0          74   1980         15.3   82       2
## 376 37.0         4         91.0          68   2025         18.2   82       3
## 377 31.0         4         91.0          68   1970         17.6   82       3
## 378 38.0         4        105.0          63   2125         14.7   82       1
## 379 36.0         4         98.0          70   2125         17.3   82       1
## 380 36.0         4        120.0          88   2160         14.5   82       3
## 381 36.0         4        107.0          75   2205         14.5   82       3
## 382 34.0         4        108.0          70   2245         16.9   82       3
## 383 38.0         4         91.0          67   1965         15.0   82       3
## 384 32.0         4         91.0          67   1965         15.7   82       3
## 385 38.0         4         91.0          67   1995         16.2   82       3
## 386 25.0         6        181.0         110   2945         16.4   82       1
## 387 38.0         6        262.0          85   3015         17.0   82       1
## 388 26.0         4        156.0          92   2585         14.5   82       1
## 389 22.0         6        232.0         112   2835         14.7   82       1
## 390 32.0         4        144.0          96   2665         13.9   82       3
## 391 36.0         4        135.0          84   2370         13.0   82       1
## 392 27.0         4        151.0          90   2950         17.3   82       1
## 393 27.0         4        140.0          86   2790         15.6   82       1
## 394 44.0         4         97.0          52   2130         24.6   82       2
## 395 32.0         4        135.0          84   2295         11.6   82       1
## 396 28.0         4        120.0          79   2625         18.6   82       1
## 397 31.0         4        119.0          82   2720         19.4   82       1
##                                   name mpg01
## 1            chevrolet chevelle malibu     0
## 2                    buick skylark 320     0
## 3                   plymouth satellite     0
## 4                        amc rebel sst     0
## 5                          ford torino     0
## 6                     ford galaxie 500     0
## 7                     chevrolet impala     0
## 8                    plymouth fury iii     0
## 9                     pontiac catalina     0
## 10                  amc ambassador dpl     0
## 11                 dodge challenger se     0
## 12                  plymouth 'cuda 340     0
## 13               chevrolet monte carlo     0
## 14             buick estate wagon (sw)     0
## 15               toyota corona mark ii     1
## 16                     plymouth duster     0
## 17                          amc hornet     0
## 18                       ford maverick     0
## 19                        datsun pl510     1
## 20        volkswagen 1131 deluxe sedan     1
## 21                         peugeot 504     1
## 22                         audi 100 ls     1
## 23                            saab 99e     1
## 24                            bmw 2002     1
## 25                         amc gremlin     0
## 26                           ford f250     0
## 27                           chevy c20     0
## 28                          dodge d200     0
## 29                            hi 1200d     0
## 30                        datsun pl510     1
```

```
## 31                 chevrolet vega 2300     1
## 32                       toyota corona     1
## 34                         amc gremlin     0
## 35           plymouth satellite custom     0
## 36           chevrolet chevelle malibu     0
## 37                      ford torino 500     0
## 38                          amc matador     0
## 39                     chevrolet impala     0
## 40           pontiac catalina brougham     0
## 41                     ford galaxie 500     0
## 42                    plymouth fury iii     0
## 43                   dodge monaco (sw)     0
## 44            ford country squire (sw)     0
## 45                  pontiac safari (sw)     0
## 46           amc hornet sportabout (sw)     0
## 47                  chevrolet vega (sw)     0
## 48                     pontiac firebird     0
## 49                         ford mustang     0
## 50                   mercury capri 2000     1
## 51                            opel 1900     1
## 52                          peugeot 304     1
## 53                            fiat 124b     1
## 54                  toyota corolla 1200     1
## 55                          datsun 1200     1
## 56                 volkswagen model 111     1
## 57                     plymouth cricket     1
## 58                toyota corona hardtop     1
## 59                   dodge colt hardtop     1
## 60                    volkswagen type 3     1
## 61                       chevrolet vega     0
## 62                   ford pinto runabout     0
## 63                     chevrolet impala     0
## 64                     pontiac catalina     0
## 65                    plymouth fury iii     0
## 66                     ford galaxie 500     0
## 67                   amc ambassador sst     0
## 68                      mercury marquis     0
## 69                 buick lesabre custom     0
## 70           oldsmobile delta 88 royale     0
## 71               chrysler newport royal     0
## 72                      mazda rx2 coupe     0
## 73                     amc matador (sw)     0
## 74     chevrolet chevelle concours (sw)     0
## 75                ford gran torino (sw)     0
## 76       plymouth satellite custom (sw)     0
## 77                      volvo 145e (sw)     0
## 78                  volkswagen 411 (sw)     0
## 79                     peugeot 504 (sw)     0
## 80                      renault 12 (sw)     1
## 81                      ford pinto (sw)     0
## 82                      datsun 510 (sw)     1
## 83          toyouta corona mark ii (sw)     1
## 84                      dodge colt (sw)     1
## 85             toyota corolla 1600 (sw)     1
```

