ASSIGNMENT 3

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```r
#Problem1(a)
# Read the data
data <- read.csv("college.csv")

#a) Analyze distribution of Grad.Rate
# Load necessary libraries
library(ggplot2)
# Plot the distribution of Grad.Rate
ggplot(data, aes(x=Grad.Rate)) + geom_histogram(binwidth=5, fill="blue", color="black") +
  labs(title="Distribution of Grad.Rate", x="Graduation Rate", y="Frequency") +
  theme_minimal()
```
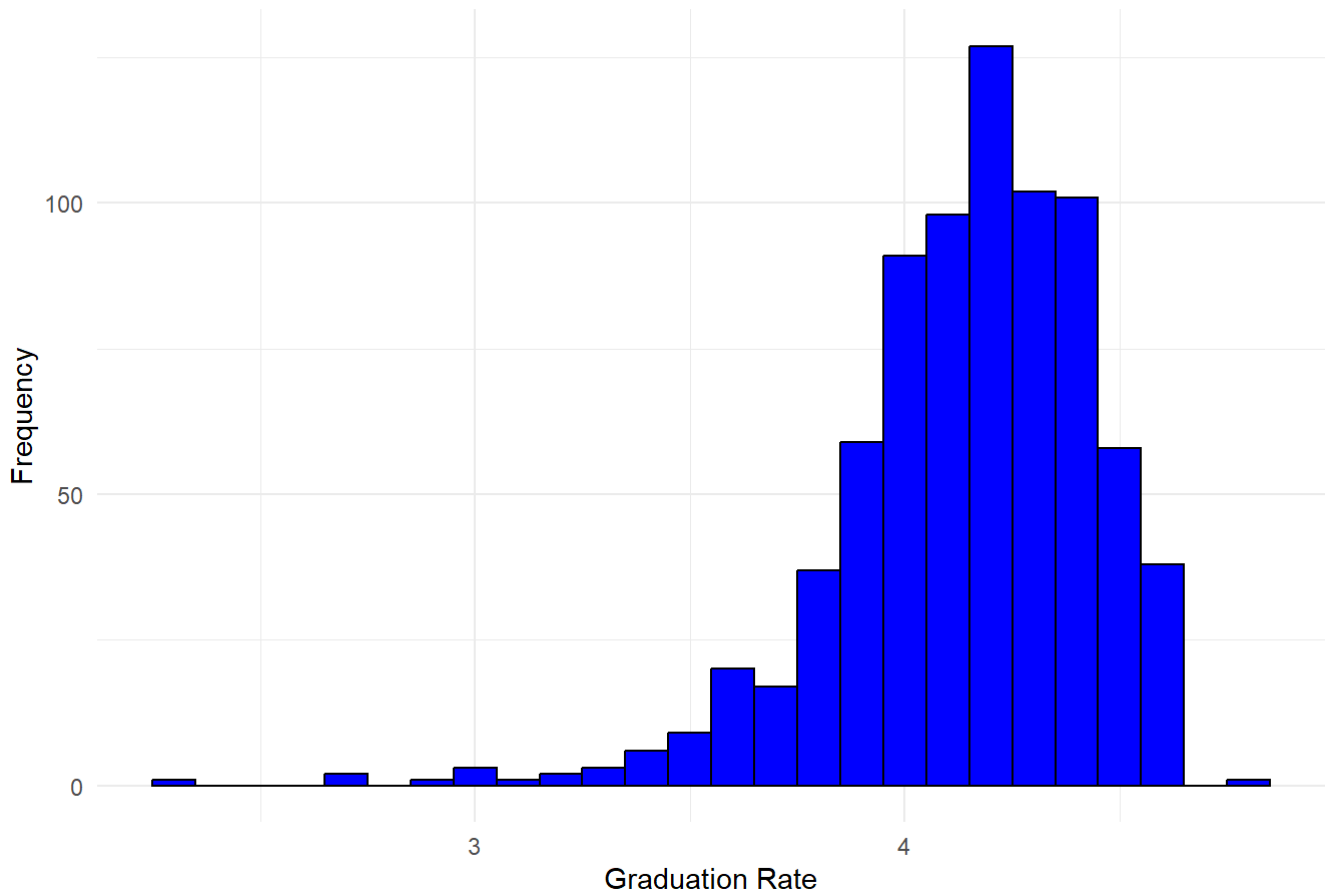

Distribution of Grad.Rate

```r
data$Grad.Rate<-log(data$Grad.Rate)

ggplot(data, aes(x=Grad.Rate)) + geom_histogram(binwidth=0.1, fill="blue", color="black") +
  labs(title="Transformed Distribution of Grad.Rate", x="Graduation Rate", y="Frequency") +
  theme_minimal()
```

Transformed Distribution of Grad.Rate

#Problem1(b)

```
#b) Scatterplots for Grad.Rate vs each independent variable
# Creating scatterplots for each variable
independent_vars <- names(data)[2:(ncol(data)-1)] # Exclude 'school' and 'Grad.Rate'
for (var in independent_vars) {
  print(ggplot(data, aes_string(x=var, y="Grad.Rate")) + geom_point(alpha=0.5) + theme_minimal())
}
```

```
## Warning: `aes_string()` was deprecated in ggplot2 3.0.0.
## i Please use tidy evaluation idioms with `aes()`.
## i See also `vignette("ggplot2-in-packages")` for more information.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```
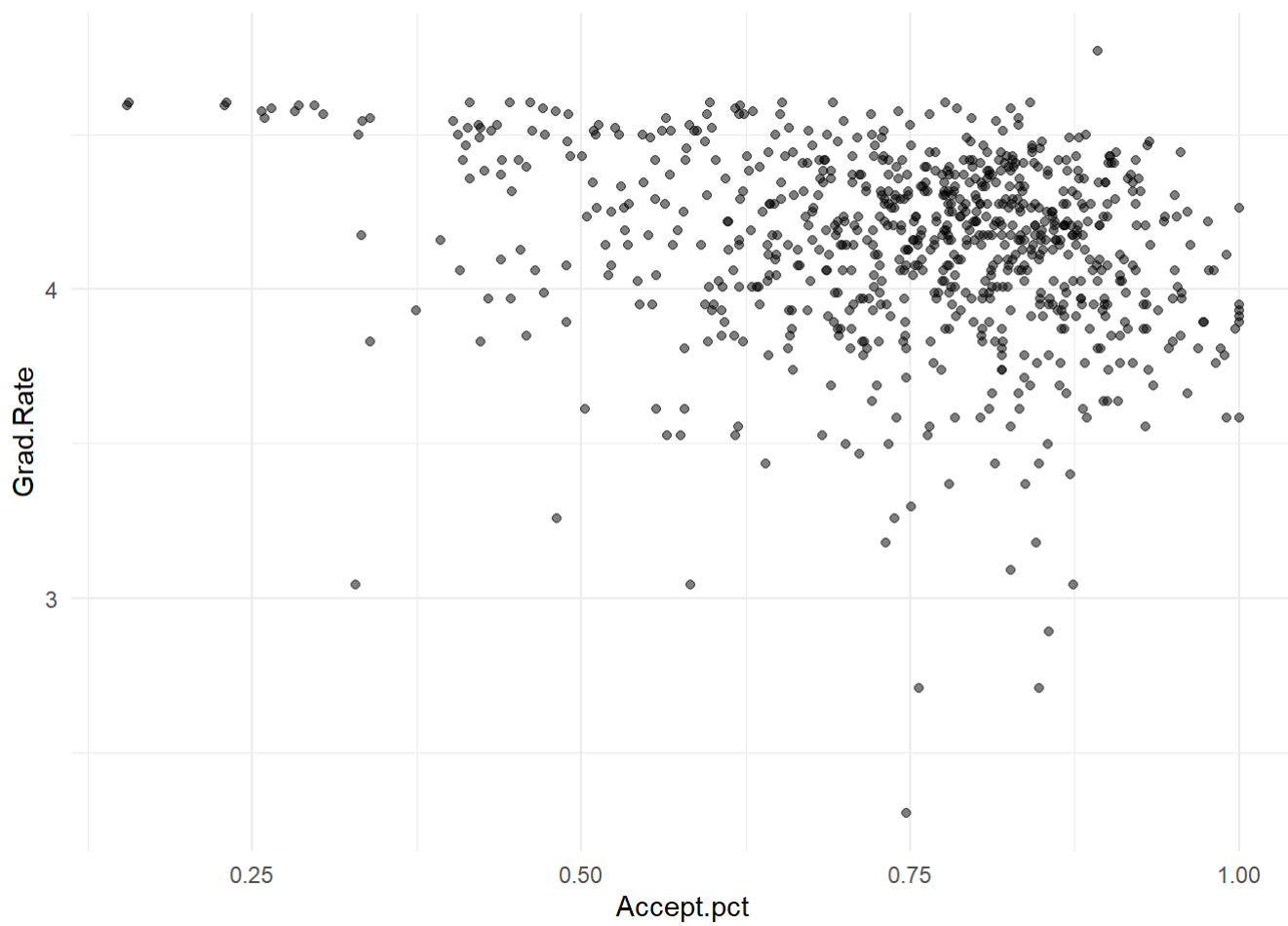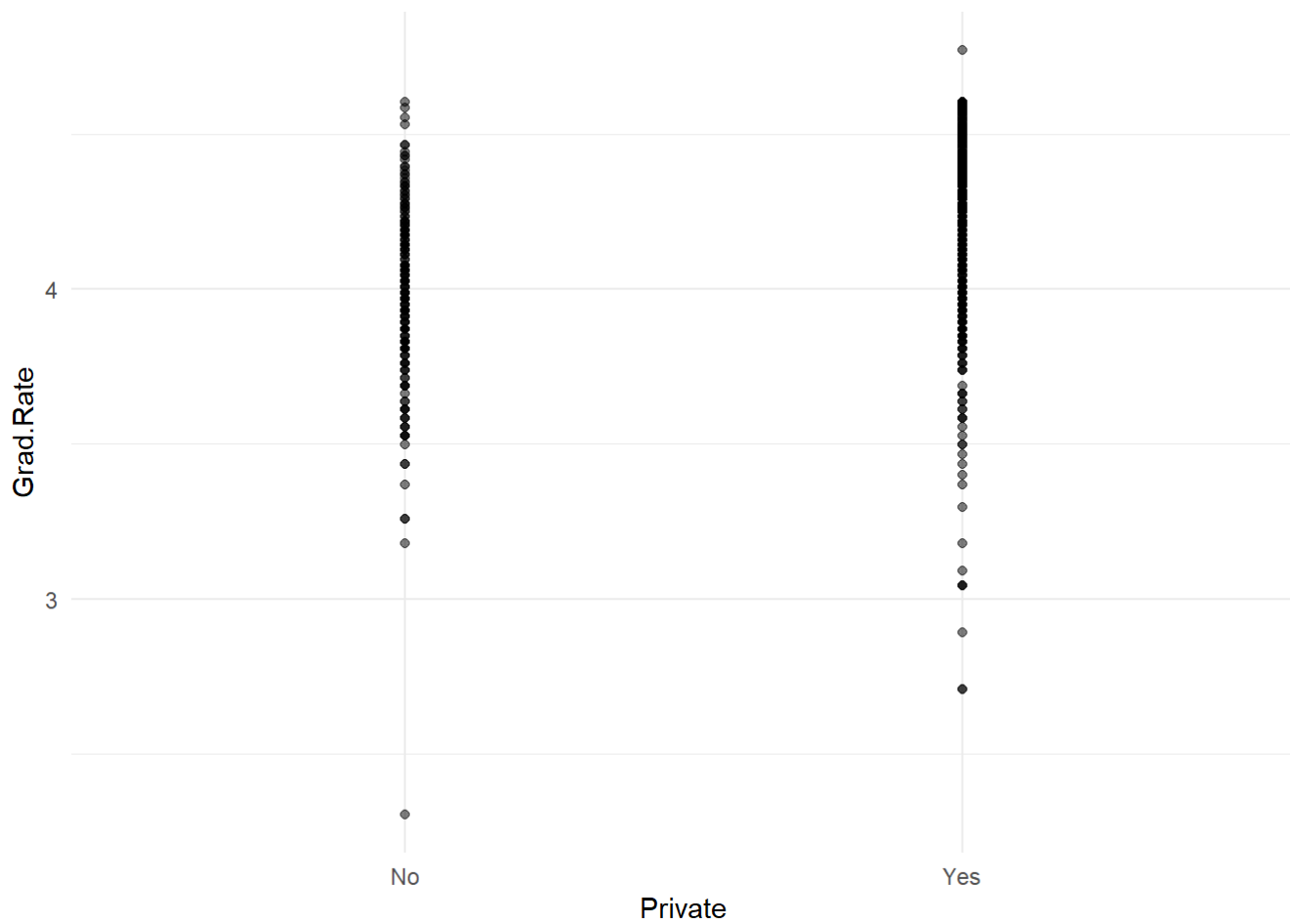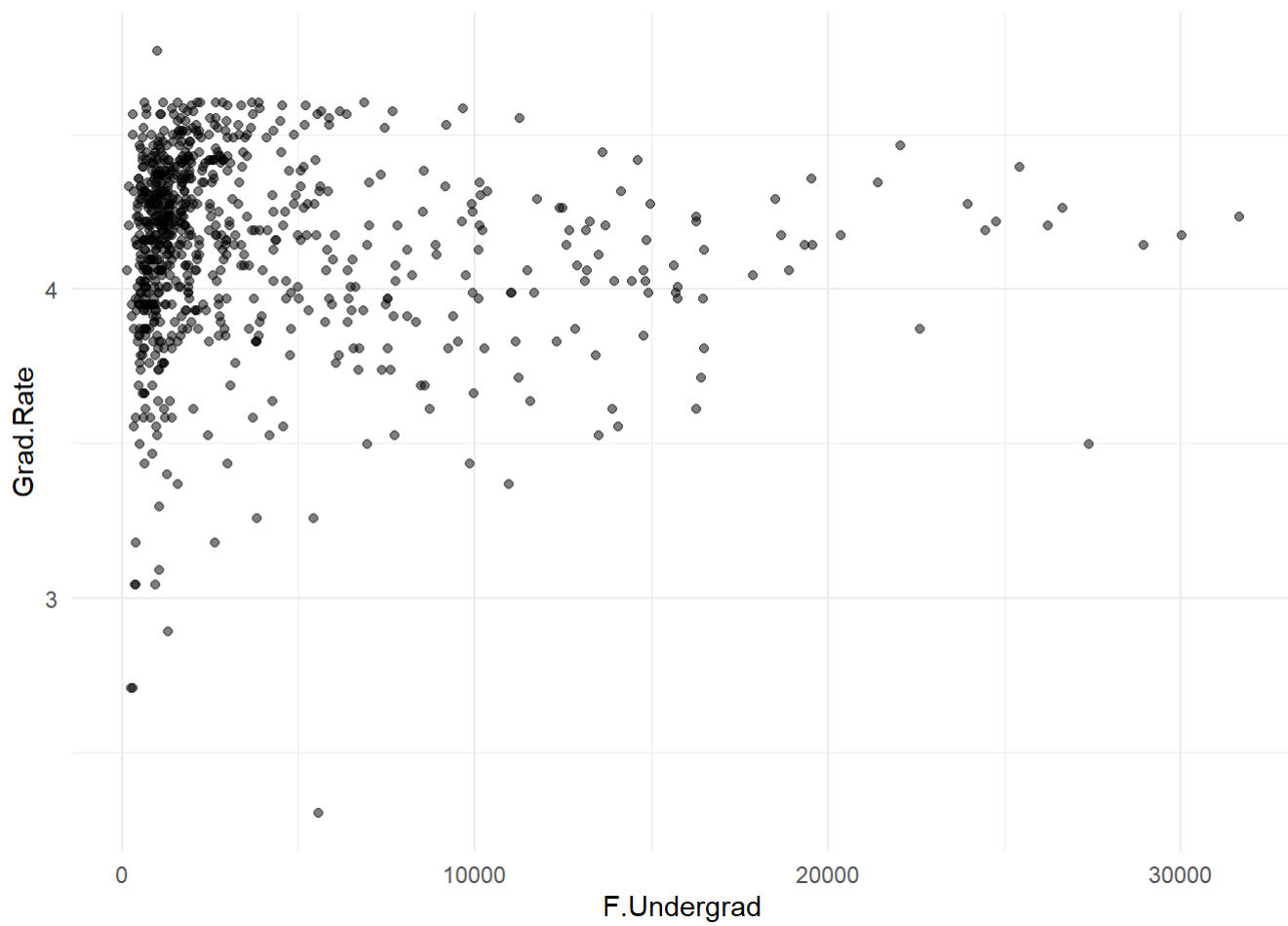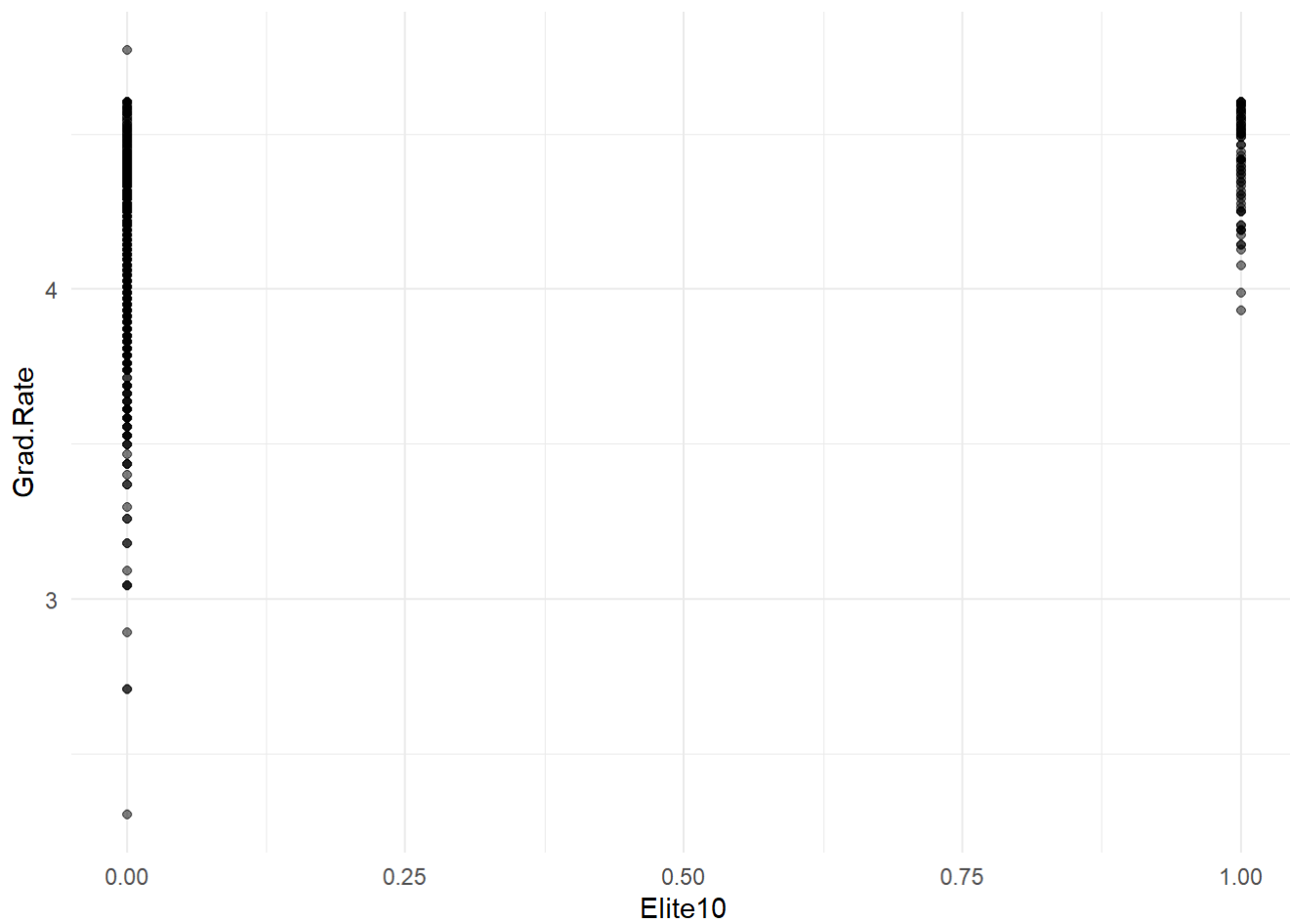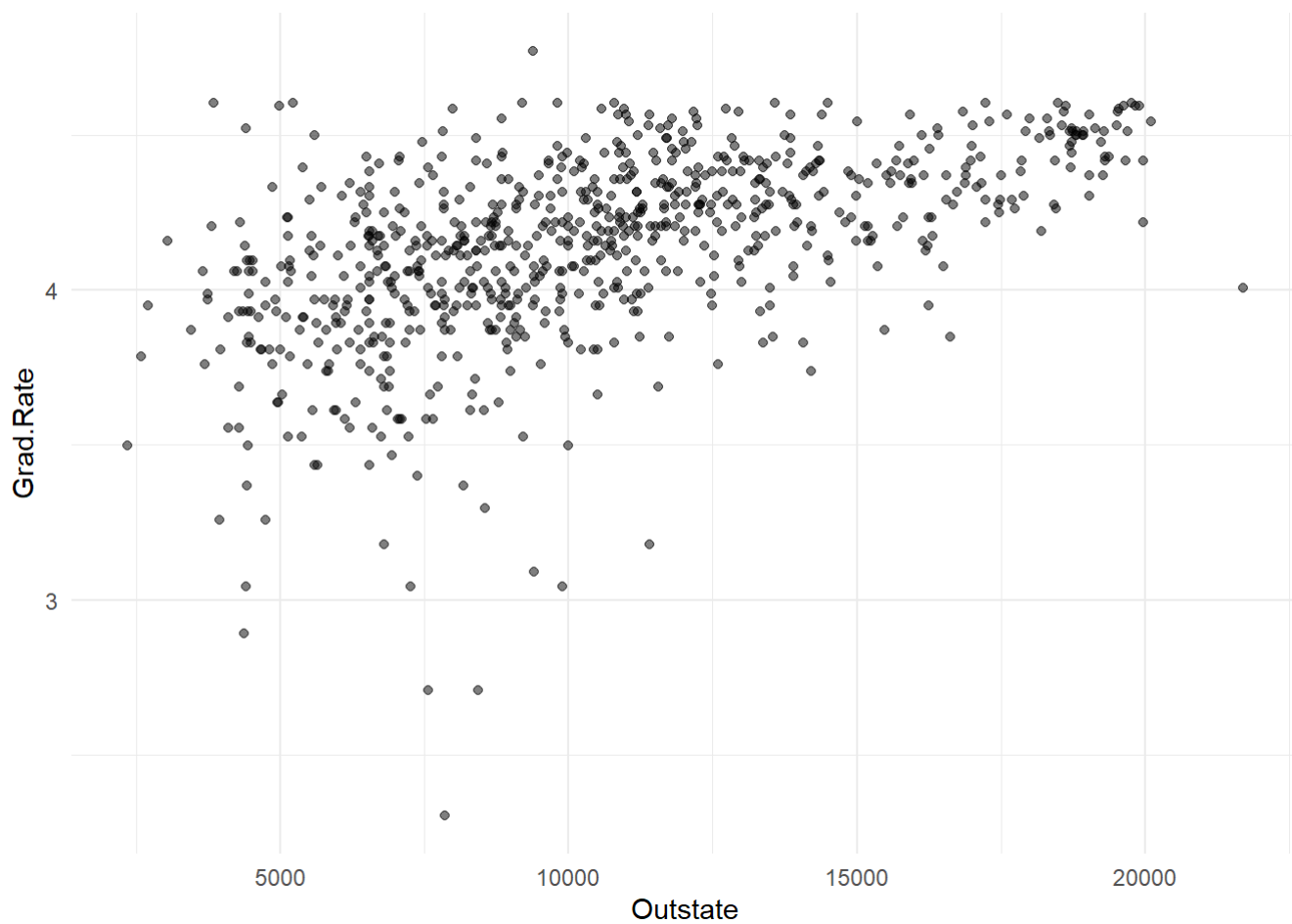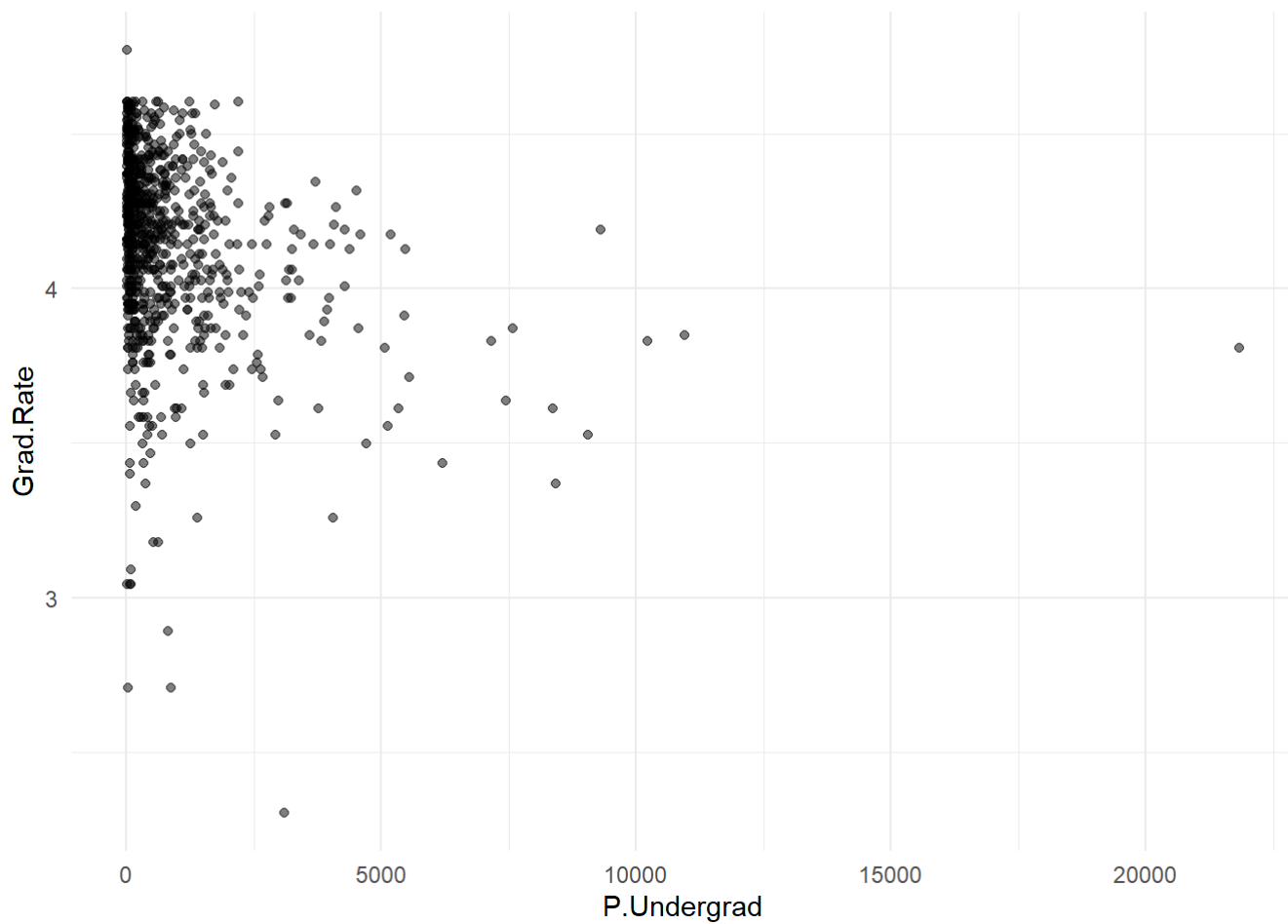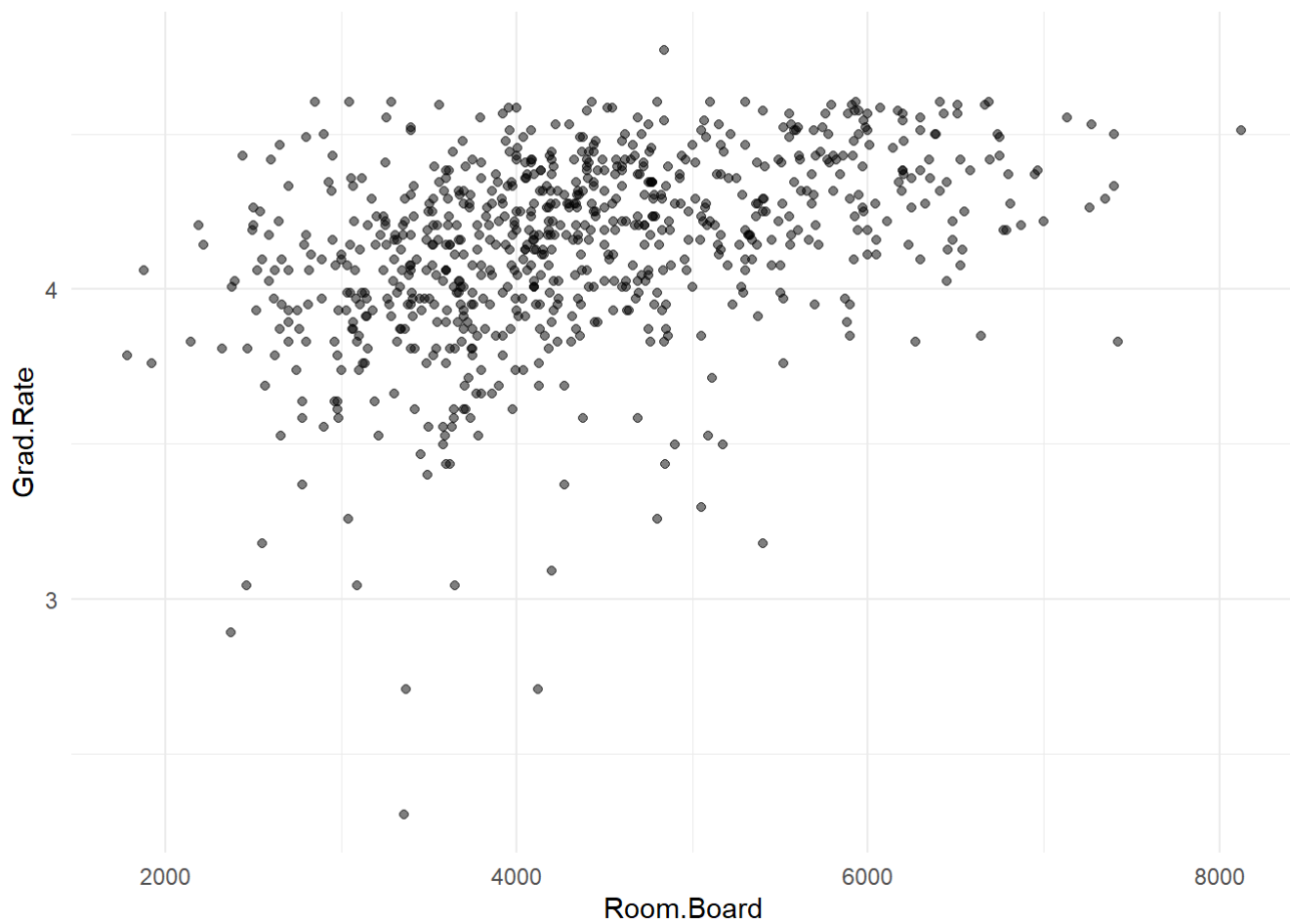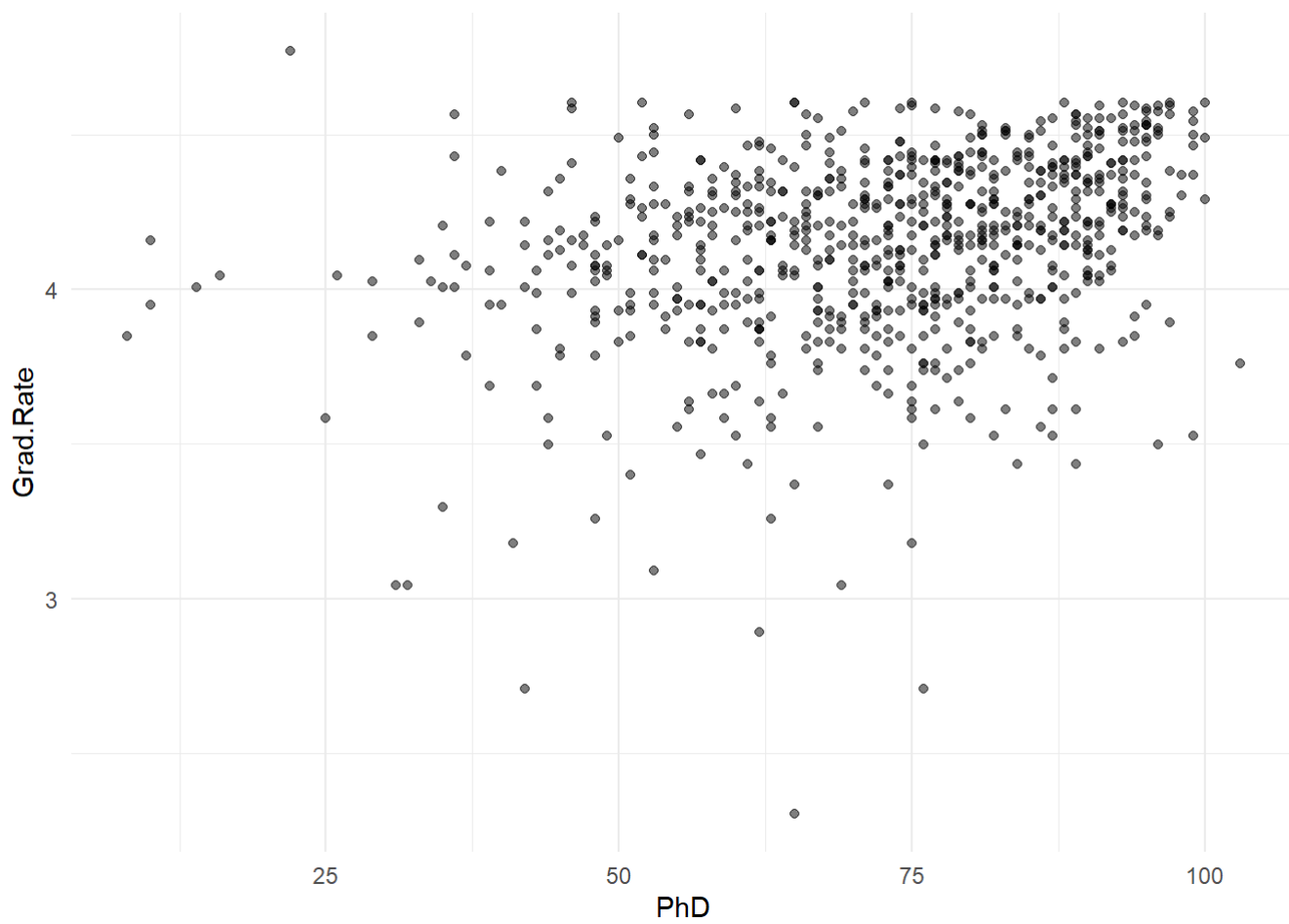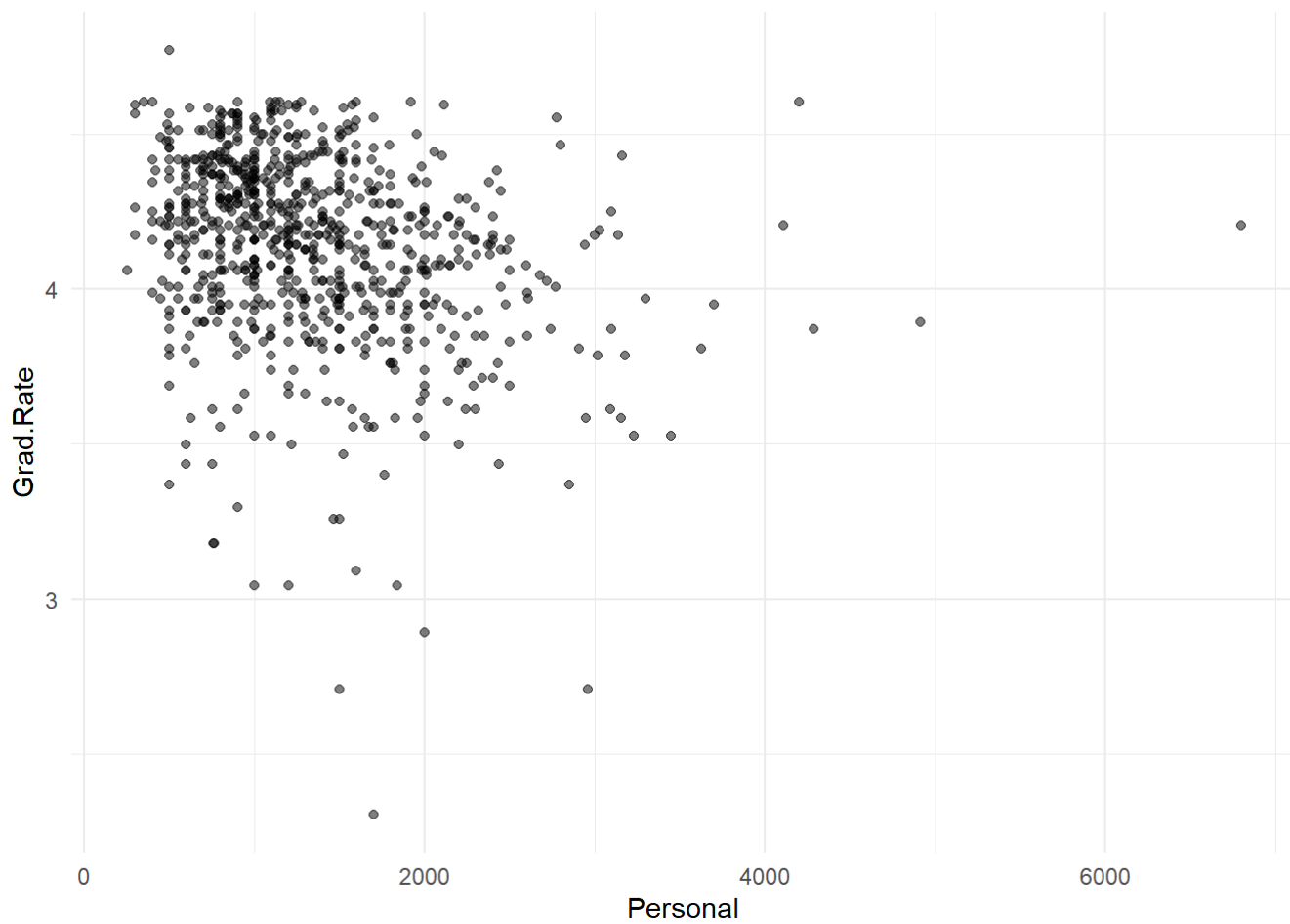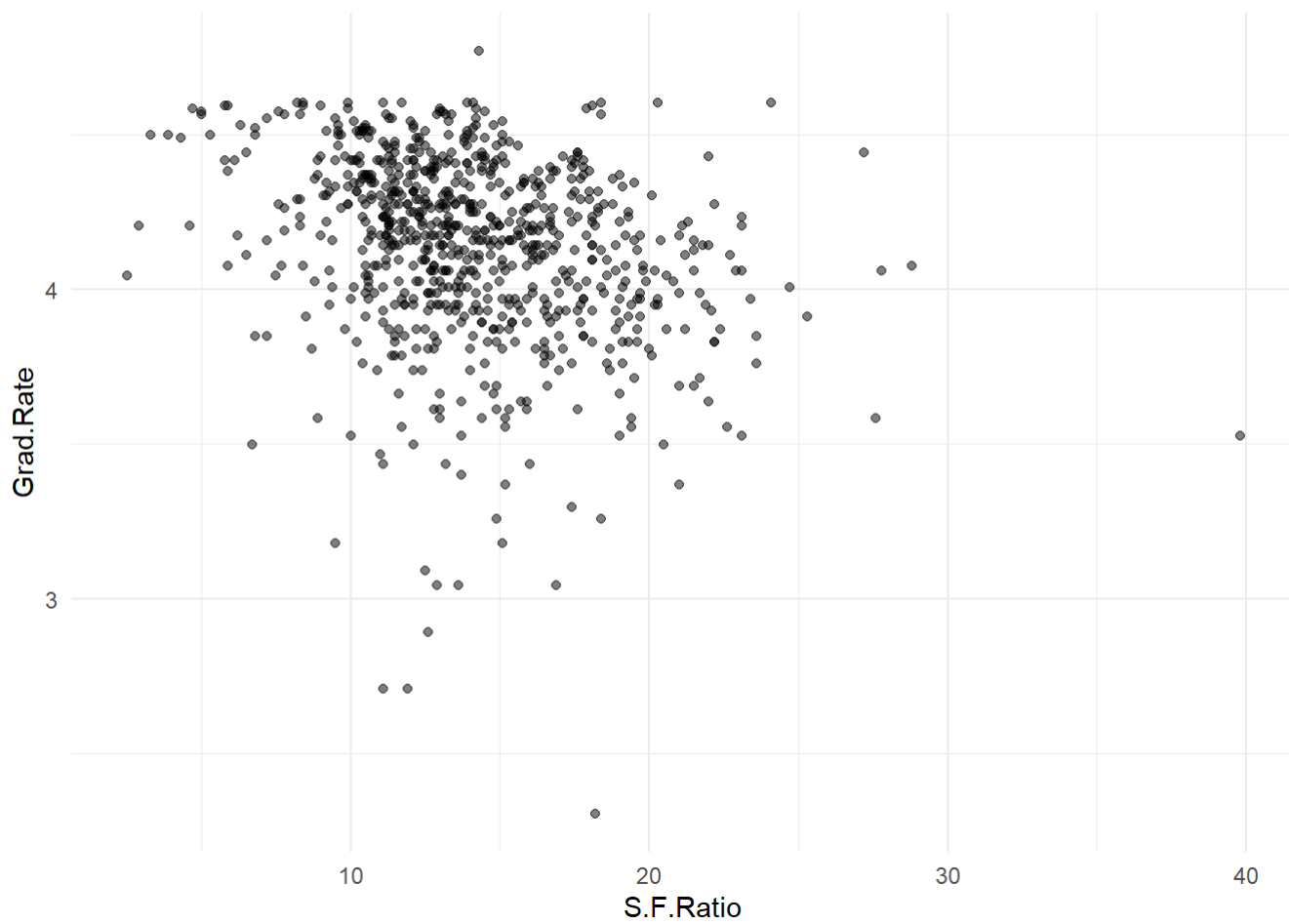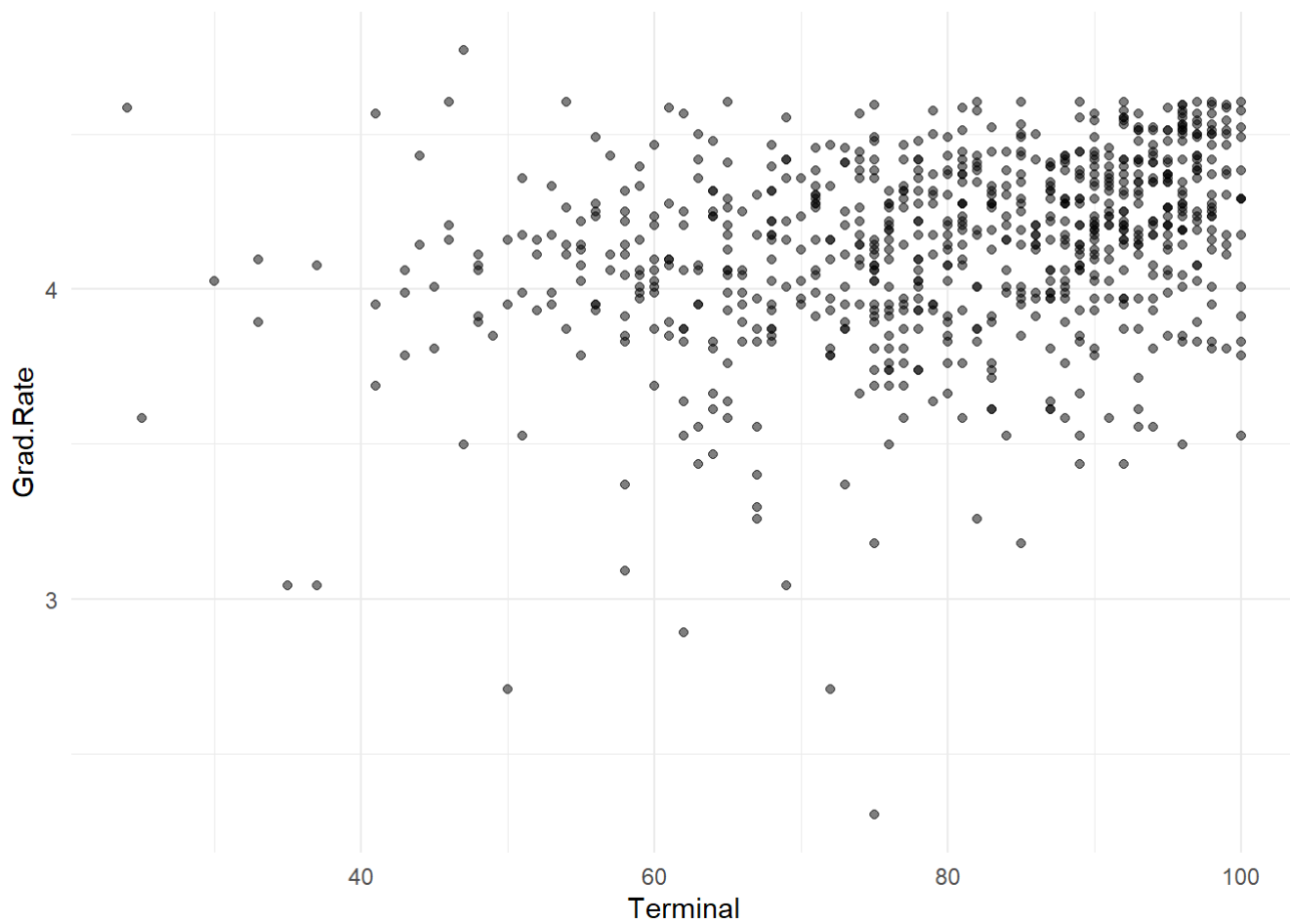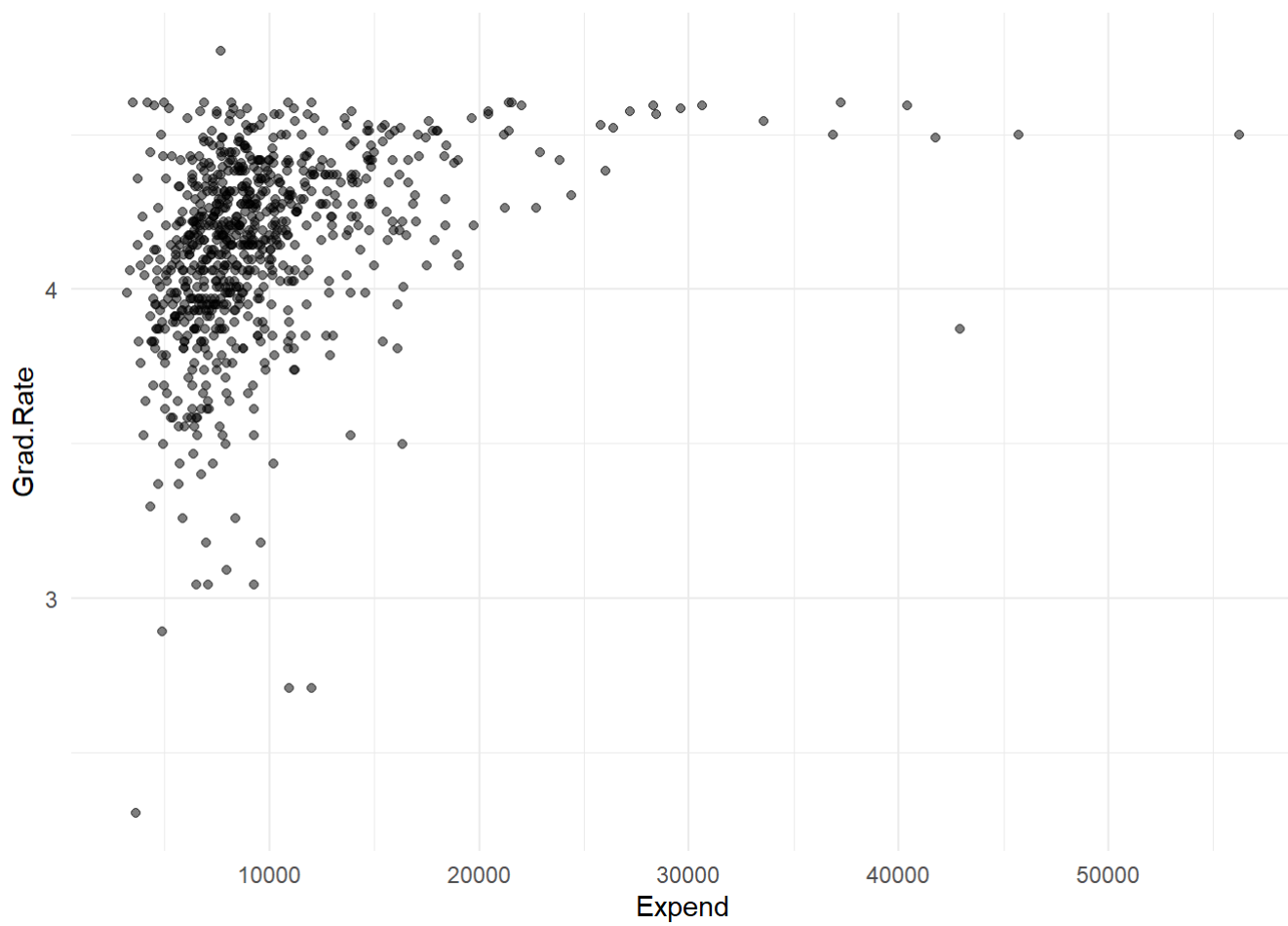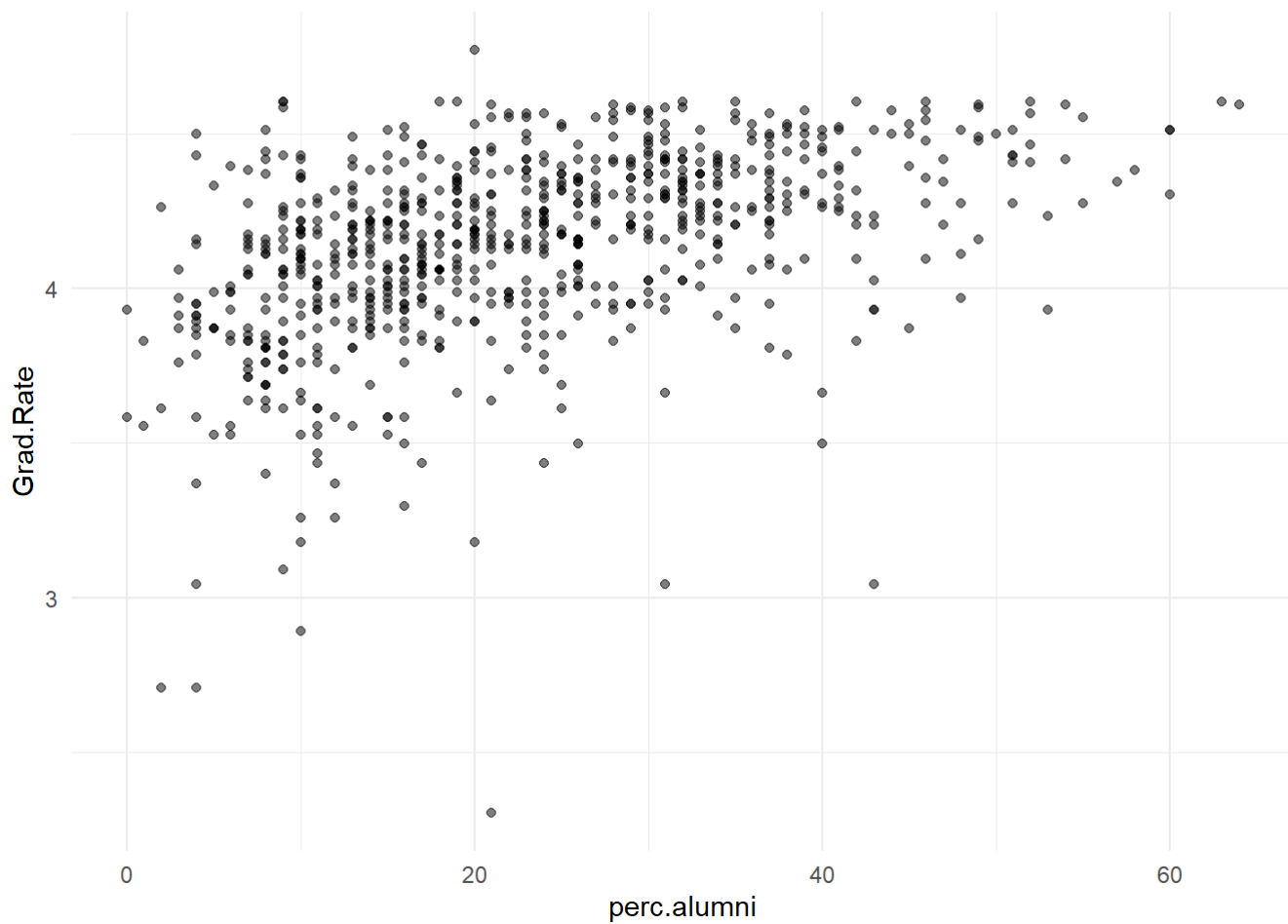
```r
# Correlation analysis

correlation_matrix<-cor(data[,-c(1,2)])
correlation_matrix
```

```
##                 Accept.pct      Elite10 F.Undergrad P.Undergrad     Outstate
## Accept.pct     1.00000000 -0.46245330 -0.15565379 -0.09228664 -0.24095073
## Elite10        -0.46245330  1.00000000  0.06083999 -0.11644570  0.39947675
## F.Undergrad    -0.15565379  0.06083999  1.00000000  0.57051219 -0.21574200
## P.Undergrad    -0.09228664 -0.11644570  0.57051219  1.00000000 -0.25351232
## Outstate       -0.24095073  0.39947675 -0.21574200 -0.25351232  1.00000000
## Room.Board     -0.31030204  0.29847208 -0.06889039 -0.06132551  0.65425640
## Books          -0.17407288  0.09217607  0.11554976  0.08119952  0.03885487
## Personal        0.01997851 -0.07526924  0.31719954  0.31988162 -0.29908690
## PhD            -0.31833394  0.34106219  0.31833697  0.14911422  0.38298241
## Terminal       -0.30379999  0.32664984  0.30001894  0.14190357  0.40798320
## S.F.Ratio       0.10998188 -0.29349738  0.27970335  0.23253051 -0.55482128
## perc.alumni    -0.13210402  0.30259090 -0.22946222 -0.28079236  0.56626242
## Expend         -0.40862232  0.55977784  0.01865162 -0.08356842  0.67277862
## Grad.Rate      -0.22948475  0.30150616 -0.06248495 -0.25004967  0.53324387
##                 Room.Board        Books     Personal         PhD     Terminal
## Accept.pct     -0.31030204 -0.174072883  0.01997851 -0.31833394 -0.30379999
## Elite10         0.29847208  0.092176073 -0.07526924  0.34106219  0.32664984
## F.Undergrad    -0.06889039  