```
## 86                     buick century 350     0
## 87                           amc matador     0
## 88                      chevrolet malibu     0
## 89                       ford gran torino     0
## 90                    dodge coronet custom     0
## 91                mercury marquis brougham     0
## 92               chevrolet caprice classic     0
## 93                              ford ltd     0
## 94                 plymouth fury gran sedan     0
## 95             chrysler new yorker brougham     0
## 96                 buick electra 225 custom     0
## 97                  amc ambassador brougham     0
## 98                      plymouth valiant     0
## 99                   chevrolet nova custom     0
## 100                           amc hornet     0
## 101                        ford maverick     0
## 102                      plymouth duster     1
## 103              volkswagen super beetle     1
## 104                     chevrolet impala     0
## 105                         ford country     0
## 106                 plymouth custom suburb     0
## 107               oldsmobile vista cruiser     0
## 108                           amc gremlin     0
## 109                        toyota carina     0
## 110                       chevrolet vega     0
## 111                           datsun 610     0
## 112                            maxda rx3     0
## 113                           ford pinto     0
## 114                     mercury capri v6     0
## 115                 fiat 124 sport coupe     1
## 116              chevrolet monte carlo s     0
## 117                   pontiac grand prix     0
## 118                             fiat 128     1
## 119                           opel manta     1
## 120                           audi 100ls     0
## 121                          volvo 144ea     0
## 122                    dodge dart custom     0
## 123                            saab 99le     1
## 124                       toyota mark ii     0
## 125                     oldsmobile omega     0
## 126                      plymouth duster     0
## 128                           amc hornet     0
## 129                       chevrolet nova     0
## 130                          datsun b210     1
## 131                           ford pinto     1
## 132                  toyota corolla 1200     1
## 133                       chevrolet vega     1
## 134    chevrolet chevelle malibu classic     0
## 135                          amc matador     0
## 136            plymouth satellite sebring     0
## 137                      ford gran torino     0
## 138              buick century luxus (sw)     0
## 139             dodge coronet custom (sw)     0
## 140                ford gran torino (sw)     0
```

```
## 141                    amc matador (sw)     0
## 142                            audi fox     1
## 143                   volkswagen dasher     1
## 144                          opel manta     1
## 145                       toyota corona     1
## 146                          datsun 710     1
## 147                          dodge colt     1
## 148                            fiat 128     1
## 149                         fiat 124 tc     1
## 150                         honda civic     1
## 151                              subaru     1
## 152                           fiat x1.9     1
## 153             plymouth valiant custom     0
## 154                      chevrolet nova     0
## 155                     mercury monarch     0
## 156                       ford maverick     0
## 157                    pontiac catalina     0
## 158                   chevrolet bel air     0
## 159                 plymouth grand fury     0
## 160                            ford ltd     0
## 161                       buick century     0
## 162           chevroelt chevelle malibu     0
## 163                         amc matador     0
## 164                       plymouth fury     0
## 165                       buick skyhawk     0
## 166                 chevrolet monza 2+2     0
## 167                     ford mustang ii     0
## 168                      toyota corolla     1
## 169                          ford pinto     1
## 170                         amc gremlin     0
## 171                       pontiac astro     1
## 172                       toyota corona     1
## 173                   volkswagen dasher     1
## 174                          datsun 710     1
## 175                          ford pinto     0
## 176                   volkswagen rabbit     1
## 177                           amc pacer     0
## 178                          audi 100ls     1
## 179                         peugeot 504     1
## 180                         volvo 244dl     0
## 181                           saab 99le     1
## 182                    honda civic cvcc     1
## 183                            fiat 131     1
## 184                           opel 1900     1
## 185                            capri ii     1
## 186                          dodge colt     1
## 187                        renault 12tl     1
## 188   chevrolet chevelle malibu classic     0
## 189              dodge coronet brougham     0
## 190                         amc matador     0
## 191                     ford gran torino     0
## 192                    plymouth valiant     0
## 193                      chevrolet nova     0
## 194                       ford maverick     1
```