0.115549761  0.31719954  0.31833697  0.30001894
## P.Undergrad    -0.06132551  0.081199521  0.31988162  0.14911422  0.14190357
## Outstate        0.65425640  0.038854868 -0.29908690  0.38298241  0.40798320
## Room.Board      1.00000000  0.127962970 -0.19942818  0.32920228  0.37453955
## Books           0.12796297  1.000000000  0.17929476  0.02690573  0.09995470
## Personal       -0.19942818  0.179294764  1.00000000 -0.01093579 -0.03061311
## PhD             0.32920228  0.026905731 -0.01093579  1.00000000  0.84958703
## Terminal        0.37453955  0.099954700 -0.03061311  0.84958703  1.00000000
## S.F.Ratio      -0.36262774 -0.031929274  0.13634483 -0.13053011 -0.16010395
## perc.alumni     0.27236345 -0.040207736 -0.28596808  0.24900866  0.26713029
## Expend          0.50173942  0.112409075 -0.09789189  0.43276168  0.43879922
## Grad.Rate       0.39867414 -0.006404662 -0.25855499  0.29453029  0.28611348
##                  S.F.Ratio perc.alumni      Expend    Grad.Rate
## Accept.pct      0.10998188 -0.13210402 -0.40862232 -0.229484755
## Elite10        -0.29349738  0.30259090  0.55977784  0.301506162
## F.Undergrad     0.27970335 -0.22946222  0.01865162 -0.062484953
## P.Undergrad     0.23253051 -0.28079236 -0.08356842 -0.250049668
## Outstate       -0.55482128  0.56626242  0.67277862  0.533243871
## Room.Board     -0.36262774  0.27236345  0.50173942  0.398674142
## Books          -0.03192927 -0.04020774  0.11240908 -0.006404662
## Personal        0.13634483 -0.28596808 -0.09789189 -0.258554989
## PhD            -0.13053011  0.24900866  0.43276168  0.294530290
## Terminal       -0.16010395  0.26713029  0.43879922  0.286113484
## S.F.Ratio       1.00000000 -0.40292917 -0.58383204 -0.274912522
## perc.alumni    -0.40292917  1.00000000  0.41771172  0.457131186
## Expend         -0.58383204  0.41771172  1.00000000  0.345480592
## Grad.Rate      -0.27491252  0.45713119  0.34548059  1.000000000
```
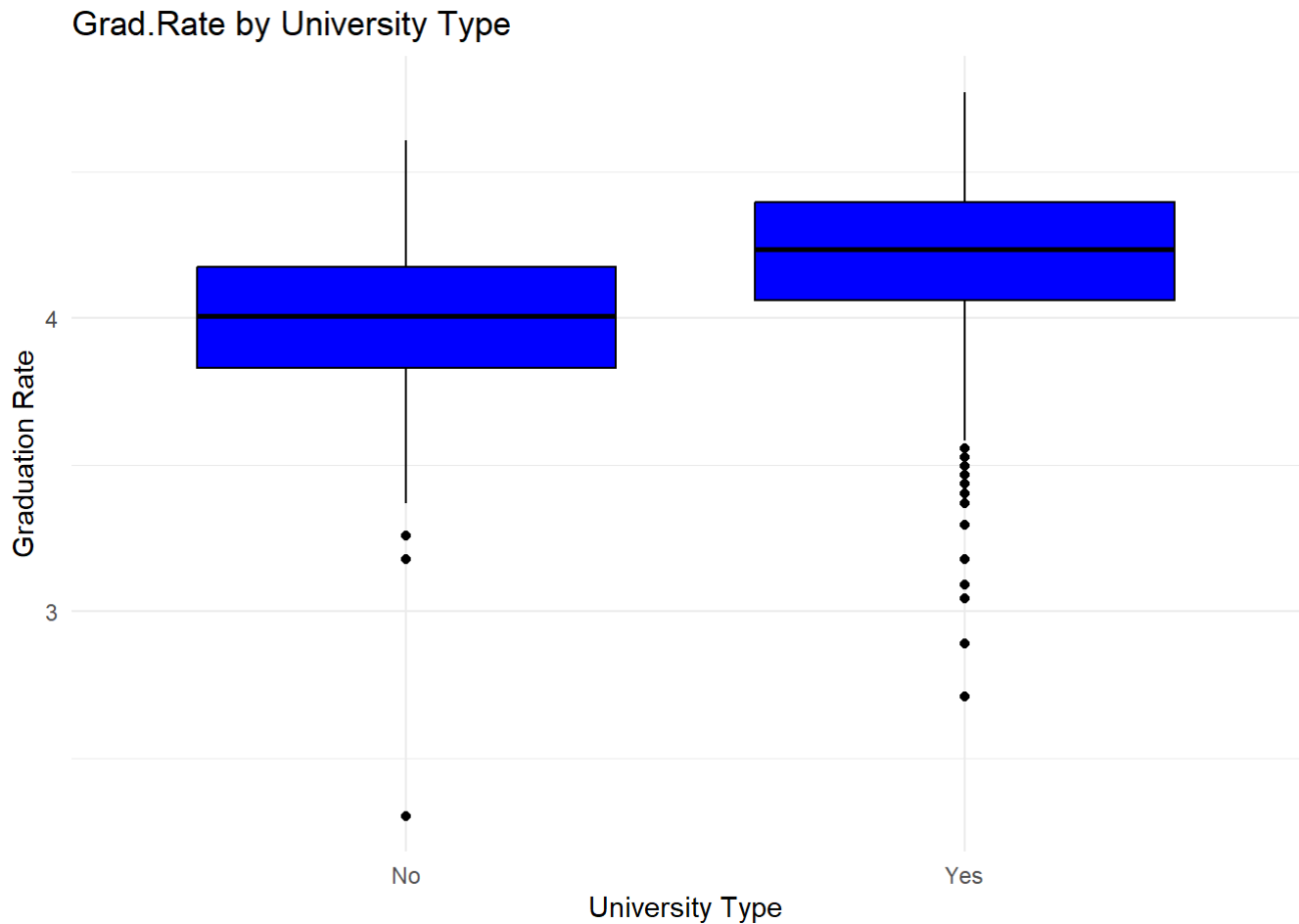
#Problem1(c)

```
#c) Boxplots for graduation rates by university type and elite status

# Boxplot for Grad.Rate by Private/Public University
ggplot(data, aes(x=Private, y=Grad.Rate)) +
  geom_boxplot(fill="blue", color="black") +
  labs(title="Grad.Rate by University Type", x="University Type", y="Graduation Rate") +
  theme_minimal()
```

Grad.Rate by University Type


```
# Boxplot for Grad.Rate by Elite/Not Elite Status
ggplot(data, aes(x=factor(Elite10), y=Grad.Rate)) +
  geom_boxplot(fill="green", color="black") +
  labs(title="Grad.Rate by Elite Status", x="Elite Status (1=Elite, 0=Not Elite)", y="Graduat
ion Rate") +
  theme_minimal()
```

Grad.Rate by Elite Status
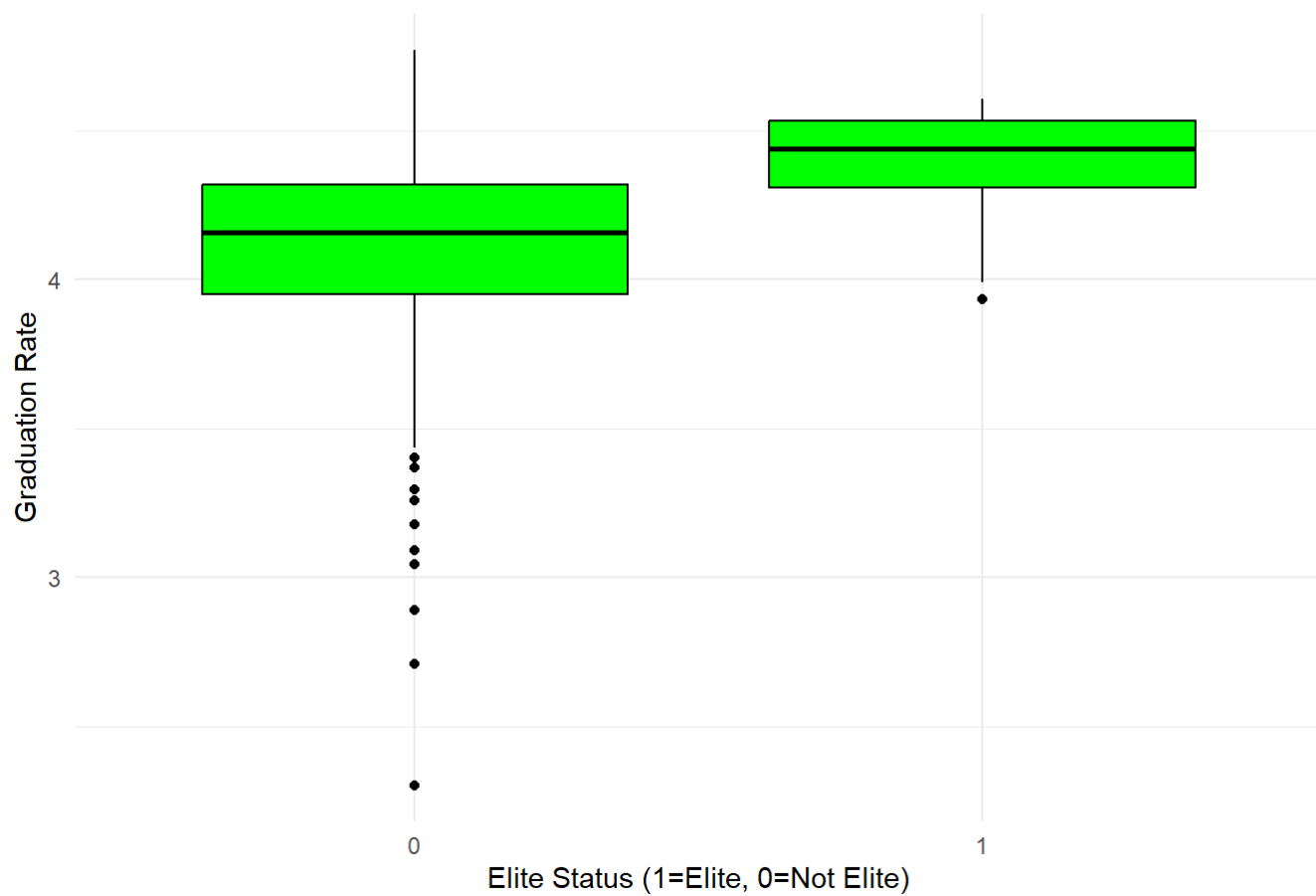
#Problem1(d)

```
#d) Fit a full model
full_model <- lm(Grad.Rate ~ . - school, data=data)
summary(full_model)
```

```
##
## Call:
## lm(formula = Grad.Rate ~ . - school, data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.65101 -0.09527  0.00743  0.12974  0.78402
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.793e+00  1.120e-01  33.883  < 2e-16 ***
## PrivateYes   7.732e-02  3.148e-02   2.456  0.01426 *
## Accept.pct  -2.152e-01  7.026e-02  -3.063  0.00227 **
## Elite10      5.042e-02  3.662e-02   1.377  0.16901
## F.Undergrad  1.292e-05  2.612e-06   4.949 9.20e-07 ***
## P.Undergrad -3.697e-05  7.138e-06  -5.179 2.86e-07 ***
## Outstate     2.066e-05  4.180e-06   4.944 9.43e-07 ***
## Room.Board   3.066e-05  1.087e-05   2.821  0.00491 **
## Books       -4.489e-05  5.423e-05  -0.828  0.40804
## Personal    -3.050e-05  1.423e-05  -2.144  0.03236 *
## PhD          2.085e-03  1.028e-03   2.029  0.04281 *
## Terminal    -5.456e-04  1.144e-03  -0.477  0.63348
## S.F.Ratio    3.465e-04  2.959e-03   0.117  0.90681
## perc.alumni  5.023e-03  8.846e-04   5.678 1.93e-08 ***
## Expend      -8.255e-06  2.775e-06  -2.975  0.00303 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2361 on 762 degrees of freedom
## Multiple R-squared:  0.3898, Adjusted R-squared:  0.3786
## F-statistic: 34.77 on 14 and 762 DF,  p-value: < 2.2e-16
```