```
## 195                     amc hornet     0
## 196             chevrolet chevette     1
## 197                chevrolet woody     1
## 198                      vw rabbit     1
## 199                    honda civic     1
## 200                 dodge aspen se     0
## 201              ford granada ghia     0
## 202             pontiac ventura sj     0
## 203                  amc pacer d/l     0
## 204              volkswagen rabbit     1
## 205                   datsun b-210     1
## 206                 toyota corolla     1
## 207                     ford pinto     1
## 208                      volvo 245     0
## 209     plymouth volare premier v8     0
## 210                    peugeot 504     0
## 211                 toyota mark ii     0
## 212             mercedes-benz 280s     0
## 213               cadillac seville     0
## 214                      chevy c10     0
## 215                      ford f108     0
## 216                     dodge d100     0
## 217              honda accord cvcc     1
## 218        buick opel isuzu deluxe     1
## 219                  renault 5 gtl     1
## 220              plymouth arrow gs     1
## 221            datsun f-10 hatchback     1
## 222        chevrolet caprice classic     0
## 223      oldsmobile cutlass supreme     0
## 224          dodge monaco brougham     0
## 225         mercury cougar brougham     0
## 226             chevrolet concours     0
## 227                  buick skylark     0
## 228          plymouth volare custom     0
## 229                   ford granada     0
## 230           pontiac grand prix lj     0
## 231    chevrolet monte carlo landau     0
## 232               chrysler cordoba     0
## 233               ford thunderbird     0
## 234        volkswagen rabbit custom     1
## 235           pontiac sunbird coupe     1
## 236        toyota corolla liftback     1
## 237             ford mustang ii 2+2     1
## 238             chevrolet chevette     1
## 239                 dodge colt m/m     1
## 240                      subaru dl     1
## 241              volkswagen dasher     1
## 242                     datsun 810     0
## 243                       bmw 320i     0
## 244                     mazda rx-4     0
## 245 volkswagen rabbit custom diesel     1
## 246                    ford fiesta     1
## 247               mazda glc deluxe     1
## 248                  datsun b210 gx     1
```