#Problem1(e)

```
#e) Multi-collinearity and VIF statistics
library(car)
```

```
## Loading required package: carData
```

```
vif_values <- vif(full_model)
print(vif_values)
```

```
##      Private  Accept.pct      Elite10 F.Undergrad P.Undergrad     Outstate
##     2.739521    1.486633     1.687903    2.233117    1.643393     3.935059
##   Room.Board        Books     Personal         PhD    Terminal    S.F.Ratio
##     1.976762    1.115823     1.290983    3.917716    3.946581     1.909722
## perc.alumni       Expend
##     1.672367     2.922643
```

#Problem1(f)

```r
#f) Variable selection procedures
# Backward Selection
backward_model <- step(full_model, direction="backward")
```

```
## Start:  AIC=-2228.14
## Grad.Rate ~ (school + Private + Accept.pct + Elite10 + F.Undergrad +
##     P.Undergrad + Outstate + Room.Board + Books + Personal +
##     PhD + Terminal + S.F.Ratio + perc.alumni + Expend) - school
##
##               Df Sum of Sq    RSS     AIC
## - S.F.Ratio    1   0.00076 42.488 -2230.1
## - Terminal     1   0.01269 42.500 -2229.9
## - Books        1   0.03821 42.526 -2229.4
## - Elite10      1   0.10568 42.593 -2228.2
## <none>                     42.488 -2228.1
## - PhD          1   0.22953 42.717 -2225.9
## - Personal     1   0.25627 42.744 -2225.5
## - Private      1   0.33641 42.824 -2224.0
## - Room.Board   1   0.44380 42.931 -2222.1
## - Expend       1   0.49334 42.981 -2221.2
## - Accept.pct   1   0.52308 43.011 -2220.6
## - Outstate     1   1.36271 43.850 -2205.6
## - F.Undergrad  1   1.36555 43.853 -2205.6
## - P.Undergrad  1   1.49556 43.983 -2203.3
## - perc.alumni  1   1.79786 44.285 -2197.9
##
## Step:  AIC=-2230.12
## Grad.Rate ~ Private + Accept.pct + Elite10 + F.Undergrad + P.Undergrad +
##     Outstate + Room.Board + Books + Personal + PhD + Terminal +
##     perc.alumni + Expend
##
##               Df Sum of Sq    RSS     AIC
## - Terminal     1   0.01283 42.501 -2231.9
## - Books        1   0.03813 42.527 -2231.4
## - Elite10      1   0.10560 42.594 -2230.2
## <none>                     42.488 -2230.1
## - PhD          1   0.23150 42.720 -2227.9
## - Personal     1   0.25962 42.748 -2227.4
## - Private      1   0.33928 42.828 -2225.9
## - Room.Board   1   0.44359 42.932 -2224.1
## - Accept.pct   1   0.53070 43.019 -2222.5
## - Expend       1   0.60488 43.093 -2221.1
## - Outstate     1   1.36521 43.854 -2207.6
## - F.Undergrad  1   1.39627 43.885 -2207.0
## - P.Undergrad  1   1.49651 43.985 -2205.2
## - perc.alumni  1   1.80214 44.291 -2199.8
##
## Step:  AIC=-2231.89
## Grad.Rate ~ Private + Accept.pct + Elite10 + F.Undergrad + P.Undergrad +
##     Outstate + Room.Board + Books + Personal + PhD + perc.alumni +
##     Expend
##
##               Df Sum of Sq    RSS     AIC
## - Books        1   0.04461 42.546 -2233.1
## - Elite10      1   0.10636 42.608 -2231.9
## <none>                     42.501 -2231.9
## - Personal     1   0.25582 42.757 -2229.2
## - PhD          1   0.35827 42.859 -2227.4
## - Private      1   0.35898 42.860 -2227.3
```

```
## - Room.Board    1    0.43261 42.934 -2226.0
## - Accept.pct    1    0.53614 43.037 -2224.2
## - Expend        1    0.61044 43.112 -2222.8
## - Outstate      1    1.35246 43.854 -2209.6
## - F.Undergrad   1    1.38679 43.888 -2208.9
## - P.Undergrad   1    1.50352 44.005 -2206.9
## - perc.alumni   1    1.78933 44.291 -2201.8
##
## Step:  AIC=-2233.07
## Grad.Rate ~ Private + Accept.pct + Elite10 + F.Undergrad + P.Undergrad +
##      Outstate + Room.Board + Personal + PhD + perc.alumni + Expend
##
##                 Df Sum of Sq    RSS     AIC
## - Elite10        1    0.10504 42.651 -2233.2
## <none>                        42.546 -2233.1
## - Personal       1    0.30274 42.849 -2229.6
## - Private        1    0.34894 42.895 -2228.7
## - PhD            1    0.37773 42.924 -2228.2
## - Room.Board     1    0.40928 42.955 -2227.6
## - Accept.pct     1    0.50692 43.053 -2225.9
## - Expend         1    0.62302 43.169 -2223.8
## - F.Undergrad    1    1.35834 43.904 -2210.7
## - Outstate       1    1.36108 43.907 -2210.6
## - P.Undergrad    1    1.49937 44.045 -2208.2
## - perc.alumni    1    1.80726 44.353 -2202.8
##
## Step:  AIC=-2233.16
## Grad.Rate ~ Private + Accept.pct + F.Undergrad + P.Undergrad +
##      Outstate + Room.Board + Personal + PhD + perc.alumni + Expend
##
##                 Df Sum of Sq    RSS     AIC
## <none>                        42.651 -2233.2
## - Personal       1    0.29979 42.951 -2229.7
## - Private        1    0.33284 42.984 -2229.1
## - Room.Board     1    0.39919 43.050 -2227.9
## - PhD            1    0.40176 43.053 -2227.9
## - Expend         1    0.52456 43.175 -2225.7
## - Accept.pct     1    0.71923 43.370 -2222.2
## - Outstate       1    1.38174 44.033 -2210.4
## - F.Undergrad    1    1.41008 44.061 -2209.9
## - P.Undergrad    1    1.66949 44.320 -2205.3
## - perc.alumni    1    1.88618 44.537 -2201.5
```

```
# Forward Selection
null_model <- lm(Grad.Rate ~ 1, data=data)
forward_model <- step(null_model, scope=list(lower=null_model, upper=full_model), direction
="forward")
```

```
## Start:  AIC=-1872.31
## Grad.Rate ~ 1
##
##                Df Sum of Sq    RSS      AIC
## + Outstate     1   19.7992 49.831 -2130.3
## + perc.alumni  1   14.5505 55.079 -2052.5
## + Room.Board   1   11.0671 58.563 -2004.8
## + Expend       1    8.3108 61.319 -1969.1
## + Private      1    6.7672 62.863 -1949.8
## + Elite10      1    6.3298 63.300 -1944.4
## + PhD          1    6.0403 63.590 -1940.8
## + Terminal     1    5.7000 63.930 -1936.7
## + S.F.Ratio    1    5.2624 64.368 -1931.4
## + Personal     1    4.6548 64.975 -1924.1
## + P.Undergrad  1    4.3536 65.276 -1920.5
## + Accept.pct   1    3.6669 65.963 -1912.3
## + F.Undergrad  1    0.2719 69.358 -1873.3
## <none>                     69.630 -1872.3
## + Books        1    0.0029 69.627 -1870.3
##
## Step:  AIC=-2130.27
## Grad.Rate ~ Outstate
##
##                Df Sum of Sq    RSS      AIC
## + perc.alumni  1   2.46802 47.363 -2167.7
## + P.Undergrad  1   0.98181 48.849 -2143.7
## + Accept.pct   1   0.75406 49.077 -2140.1
## + Personal     1   0.75053 49.080 -2140.1
## + PhD          1   0.66547 49.165 -2138.7
## + Elite10      1   0.64873 49.182 -2138.4
## + Terminal     1   0.39264 49.438 -2134.4
## + Room.Board   1   0.30187 49.529 -2133.0
## + F.Undergrad  1   0.20173 49.629 -2131.4
## <none>                     49.831 -2130.3
## + Books        1   0.05130 49.779 -2129.1
## + S.F.Ratio    1   0.04412 49.787 -2129.0
## + Private      1   0.02916 49.802 -2128.7
## + Expend       1   0.02242 49.808 -2128.6
##
## Step:  AIC=-2167.74
## Grad.Rate ~ Outstate + perc.alumni
##
##                Df Sum of Sq    RSS      AIC
## + Accept.pct   1   0.76895 46.594 -2178.5
## + Room.Board   1   0.65088 46.712 -2176.5
## + PhD          1   0.56267 46.800 -2175.0
## + P.Undergrad  1   0.53489 46.828 -2174.6
## + F.Undergrad  1   0.44159 46.921 -2173.0
## + Elite10      1   0.42245 46.940 -2172.7
## + Personal     1   0.41023 46.952 -2172.5
## + Terminal     1   0.30456 47.058 -2170.8
## + S.F.Ratio    1   0.17380 47.189 -2168.6
## <none>                     47.363 -2167.7
## + Expend       1   0.05994 47.303 -2166.7
## + Books        1   0.01170 47.351 -2165.9
```

```
## + Private      1   0.00395 47.359 -2165.8
##
## Step:  AIC=-2178.46
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct
##
##                 Df Sum of Sq    RSS     AIC
## + P.Undergrad  1   0.78875 45.805 -2189.7
## + Personal     1   0.47712 46.117 -2184.4
## + Room.Board   1   0.40579 46.188 -2183.2
## + Expend       1   0.33908 46.255 -2182.1
## + PhD          1   0.29847 46.295 -2181.4
## + F.Undergrad  1   0.23346 46.360 -2180.4
## + S.F.Ratio    1   0.15344 46.440 -2179.0
## + Terminal     1   0.12805 46.466 -2178.6
## <none>                     46.594 -2178.5
## + Elite10      1   0.09922 46.495 -2178.1
## + Books        1   0.06809 46.526 -2177.6
## + Private      1   0.03330 46.560 -2177.0
##
## Step:  AIC=-2189.72
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad
##
##                 Df Sum of Sq    RSS     AIC
## + F.Undergrad  1   1.22083 44.584 -2208.7
## + PhD          1   0.64320 45.162 -2198.7
## + Room.Board   1   0.51487 45.290 -2196.5
## + Terminal     1   0.37589 45.429 -2194.1
## + Expend       1   0.25996 45.545 -2192.2
## + Personal     1   0.24233 45.563 -2191.8
## + S.F.Ratio    1   0.22478 45.580 -2191.6
## <none>                     45.805 -2189.7
## + Elite10      1   0.06171 45.743 -2188.8
## + Books        1   0.04467 45.760 -2188.5
## + Private      1   0.01709 45.788 -2188.0
##
## Step:  AIC=-2208.71
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad +
##     F.Undergrad
##
##                 Df Sum of Sq    RSS     AIC
## + Room.Board   1   0.53677 44.047 -2216.1
## + Expend       1   0.47715 44.107 -2215.1
## + Personal     1   0.44653 44.138 -2214.5
## + Private      1   0.23306 44.351 -2210.8
## + PhD          1   0.19653 44.388 -2210.2
## <none>                     44.584 -2208.7
## + S.F.Ratio    1   0.09239 44.492 -2208.3
## + Books        1   0.08016 44.504 -2208.1
## + Terminal     1   0.06417 44.520 -2207.8
## + Elite10      1   0.00468 44.580 -2206.8
##
## Step:  AIC=-2216.12
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad +
##     F.Undergrad + Room.Board
##
##                 Df Sum of Sq    RSS     AIC
```

```
## + Expend     1    0.52950 43.518 -2223.5
## + Personal   1    0.38784 43.660 -2221.0
## + Private    1    0.17487 43.873 -2217.2
## + PhD        1    0.16029 43.887 -2217.0
## + Books      1    0.12290 43.925 -2216.3
## <none>                    44.047 -2216.1
## + S.F.Ratio  1    0.10797 43.939 -2216.0
## + Terminal   1    0.02887 44.019 -2214.6
## + Elite10    1    0.00569 44.042 -2214.2
##
## Step:  AIC=-2223.52
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad +
##     F.Undergrad + Room.Board + Expend
##
##              Df Sum of Sq    RSS     AIC
## + Personal   1  0.295342 43.223 -2226.8
## + PhD        1  0.242133 43.276 -2225.9
## + Private    1  0.163862 43.354 -2224.4
## <none>                   43.518 -2223.5
## + Elite10    1  0.107978 43.410 -2223.4
## + Books      1  0.098685 43.419 -2223.3
## + Terminal   1  0.063646 43.454 -2222.7
## + S.F.Ratio  1  0.000864 43.517 -2221.5
##
## Step:  AIC=-2226.81
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad +
##     F.Undergrad + Room.Board + Expend + Personal
##
##              Df Sum of Sq    RSS     AIC
## + PhD        1  0.238862 42.984 -2229.1
## + Private    1  0.169940 43.053 -2227.9
## <none>                   43.223 -2226.8
## + Elite10    1  0.110612 43.112 -2226.8
## + Terminal   1  0.059691 43.163 -2225.9
## + Books      1  0.050175 43.172 -2225.7
## + S.F.Ratio  1  0.000101 43.222 -2224.8
##
## Step:  AIC=-2229.12
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad +
##     F.Undergrad + Room.Board + Expend + Personal + PhD
##
##              Df Sum of Sq    RSS     AIC
## + Private    1   0.33284 42.651 -2233.2
## <none>                   42.984 -2229.1
## + Elite10    1   0.08893 42.895 -2228.7
## + Terminal   1   0.04108 42.943 -2227.9
## + Books      1   0.03370 42.950 -2227.7
## + S.F.Ratio  1   0.00344 42.980 -2227.2
##
## Step:  AIC=-2233.16
## Grad.Rate ~ Outstate + perc.alumni + Accept.pct + P.Undergrad +
##     F.Undergrad + Room.Board + Expend + Personal + PhD + Private
##
##              Df Sum of Sq    RSS     AIC
## <none>                   42.651 -2233.2
## + Elite10    1  0.105038 42.546 -2233.1
```

```
## + Books       1   0.043282 42.608 -2231.9
## + Terminal    1   0.020120 42.631 -2231.5
## + S.F.Ratio   1   0.000759 42.650 -2231.2
```

#Problem1(g)

```
#g) Fit a final regression model M1
#final Model based on the backward selection as observed in the output
M1 <- lm(Grad.Rate ~ Private + Accept.pct + Elite10 + F.Undergrad + P.Undergrad +
         Outstate + Room.Board + Personal + PhD + perc.alumni + Expend, data=data)
summary(M1)
```

```
##
## Call:
## lm(formula = Grad.Rate ~ Private + Accept.pct + Elite10 + F.Undergrad +
##     P.Undergrad + Outstate + Room.Board + Personal + PhD + perc.alumni +
##     Expend, data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.65407 -0.09599  0.00627  0.13276  0.80185
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.764e+00  8.441e-02  44.591  < 2e-16 ***
## PrivateYes   7.728e-02  3.085e-02   2.505 0.012457 *
## Accept.pct  -2.094e-01  6.936e-02  -3.019 0.002620 **
## Elite10      5.026e-02  3.657e-02   1.374 0.169757
## F.Undergrad  1.274e-05  2.578e-06   4.942 9.50e-07 ***
## P.Undergrad -3.700e-05  7.126e-06  -5.192 2.67e-07 ***
## Outstate     2.051e-05  4.146e-06   4.947 9.27e-07 ***
## Room.Board   2.913e-05  1.074e-05   2.713 0.006822 **
## Personal    -3.255e-05  1.395e-05  -2.333 0.019901 *
## PhD          1.764e-03  6.769e-04   2.606 0.009336 **
## perc.alumni  5.004e-03  8.778e-04   5.700 1.71e-08 ***
## Expend      -8.500e-06  2.540e-06  -3.347 0.000857 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2358 on 765 degrees of freedom
## Multiple R-squared:  0.389,  Adjusted R-squared:  0.3802
## F-statistic: 44.27 on 11 and 765 DF,  p-value: < 2.2e-16
```

#Problem1(h)

```
#h) Scatter plot of studentized residuals against predicted values
# Compute studentized residuals
studentized_residuals <- rstudent(M1)

# Scatter plot
ggplot(data, aes(x=predict(M1), y=studentized_residuals)) +
  geom_point(alpha=0.5) +
  geom_hline(yintercept = 0, linetype = "dashed") +
  labs(title="Studentized Residuals vs. Predicted Values", x="Predicted Values", y="Studentiz
ed Residuals") +
  theme_minimal()
```

Studentized Residuals vs. Predicted Values
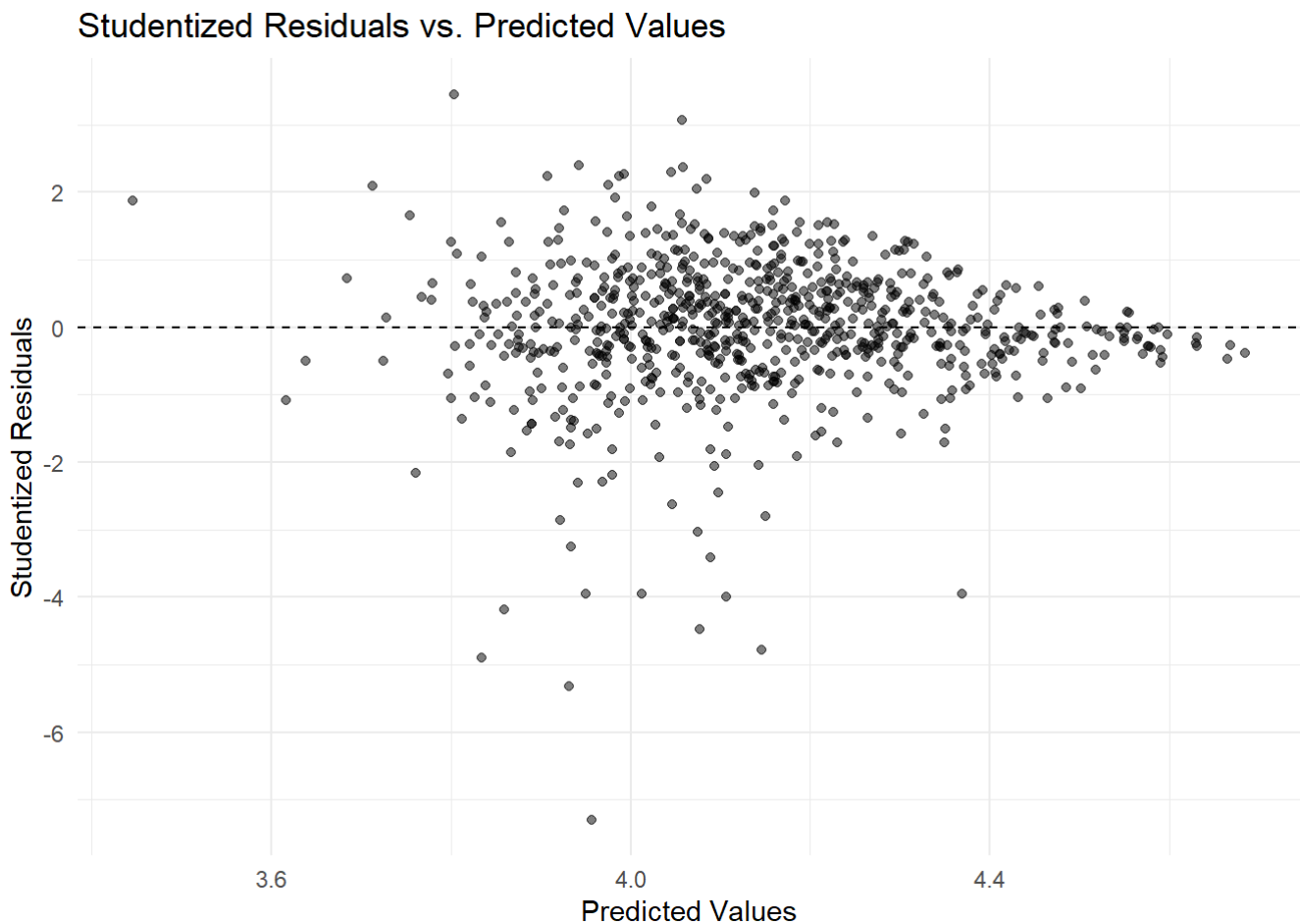
#Problem1(i)

```
#i) Normal probability plot of residuals
qqnorm(studentized_residuals)
qqline(studentized_residuals)
```