```
## 249                       honda civic cvcc     1
## 250    oldsmobile cutlass salon brougham     0
## 251                        dodge diplomat     0
## 252                  mercury monarch ghia     0
## 253                    pontiac phoenix lj     0
## 254                      chevrolet malibu     0
## 255                  ford fairmont (auto)     0
## 256                   ford fairmont (man)     1
## 257                       plymouth volare     0
## 258                           amc concord     0
## 259                 buick century special     0
## 260                        mercury zephyr     0
## 261                           dodge aspen     0
## 262                       amc concord d/l     0
## 263          chevrolet monte carlo landau     0
## 264       buick regal sport coupe (turbo)     0
## 265                           ford futura     0
## 266                       dodge magnum xe     0
## 267                   chevrolet chevette     1
## 268                         toyota corona     1
## 269                            datsun 510     1
## 270                            dodge omni     1
## 271             toyota celica gt liftback     0
## 272                      plymouth sapporo     1
## 273                oldsmobile starfire sx     1
## 274                         datsun 200-sx     1
## 275                             audi 5000     0
## 276                           volvo 264gl     0
## 277                            saab 99gle     0
## 278                         peugeot 604sl     0
## 279                   volkswagen scirocco     1
## 280                        honda accord lx     1
## 281                     pontiac lemans v6     0
## 282                      mercury zephyr 6     0
## 283                       ford fairmont 4     0
## 284                      amc concord dl 6     0
## 285                         dodge aspen 6     0
## 286              chevrolet caprice classic     0
## 287                       ford ltd landau     0
## 288                 mercury grand marquis     0
## 289                       dodge st. regis     0
## 290               buick estate wagon (sw)     0
## 291              ford country squire (sw)     0
## 292         chevrolet malibu classic (sw)     0
## 293 chrysler lebaron town @ country (sw)     0
## 294                      vw rabbit custom     1
## 295                      maxda glc deluxe     1
## 296           dodge colt hatchback custom     1
## 297                          amc spirit dl     1
## 298                    mercedes benz 300d     1
## 299                     cadillac eldorado     1
## 300                           peugeot 504     1
## 301    oldsmobile cutlass salon brougham     1
## 302                      plymouth horizon     1
```

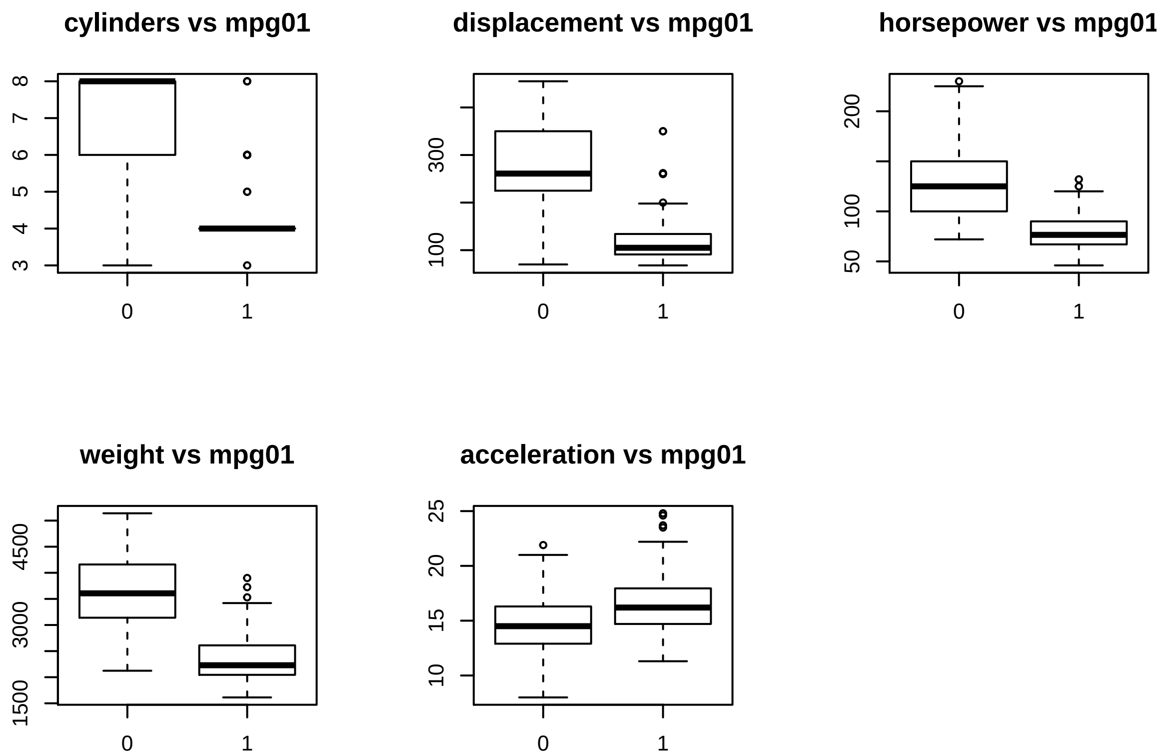
```
## 303              plymouth horizon tc3     1
## 304                        datsun 210     1
## 305                fiat strada custom     1
## 306             buick skylark limited     1
## 307                chevrolet citation     1
## 308          oldsmobile omega brougham    1
## 309                   pontiac phoenix     1
## 310                         vw rabbit     1
## 311             toyota corolla tercel     1
## 312                chevrolet chevette     1
## 313                        datsun 310     1
## 314                chevrolet citation     1
## 315                     ford fairmont     1
## 316                       amc concord     1
## 317                       dodge aspen     0
## 318                         audi 4000     1
## 319            toyota corona liftback     1
## 320                         mazda 626     1
## 321              datsun 510 hatchback     1
## 322                    toyota corolla     1
## 323                         mazda glc     1
## 324                        dodge colt     1
## 325                        datsun 210     1
## 326              vw rabbit c (diesel)     1
## 327                vw dasher (diesel)     1
## 328               audi 5000s (diesel)     1
## 329                mercedes-benz 240d     1
## 330               honda civic 1500 gl     1
## 332                         subaru dl     1
## 333                  vokswagen rabbit     1
## 334                     datsun 280-zx     1
## 335                     mazda rx-7 gs     1
## 336                 triumph tr7 coupe     1
## 338                      honda accord     1
## 339                  plymouth reliant     1
## 340                     buick skylark     1
## 341            dodge aries wagon (sw)     1
## 342                chevrolet citation     1
## 343                  plymouth reliant     1
## 344                    toyota starlet     1
## 345                    plymouth champ     1
## 346                  honda civic 1300     1
## 347                            subaru     1
## 348                    datsun 210 mpg     1
## 349                     toyota tercel     1
## 350                       mazda glc 4     1
## 351                plymouth horizon 4     1
## 352                    ford escort 4w     1
## 353                    ford escort 2h     1
## 354                  volkswagen jetta     1
## 356                     honda prelude     1
## 357                    toyota corolla     1
## 358                      datsun 200sx     1
## 359                         mazda 626     1
```