Normal Q-Q Plot
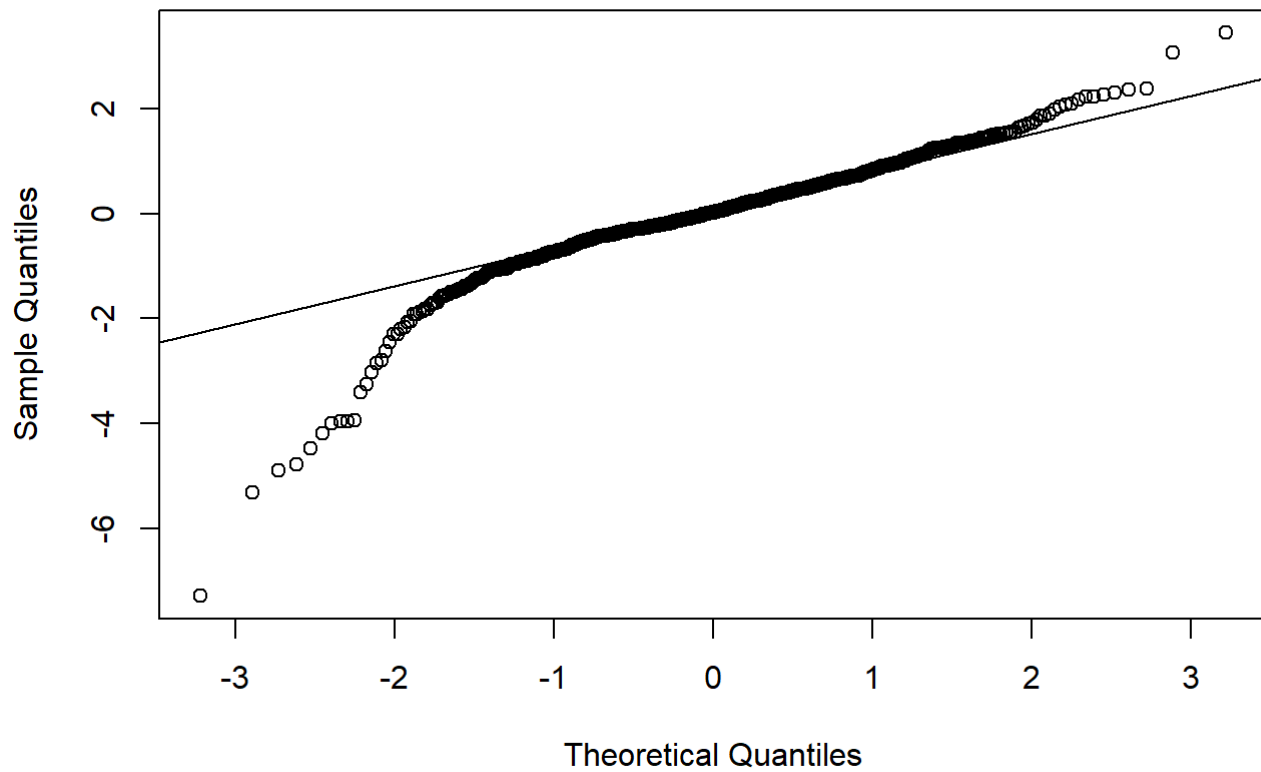
#Problem1(j)

```
#j) Outliers or Influential Points
# Cook's distance to detect influential observations
cook_d <- cooks.distance(M1)

a<-influence.measures(M1)
summary(a)
```

```
## Potentially influential observations of
##     lm(formula = Grad.Rate ~ Private + Accept.pct + Elite10 + F.Undergrad +      P.Undergrad
+ Outstate + Room.Board + Personal + PhD + perc.alumni +      Expend, data = data) :
##
##      dfb.1_ dfb.PrvY dfb.Acc. dfb.El10 dfb.F.Un dfb.P.Un dfb.Otst dfb.Rm.B
## 5     0.01  -0.28     0.02     0.05     0.14    -0.03     0.24     0.04
## 17   -0.02   0.01     0.03    -0.01     0.01     0.00    -0.01     0.01
## 21    0.01   0.02    -0.04     0.05     0.01     0.00     0.02     0.04
## 24    0.02  -0.02    -0.01    -0.01    -0.03    -0.04     0.00    -0.01
## 38    0.01   0.01     0.00    -0.03     0.00     0.00     0.00    -0.03
## 48   -0.17   0.13     0.07     0.08    -0.01    -0.01    -0.27     0.14
## 67   -0.04  -0.29    -0.01    -0.08     0.02    -0.03     0.17     0.19
## 70    0.06  -0.81     0.08     0.11    -1.15_*   0.36     0.66    -0.09
## 96    0.12  -0.06     0.09     0.04     0.08    -0.01     0.00     0.14
## 99   -0.05   0.08    -0.10    -0.01     0.00    -0.04    -0.02    -0.19
## 101  -0.06   0.03     0.02     0.01    -0.01     0.00     0.00    -0.07
## 107   0.03  -0.01    -0.04    -0.06     0.01    -0.01     0.03     0.00
## 114  -0.30  -0.31     0.33     0.10    -0.03     0.04     0.36     0.21
## 145   0.03   0.00    -0.03     0.01    -0.01    -0.01    -0.01     0.00
## 198  -0.18   0.19     0.04     0.03     0.13     0.02    -0.08     0.18
## 199  -0.04  -0.07    -0.03    -0.02    -0.01     0.06    -0.02     0.00
## 202   0.04  -0.01    -0.06     0.03    -0.16     0.44     0.08    -0.16
## 216  -0.02  -0.11    -0.03    -0.04    -0.03     0.00     0.08    -0.03
## 224  -0.01   0.00     0.01    -0.01     0.05    -0.10    -0.02     0.04
## 239   0.18   0.16    -0.13     0.25     0.03     0.02    -0.11    -0.07
## 251   0.01   0.00    -0.02    -0.01     0.00    -0.01    -0.01     0.00
## 254   0.00   0.00     0.00    -0.01     0.00     0.00     0.00     0.00
## 265  -0.64  -0.15     0.60     0.16    -0.03     0.09    -0.05     0.23
## 266   0.04   0.04     0.05     0.06     0.01     0.02     0.02     0.02
## 275   0.00   0.00     0.00     0.00    -0.02     0.00     0.00     0.00
## 276  -0.21  -0.08     0.18     0.03    -0.05     0.00    -0.03     0.07
## 282  -0.18   0.13     0.19     0.08     0.10     0.03     0.16    -0.17
## 285  -0.02  -0.02     0.05    -0.07    -0.06     0.04    -0.18     0.01
## 318  -0.01   0.09    -0.16    -0.01    -0.02    -0.11     0.05     0.07
## 355   0.01   0.00    -0.01     0.00     0.00     0.00     0.00    -0.01
## 358  -0.09  -0.10     0.07     0.00     0.00     0.01     0.04     0.05
## 367   0.00   0.01     0.01     0.00     0.04     0.00     0.01    -0.01
## 369  -0.01   0.00     0.01     0.01     0.00    -0.01     0.00     0.01
## 378   0.19  -0.19     0.07     0.08    -0.11     0.14    -0.03    -0.05
## 379  -0.15  -0.02     0.05    -0.04    -0.06     0.03     0.02    -0.17
## 385  -0.06  -0.07    -0.05     0.03     0.06     0.11    -0.05     0.13
## 395  -0.16   0.10    -0.06    -0.03    -0.06    -0.03    -0.05     0.00
## 419   0.05  -0.05    -0.02    -0.02     0.02    -0.21     0.00    -0.07
## 427  -0.05   0.02    -0.05    -0.04    -0.02    -0.02     0.00    -0.11
## 431   0.00   0.00     0.00     0.01     0.00     0.00     0.00     0.00
## 446  -0.04  -0.03     0.06     0.05    -0.21     0.09    -0.05     0.02
## 452   0.06  -0.18    -0.04     0.00     0.03     0.02     0.23     0.01
## 457   0.02   0.00    -0.02    -0.05     0.01     0.00    -0.03     0.02
## 460  -0.01   0.00     0.02     0.00     0.00     0.00     0.00     0.00
## 462   0.00   0.00     0.00     0.00     0.00     0.00     0.00     0.00
## 498  -0.18   0.04     0.05    -0.05    -0.04    -0.06     0.00     0.03
## 507   0.12   0.01    -0.01     0.00     0.02    -0.01     0.06    -0.05
## 543   0.00   0.01    -0.01     0.00     0.00     0.00    -0.01     0.01
## 582   0.00  -0.02     0.00     0.01    -0.04     0.01     0.01     0.00
## 586  -0.24   0.48     0.04    -0.09     0.27    -0.38    -0.34     0.13
```

```
## 591  0.01   0.00  -0.01  -0.02   0.00   0.00   0.01   0.00
## 606  0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
## 610 -0.01   0.00   0.01   0.00  -0.01   0.00  -0.02   0.00
## 620  0.00   0.00   0.00  -0.01  -0.01   0.00   0.00   0.00
## 624 -0.02   0.02   0.02   0.05   0.07  -0.03  -0.01   0.01
## 638  0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
## 641 -0.04   0.06   0.02   0.06  -0.37   1.29_*  0.03  -0.16
## 645 -0.01  -0.02   0.00   0.00  -0.03   0.03   0.01   0.01
## 677  0.01   0.02  -0.01   0.01  -0.03   0.18   0.00  -0.03
## 686 -0.01   0.05  -0.01  -0.01   0.09   0.00  -0.01  -0.01
## 688  0.01   0.00   0.00   0.00   0.00   0.00   0.01   0.00
## 692  0.03   0.00  -0.03  -0.01   0.02  -0.08   0.00   0.00
## 701  0.00   0.00   0.00   0.00   0.01   0.00   0.00   0.00
## 713 -0.03   0.17  -0.06  -0.01   0.06   0.05   0.07  -0.16
## 715 -0.02  -0.07  -0.03  -0.03  -0.02   0.03   0.02   0.03
## 721  0.03   0.04  -0.01  -0.01  -0.02   0.00  -0.15  -0.07
## 729 -0.08  -0.01   0.13   0.01  -0.03   0.04  -0.10  -0.02
## 732  0.22   0.15  -0.24  -0.03   0.00  -0.05  -0.03  -0.11
## 736  0.03  -0.02   0.04  -0.02   0.03  -0.01  -0.03   0.08
## 763  0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
## 766  0.01   0.10   0.00   0.01   0.00  -0.03  -0.03  -0.06
## 776  0.01   0.00  -0.02  -0.01   0.00  -0.01  -0.02   0.00
##      dfb.Prsn dfb.PhD dfb.prc. dfb.Expn dffit   cov.r  cook.d hat
## 5      0.02  -0.27   0.38  -0.23  -0.61_*  0.67_*  0.03   0.01
## 17    -0.01   0.01  -0.02   0.01  -0.05   1.05_*  0.00   0.03
## 21     0.02   0.02   0.01  -0.16  -0.17   1.16_*  0.00   0.13_*
## 24     0.01   0.00   0.01   0.02  -0.08   1.05_*  0.00   0.04
## 38     0.00   0.01   0.00   0.02  -0.05   1.05_*  0.00   0.03
## 48     0.04   0.24   0.03  -0.02  -0.36   1.04   0.01   0.05_*
## 67    -0.10  -0.14   0.11  -0.03  -0.47_*  0.78_*  0.02   0.01
## 70     0.20  -0.04  -0.41  -0.08  -1.37_*  0.89_*  0.15   0.11_*
## 96    -0.14  -0.37   0.02   0.05   0.45_*  0.90_*  0.02   0.02
## 99     0.10   0.32   0.01  -0.06  -0.43_*  0.80_*  0.02   0.01
## 101    0.03   0.14   0.03  -0.04  -0.17   1.06_*  0.00   0.05_*
## 107    0.00  -0.02  -0.05   0.01  -0.09   1.05_*  0.00   0.04
## 114    0.10  -0.16  -0.17  -0.08  -0.65_*  0.76_*  0.03   0.02
## 145   -0.04   0.00  -0.05   0.06   0.12   1.05_*  0.00   0.04
## 198    0.15  -0.05   0.11  -0.04  -0.38_*  0.87_*  0.01   0.01
## 199   -0.06   0.10   0.17  -0.02  -0.30   0.80_*  0.01   0.01
## 202    0.10   0.01   0.08  -0.05   0.52_*  1.01   0.02   0.06_*
## 216    0.15  -0.04   0.11   0.03  -0.26   0.89_*  0.01   0.01
## 224   -0.04  -0.01   0.00   0.01  -0.13   1.08_*  0.00   0.06_*
## 239   -0.12   0.03  -0.04  -0.12   0.40_*  1.00   0.01   0.04
## 251    0.01  -0.01   0.01   0.03   0.05   1.07_*  0.00   0.05_*
## 254    0.00   0.00   0.00   0.00  -0.01   1.05_*  0.00   0.03
## 265   -0.09   0.32   0.21  -0.08  -0.78_*  0.83_*  0.05   0.04
## 266    0.01  -0.13  -0.10  -0.01   0.24   0.95_*  0.00   0.01
## 275    0.00   0.01   0.00   0.00  -0.02   1.05_*  0.00   0.04
## 276    0.05   0.10   0.06   0.04  -0.26   0.94_*  0.01   0.01
## 282    0.01   0.07  -0.02  -0.08  -0.39_*  0.91_*  0.01   0.02
## 285   -0.06  -0.05  -0.03   0.52   0.55_*  1.17_*  0.03   0.16_*
## 318    0.42   0.02  -0.05  -0.18   0.50_*  0.97   0.02   0.04
## 355    0.01   0.00  -0.01   0.03   0.05   1.05_*  0.00   0.03
## 358   -0.01   0.00   0.07   0.00  -0.18   0.95_*  0.00   0.01
## 367   -0.03   0.00  -0.01   0.00   0.06   1.07_*  0.00   0.05_*
## 369    0.05  -0.02   0.01   0.00   0.06   1.08_*  0.00   0.06_*
```

```
## 378 -0.27    -0.13   -0.04    0.05     0.45_*  0.86_*  0.02    0.02
## 379  0.06     0.26    0.01    0.09    -0.39_*  0.86_*  0.01    0.01
## 385 -0.42     0.24    0.26   -0.27    -0.72_*  0.72_*  0.04    0.02
## 395 -0.03     0.48   -0.40    0.04    -0.65_*  0.73_*  0.03    0.02
## 419  0.01     0.03   -0.01    0.03    -0.25    1.09_*  0.01    0.08_*
## 427  0.09     0.17   -0.06    0.07    -0.28    0.91_*  0.01    0.01
## 431  0.01     0.00    0.00    0.00     0.01    1.08_*  0.00    0.06_*
## 446 -0.02     0.06   -0.01    0.03    -0.24    1.07_*  0.00    0.06_*
## 452  0.11    -0.25    0.05   -0.05    -0.35    0.93_*  0.01    0.02
## 457 -0.03    -0.01    0.03    0.02    -0.08    1.05_*  0.00    0.03
## 460 -0.01     0.01   -0.01   -0.01    -0.03    1.05_*  0.00    0.03
## 462  0.00     0.00    0.00    0.00     0.01    1.06_*  0.00    0.04
## 498  0.42     0.04    0.01    0.08     0.45_*  1.11_*  0.02    0.11_*
## 507 -0.10    -0.12   -0.13    0.04     0.23    0.94_*  0.00    0.01
## 543  0.01     0.00    0.00    0.00     0.02    1.05_*  0.00    0.03
## 582  0.00     0.00   -0.01    0.00    -0.05    1.09_*  0.00    0.07_*
## 586 -0.06     0.23   -0.20    0.30    -0.81_*  0.46_*  0.05    0.01
## 591  0.00     0.00   -0.01    0.00    -0.03    1.05_*  0.00    0.03
## 606  0.00     0.00    0.00    0.00     0.00    1.05_*  0.00    0.03
## 610  0.00     0.00   -0.01    0.07     0.08    1.06_*  0.00    0.04
## 620  0.00     0.00    0.00    0.00    -0.01    1.06_*  0.00    0.05
## 624  0.00    -0.01   -0.01   -0.02     0.09    1.08_*  0.00    0.06_*
## 638  0.00     0.00    0.00    0.00    -0.01    1.06_*  0.00    0.04
## 641 -0.04    -0.08    0.27    0.10     1.34_*  1.45_*  0.15    0.34_*
## 645  0.06    -0.01    0.01   -0.01     0.08    1.05_*  0.00    0.04
## 677 -0.02     0.00   -0.01    0.02     0.19    1.08_*  0.00    0.07_*
## 686  0.02     0.00    0.00   -0.01     0.11    1.07_*  0.00    0.05_*
## 688  0.00    -0.01    0.00    0.00     0.02    1.05_*  0.00    0.03
## 692 -0.02    -0.01    0.00   -0.01    -0.10    1.05_*  0.00    0.04
## 701  0.00     0.00    0.00    0.00     0.01    1.05_*  0.00    0.03
## 713  0.11     0.06    0.01   -0.02    -0.29    0.95_*  0.01    0.02
## 715 -0.04     0.04    0.09   -0.02    -0.20    0.94_*  0.00    0.01
## 721 -0.03     0.01   -0.01    0.33     0.37    1.08_*  0.01    0.08_*
## 729 -0.02    -0.05   -0.06    0.41     0.45_*  1.09_*  0.02    0.09_*
## 732  0.07     0.00   -0.12   -0.04     0.35    0.95_*  0.01    0.02
## 736 -0.04    -0.17   -0.03    0.12     0.23    1.06_*  0.00    0.05_*
## 763 -0.01     0.00    0.00    0.00    -0.01    1.05_*  0.00    0.03
## 766  0.01     0.07   -0.12    0.01     0.19    0.95_*  0.00    0.01
```

```
plot(rstudent(M1)~hatvalues(M1))
abline(a=3, b=0, col= 'red')
abline(a=-3, b=0,col='red')
```
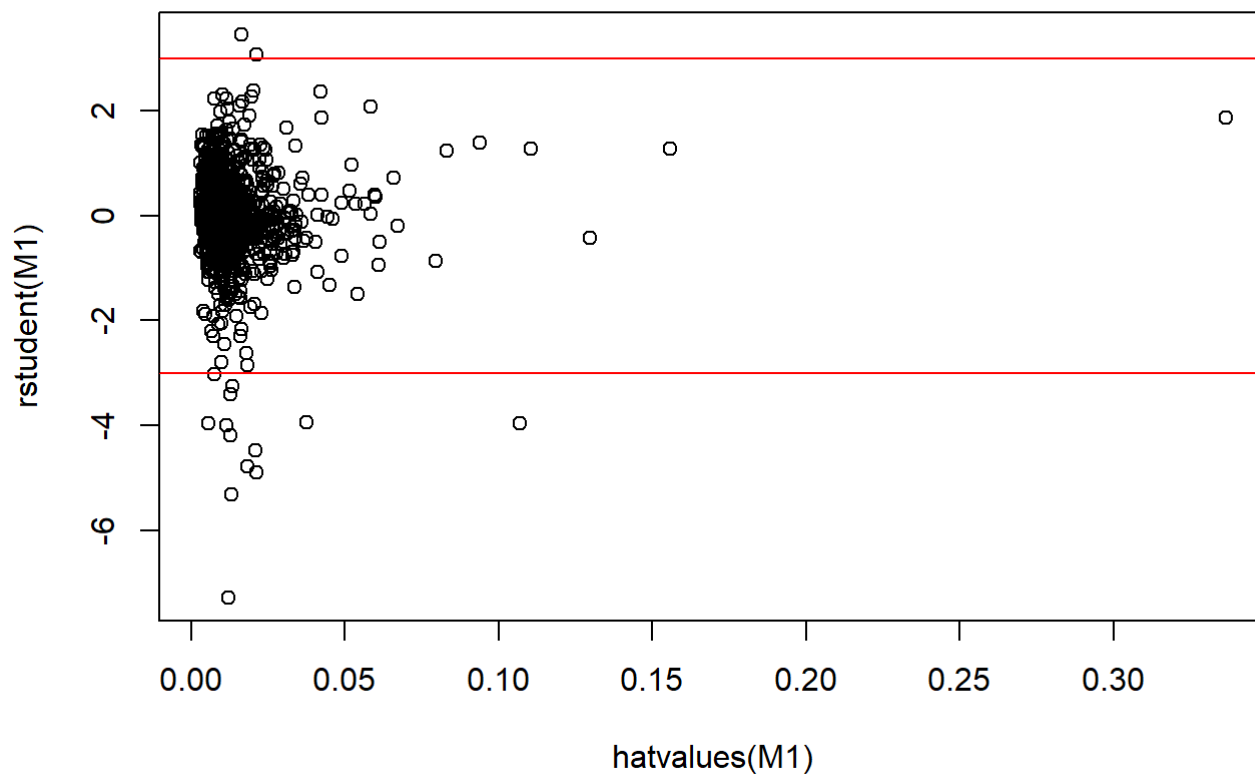
```
# Flag observations with Cook's distance > 4/n
influential_points <- as.numeric(names(cook_d)[(cook_d > 4/length(cook_d))])
print(influential_points)
```

```
##  [1]   5  48  67  70  96  99 114 143 153 170 198 199 202 216 239 265 276 282 285
## [20] 304 318 320 378 379 385 395 419 427 452 498 586 588 592 604 629 641 713 721
## [39] 729 732 777
```

```
# For outliers, you can inspect large studentized residuals
outliers <- which(abs(studentized_residuals) > 2) # Adjust the threshold as necessary
print(outliers)
```

```
##    5  67  70  96  99 114 170 198 199 202 216 265 266 273 276 282 304 318 320 358
##    5  67  70  96  99 114 170 198 199 202 216 265 266 273 276 282 304 318 320 358
## 378 379 385 395 427 440 452 507 586 590 713 715 732 766 777
## 378 379 385 395 427 440 452 507 586 590 713 715 732 766 777
```