```
## 360           peugeot 505s turbo diesel     1
## 361                        volvo diesel     1
## 362                     toyota cressida     1
## 363                   datsun 810 maxima     1
## 364                       buick century     0
## 365               oldsmobile cutlass ls     1
## 366                     ford granada gl     0
## 367              chrysler lebaron salon     0
## 368                 chevrolet cavalier      1
## 369           chevrolet cavalier wagon      1
## 370          chevrolet cavalier 2-door      1
## 371         pontiac j2000 se hatchback      1
## 372                     dodge aries se      1
## 373                    pontiac phoenix      1
## 374               ford fairmont futura      1
## 375                 volkswagen rabbit l     1
## 376                  mazda glc custom l     1
## 377                    mazda glc custom     1
## 378              plymouth horizon miser     1
## 379                      mercury lynx l     1
## 380                    nissan stanza xe     1
## 381                        honda accord     1
## 382                      toyota corolla     1
## 383                         honda civic     1
## 384                  honda civic (auto)     1
## 385                       datsun 310 gx     1
## 386               buick century limited     1
## 387   oldsmobile cutlass ciera (diesel)     1
## 388          chrysler lebaron medallion     1
## 389                      ford granada l     0
## 390                    toyota celica gt     1
## 391                   dodge charger 2.2     1
## 392                    chevrolet camaro     1
## 393                     ford mustang gl     1
## 394                           vw pickup     1
## 395                       dodge rampage     1
## 396                         ford ranger     1
## 397                          chevy s-10     1
```

(b)

```
par(mfrow=c(2,3))
name=c("cylinders","displacement","horsepower","weight","acceleration")

boxplot(cylinders ~ mpg01, data = mpg01, main = "cylinders vs mpg01")
boxplot(displacement ~ mpg01, data = mpg01, main = "displacement vs mpg01")
boxplot(horsepower~ mpg01, data = mpg01, main = "horsepower vs mpg01")
boxplot(weight ~ mpg01, data = mpg01, main = "weight vs mpg01")
boxplot(acceleration ~ mpg01, data = mpg01, main = "acceleration vs mpg01")
```



#(c)

```r
set.seed(1)
rows <- sample(x=nrow(mpg01), size=0.8*nrow(mpg01))
rows
```

```
##   [1] 105 146 224 354  79 348 365 255 242  24 388  68 262 391 292 188 270
##  [18] 372 143 290 387 382 384  47  99 142   5 140 317 124 175 217 178  67
##  [35] 297 239 283  39 257 379 289 228 275 194 185 274   9 165 252 238 164
##  [52] 294 149  83 383  34 107 174 222 136 304  98 152 110 214  85 157 250
##  [69]  28 356 329 376 111 336 330 323 347 123 245 301 333 334 363 101 234
##  [86]  63 218  38  75  44  73  18 193 263 233 237 135 121 357 360 192 103
## [103] 371 287 183  62 305 137 299 170 276 206 100 295  42   4 198  29 315
## [120] 362 321 296 131 369 203 122 312  55  61 326 151  21  10 167 240 154
## [137] 144 271 251 129 173 380  60  65 181 112 303 288  26 211 340 385 373
## [154] 109 120  43 125 313 249  50 359 207 291 179 201  94  15  76 163 225
## [171] 386 186 189  86 339 195 311 160 130 300 307  41 187 106 314  40 284
## [188] 370 213 247 256 258 261 375  57 117  22 342 352 318  52 278 368  51
## [205]  35  97 392 338  48 132 273  19 138 364 353 265 115 259 166  59  46
## [222] 350 177  87 156 219 358   8  69 216 282 196 325 309 349 341 108 169
## [239] 232  70 269  88 285 161 158  32 212  20 389 241 281 208  66  84 202
## [256] 226 337 381 298 236 153 191  37 102  90 200 346  95  77 127 345  14
## [273] 172 316  36  23  30 119 229 254 277 344 210 243   6 150 377  17 279
## [290] 197 199 104 190  33 134 180 260  12 366 155 148 126  45 272 266  93
## [307]  16 141 168 113 133 182 374
```

```r
trainset <- mpg01[rows, ]
testset <- mpg01[-rows, ]
```

(d)

```
lda.fit <- lda(mpg01 ~ displacement+horsepower+weight+acceleration+year+cylinders+origin, data=trainset)
lda.pred <- predict(lda.fit, testset)
table(testset$mpg01, lda.pred$class)
```

```
##
##      0  1
##   0 30  5
##   1  0 44
```

```
# accuracy of 0=100%, accuracy of 1=44/(44+5)
```

(e)

```
qda.fit <- qda(mpg01 ~ displacement+horsepower+weight+acceleration+year+cylinders+origin, data=trainset)
qda.pred <- predict(qda.fit, testset)
table(testset$mpg01, qda.pred$class)
```

```
##
##      0  1
##   0 32  3
##   1  2 42
```

```
# accuracy of 0=32/(32+2), accuracy of 1=42/(3+42)
```

(f)

```
modf <- glm(as.factor(mpg01) ~ displacement+horsepower+weight+acceleration+year+cylinders+origin, data=
lr.probs <- predict(modf , testset, type="response")
lr.pred <- ifelse(lr.probs>0.5, "1", "0")
table(testset$mpg01, lr.pred)
```

```
##    lr.pred
##      0  1
##   0 30  5
##   1  1 43
```

```
# accuracy of 0=30/(30+1), accuracy of 1=43/(5+43)
```

(g)

4.12 (a)

```
Power <- function(){ print( 2^3)}
Power()
```

```
## [1] 8
```

(b)

```r
Power2 <- function(x,a){
  print( x^a)
}

Power2(3,8)
```

```
## [1] 6561
```

(c)

```r
Power2(10,3)
```

```
## [1] 1000
```

```r
Power2(8,17)
```

```
## [1] 2.2518e+15
```

```r
Power2(131,3)
```

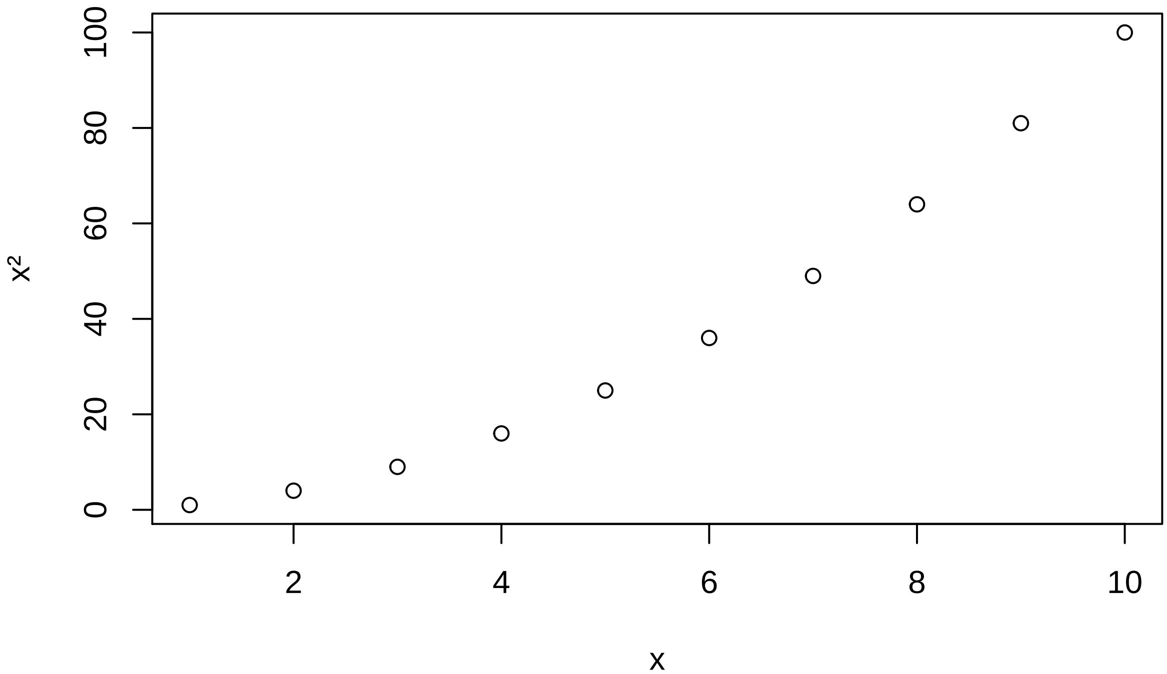
```
## [1] 2248091
```

(d)

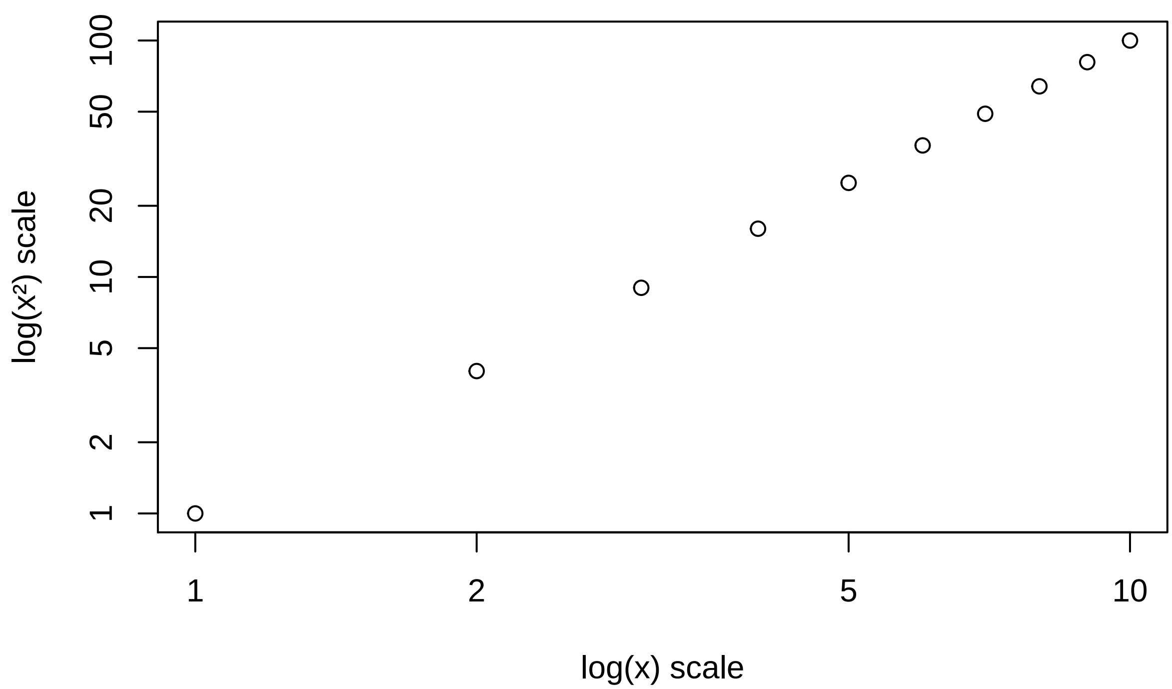
```r
Power3 <- function(x,a){
  return( x^a)
}
```

(f)

```r
plot(x = x<-1:10, y= y<-Power3(x,2), xlab="x", ylab="x²")
```



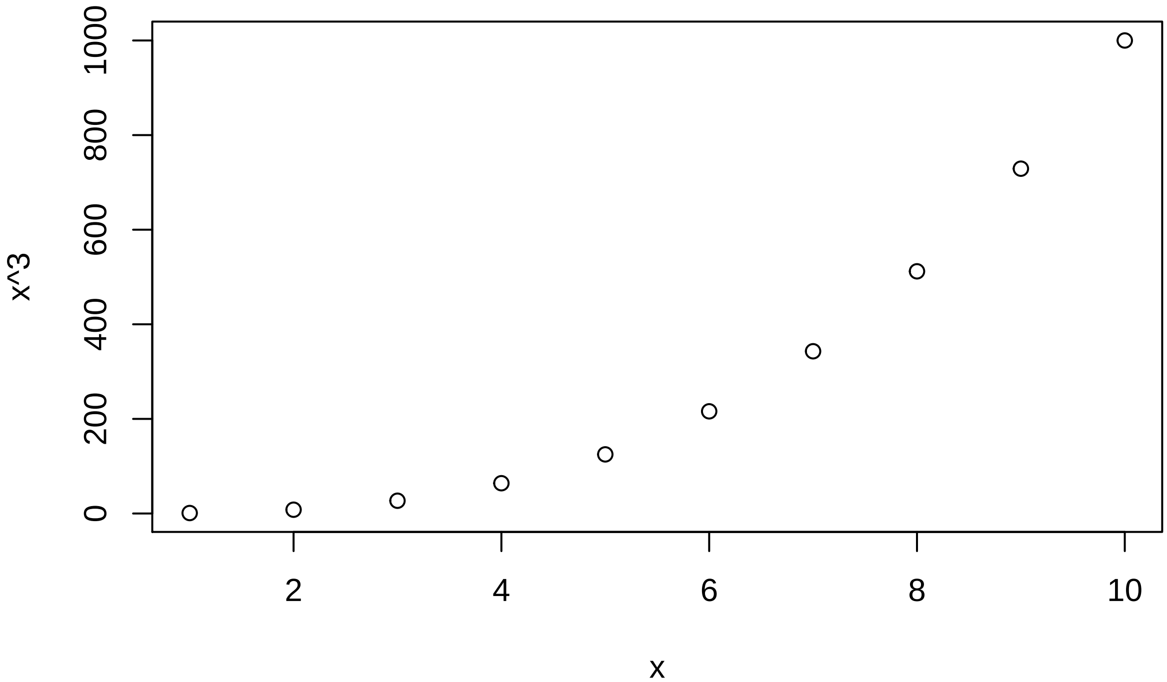

```
plot(x,y,log="xy", xlab="log(x) scale", ylab="log(x²) scale")
```



#(g)

```
PlotPower <- function(x,a){
  plot(x = x, y= y<-Power3(x,a), xlab="x", ylab=paste0("x^",a))
}

PlotPower(1:10,3)
```



1000
800
600
400
200
0
x^3
2
4
6
8
10
x