#Problem1(k)

```
#k) adjusted r2 value
r_squared <- summary(M1)$r.squared
print(r_squared)
```

```
## [1] 0.3889722
```

#Problem2

```
# Load the necessary library
library(tidyverse)
```

```
## ── Attaching core tidyverse packages ──────────────────── tidyverse 2.0.0 ──
## ✓ dplyr     1.1.3     ✓ readr     2.1.4
## ✓ forcats   1.0.0     ✓ stringr   1.5.0
## ✓ lubridate 1.9.3     ✓ tibble    3.2.1
## ✓ purrr     1.0.2     ✓ tidyr     1.3.0
## ── Conflicts ──────────────────────────────────── tidyverse_conflicts() ──
## ✗ dplyr::filter() masks stats::filter()
## ✗ dplyr::lag()    masks stats::lag()
## ✗ dplyr::recode() masks car::recode()
## ✗ purrr::some()   masks car::some()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to be
come errors
```

```
# Load the data
college_data <- read.csv("college.csv")

#problem2(A)
# Fit the model with interaction terms
model_a <- lm(Grad.Rate ~ (Elite10 + Accept.pct + Outstate + perc.alumni + Expend)^2, data =
college_data)
summary(model_a)
```

```
##
## Call:
## lm(formula = Grad.Rate ~ (Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend)^2, data = college_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -53.384  -7.793   0.274   7.560  57.038
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)             4.698e+01  9.094e+00   5.166 3.05e-07 ***
## Elite10                 3.524e+01  1.057e+01   3.333 0.000901 ***
## Accept.pct             -1.573e+01  9.930e+00  -1.584 0.113673
## Outstate                3.799e-03  1.355e-03   2.804 0.005183 **
## perc.alumni             5.232e-01  3.704e-01   1.413 0.158180
## Expend                 -1.436e-03  9.098e-04  -1.579 0.114866
## Elite10:Accept.pct     -2.876e+01  1.229e+01  -2.340 0.019526 *
## Elite10:Outstate       -2.267e-03  6.272e-04  -3.614 0.000321 ***
## Elite10:perc.alumni    -1.428e-01  1.716e-01  -0.832 0.405469
## Elite10:Expend          1.821e-03  4.763e-04   3.824 0.000142 ***
## Accept.pct:Outstate    -1.083e-03  1.461e-03  -0.741 0.458660
## Accept.pct:perc.alumni -1.732e-01  3.892e-01  -0.445 0.656448
## Accept.pct:Expend       1.480e-03  9.472e-04   1.563 0.118541
## Outstate:perc.alumni   -5.319e-06  1.432e-05  -0.371 0.710419
## Outstate:Expend        -6.064e-08  3.942e-08  -1.538 0.124350
## perc.alumni:Expend      2.098e-06  1.536e-05   0.137 0.891420
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.12 on 761 degrees of freedom
## Multiple R-squared:  0.4281, Adjusted R-squared:  0.4169
## F-statistic: 37.98 on 15 and 761 DF,  p-value: < 2.2e-16
```

```
X.var=model.matrix(model_a)[,-1]
library(leaps)
#backward selection
bward=step(model_a,direction="backward",trace=TRUE)
```

```
## Start:  AIC=4015.73
## Grad.Rate ~ (Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend)^2
##
##                            Df Sum of Sq    RSS    AIC
## - perc.alumni:Expend        1      3.21 130945 4013.7
## - Outstate:perc.alumni      1     23.74 130965 4013.9
## - Accept.pct:perc.alumni    1     34.07 130975 4013.9
## - Accept.pct:Outstate       1     94.59 131036 4014.3
## - Elite10:perc.alumni       1    119.21 131061 4014.4
## <none>                                   130941 4015.7
## - Outstate:Expend           1    407.26 131349 4016.1
## - Accept.pct:Expend         1    420.18 131362 4016.2
## - Elite10:Accept.pct        1    942.40 131884 4019.3
## - Elite10:Outstate          1   2247.56 133189 4027.0
## - Elite10:Expend            1   2515.78 133457 4028.5
##
## Step:  AIC=4013.75
## Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
##     Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni +
##     Elite10:Expend + Accept.pct:Outstate + Accept.pct:perc.alumni +
##     Accept.pct:Expend + Outstate:perc.alumni + Outstate:Expend
##
##                            Df Sum of Sq    RSS    AIC
## - Outstate:perc.alumni      1     21.97 130967 4011.9
## - Accept.pct:perc.alumni    1     42.75 130987 4012.0
## - Accept.pct:Outstate       1     91.88 131036 4012.3
## - Elite10:perc.alumni       1    120.08 131065 4012.5
## <none>                                   130945 4013.7
## - Accept.pct:Expend         1    421.83 131366 4014.2
## - Outstate:Expend           1    470.21 131415 4014.5
## - Elite10:Accept.pct        1    946.63 131891 4017.3
## - Elite10:Outstate          1   2373.48 133318 4025.7
## - Elite10:Expend            1   2522.64 133467 4026.6
##
## Step:  AIC=4011.88
## Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
##     Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni +
##     Elite10:Expend + Accept.pct:Outstate + Accept.pct:perc.alumni +
##     Accept.pct:Expend + Outstate:Expend
##
##                            Df Sum of Sq    RSS    AIC
## - Accept.pct:perc.alumni    1     31.76 130998 4010.1
## - Accept.pct:Outstate       1    101.00 131068 4010.5
## - Elite10:perc.alumni       1    163.91 131130 4010.9
## <none>                                   130967 4011.9
## - Accept.pct:Expend         1    428.17 131395 4012.4
## - Outstate:Expend           1    648.13 131615 4013.7
## - Elite10:Accept.pct        1    953.00 131920 4015.5
## - Elite10:Outstate          1   2395.41 133362 4024.0
## - Elite10:Expend            1   2798.12 133765 4026.3
##
## Step:  AIC=4010.07
## Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
##     Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni +
```

```
##      Elite10:Expend + Accept.pct:Outstate + Accept.pct:Expend +
##      Outstate:Expend
##
##                           Df Sum of Sq    RSS    AIC
## - Elite10:perc.alumni  1     132.44 131131 4008.9
## - Accept.pct:Outstate  1     195.21 131194 4009.2
## <none>                             130998 4010.1
## - Accept.pct:Expend    1     415.46 131414 4010.5
## - Outstate:Expend      1     644.20 131642 4011.9
## - Elite10:Accept.pct   1    1032.09 132030 4014.2
## - Elite10:Outstate     1    2516.26 133515 4022.9
## - Elite10:Expend       1    2773.09 133771 4024.3
##
## Step:  AIC=4008.85
## Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
##      Elite10:Accept.pct + Elite10:Outstate + Elite10:Expend +
##      Accept.pct:Outstate + Accept.pct:Expend + Outstate:Expend
##
##                           Df Sum of Sq    RSS    AIC
## - Accept.pct:Outstate  1     174.0 131305 4007.9
## <none>                             131131 4008.9
## - Accept.pct:Expend    1     445.5 131576 4009.5
## - Outstate:Expend      1     610.8 131741 4010.5
## - Elite10:Accept.pct   1    1020.0 132151 4012.9
## - Elite10:Expend       1    2824.5 133955 4023.4
## - Elite10:Outstate     1    3345.2 134476 4026.4
## - perc.alumni          1    8938.9 140070 4058.1
##
## Step:  AIC=4007.88
## Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
##      Elite10:Accept.pct + Elite10:Outstate + Elite10:Expend +
##      Accept.pct:Expend + Outstate:Expend
##
##                          Df Sum of Sq    RSS    AIC
## - Accept.pct:Expend    1     271.7 131576 4007.5
## <none>                             131305 4007.9
## - Outstate:Expend      1     473.2 131778 4008.7
## - Elite10:Accept.pct   1    1224.0 132529 4013.1
## - Elite10:Expend       1    2861.6 134166 4022.6
## - Elite10:Outstate     1    3438.3 134743 4026.0
## - perc.alumni          1    8986.1 140291 4057.3
##
## Step:  AIC=4007.49
## Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
##      Elite10:Accept.pct + Elite10:Outstate + Elite10:Expend +
##      Outstate:Expend
##
##                          Df Sum of Sq    RSS    AIC
## <none>                             131576 4007.5
## - Outstate:Expend      1     589.5 132166 4009.0
## - Elite10:Accept.pct   1     970.5 132547 4011.2
## - Elite10:Expend       1    2892.9 134469 4022.4
## - Elite10:Outstate     1    3228.4 134805 4024.3
## - perc.alumni          1    8861.3 140438 4056.1
```

```
#forward selection
step(model_a,direction="forward",trace=TRUE)
```

```
## Start:  AIC=4015.73
## Grad.Rate ~ (Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend)^2
```

```
##
## Call:
## lm(formula = Grad.Rate ~ (Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend)^2, data = college_data)
##
## Coefficients:
##           (Intercept)               Elite10             Accept.pct
##             4.698e+01             3.524e+01             -1.573e+01
##              Outstate            perc.alumni                 Expend
##             3.799e-03             5.232e-01             -1.436e-03
##     Elite10:Accept.pct       Elite10:Outstate     Elite10:perc.alumni
##            -2.876e+01            -2.267e-03             -1.428e-01
##         Elite10:Expend    Accept.pct:Outstate  Accept.pct:perc.alumni
##             1.821e-03            -1.083e-03             -1.732e-01
##        Accept.pct:Expend  Outstate:perc.alumni        Outstate:Expend
##             1.480e-03            -5.319e-06             -6.064e-08
##       perc.alumni:Expend
##             2.098e-06
```

```
model1 <- lm(Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend + Elite10:Acc
ept.pct + Elite10:Outstate + Elite10:perc.alumni + Elite10 : Expend,data=college_data)
# Summary of the model
summary(model1)
```

```
##
## Call:
## lm(formula = Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend + Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni +
##     Elite10:Expend, data = college_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -53.787  -7.785  -0.400   7.769  57.177
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)          5.316e+01  3.592e+00  14.801  < 2e-16 ***
## Elite10              3.763e+01  1.000e+01   3.762 0.000181 ***
## Accept.pct          -1.519e+01  4.129e+00  -3.678 0.000251 ***
## Outstate             2.296e-03  1.991e-04  11.532  < 2e-16 ***
## perc.alumni          3.505e-01  5.030e-02   6.968 6.95e-12 ***
## Expend              -9.536e-04  2.073e-04  -4.601 4.93e-06 ***
## Elite10:Accept.pct  -2.274e+01  9.822e+00  -2.315 0.020881 *
## Elite10:Outstate    -2.054e-03  5.390e-04  -3.811 0.000150 ***
## Elite10:perc.alumni -1.227e-01  1.347e-01  -0.911 0.362485
## Elite10:Expend       1.050e-03  2.889e-04   3.635 0.000297 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.12 on 767 degrees of freedom
## Multiple R-squared:  0.4234, Adjusted R-squared:  0.4167
## F-statistic: 62.58 on 9 and 767 DF,  p-value: < 2.2e-16
```

#problem2(B)

```
#fit the model after removing the unsignificant terms
model2 <- lm(Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend + Elite10:Acc
ept.pct + Elite10:Outstate + Elite10:Expend,data=college_data)
summary(model2)
```

```
## 
## Call:
## lm(formula = Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend + Elite10:Accept.pct + Elite10:Outstate + Elite10:Expend,
##     data = college_data)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max
## -53.724  -7.744  -0.468   7.727  57.150
## 
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        5.314e+01  3.591e+00  14.797  < 2e-16 ***
## Elite10            3.585e+01  9.808e+00   3.655 0.000275 ***
## Accept.pct        -1.505e+01  4.126e+00  -3.647 0.000283 ***
## Outstate           2.322e-03  1.970e-04  11.786  < 2e-16 ***
## perc.alumni        3.334e-01  4.666e-02   7.145 2.09e-12 ***
## Expend            -9.506e-04  2.072e-04  -4.587 5.24e-06 ***
## Elite10:Accept.pct -2.164e+01  9.747e+00  -2.220 0.026705 *
## Elite10:Outstate   -2.253e-03  4.926e-04  -4.575 5.56e-06 ***
## Elite10:Expend     1.057e-03  2.888e-04   3.661 0.000268 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 13.12 on 768 degrees of freedom
## Multiple R-squared:  0.4228, Adjusted R-squared:  0.4168
## F-statistic: 70.32 on 8 and 768 DF,  p-value: < 2.2e-16
```

#Problem2(c)

```
fitmodel <- lm(Elite10 ~ Grad.Rate + Accept.pct + Outstate + perc.alumni + Expend, data = col
lege_data)
summary(fitmodel)
```

```
## 
## Call:
## lm(formula = Elite10 ~ Grad.Rate + Accept.pct + Outstate + perc.alumni +
##     Expend, data = college_data)
## 
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.75664 -0.11744 -0.03826  0.04361  0.99371
## 
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.572e-01  6.830e-02   2.301  0.02163 *
## Grad.Rate    1.737e-03  6.319e-04   2.749  0.00611 **
## Accept.pct  -5.461e-01  6.440e-02  -8.481  < 2e-16 ***
## Outstate    -2.460e-06  3.354e-06  -0.733  0.46361
## perc.alumni  1.644e-03  8.572e-04   1.918  0.05550 .
## Expend       2.336e-05  2.338e-06   9.991  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 0.2351 on 771 degrees of freedom
## Multiple R-squared:  0.3926, Adjusted R-squared:  0.3887
## F-statistic: 99.68 on 5 and 771 DF,  p-value: < 2.2e-16
```

```
fittedmodel <- lm(Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend +
                  Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni + Elite10:Exp
end,
                data=college_data)
summary(fittedmodel)
```

```
##
## Call:
## lm(formula = Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend + Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni +
##     Elite10:Expend, data = college_data)
##
## Residuals:
##     Min     1Q  Median     3Q     Max
## -53.787  -7.785  -0.400   7.769  57.177
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)         5.316e+01  3.592e+00  14.801  < 2e-16 ***
## Elite10             3.763e+01  1.000e+01   3.762 0.000181 ***
## Accept.pct         -1.519e+01  4.129e+00  -3.678 0.000251 ***
## Outstate            2.296e-03  1.991e-04  11.532  < 2e-16 ***
## perc.alumni         3.505e-01  5.030e-02   6.968 6.95e-12 ***
## Expend             -9.536e-04  2.073e-04  -4.601 4.93e-06 ***
## Elite10:Accept.pct -2.274e+01  9.822e+00  -2.315 0.020881 *
## Elite10:Outstate   -2.054e-03  5.390e-04  -3.811 0.000150 ***
## Elite10:perc.alumni -1.227e-01  1.347e-01  -0.911 0.362485
## Elite10:Expend      1.050e-03  2.889e-04   3.635 0.000297 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.12 on 767 degrees of freedom
## Multiple R-squared:  0.4234, Adjusted R-squared:  0.4167
## F-statistic: 62.58 on 9 and 767 DF,  p-value: < 2.2e-16
```

#problem2(d)

```
#5-fold cross validation
# split samples (75% for training and 25% for testing)
library(DAAG)
```

```
##
## Attaching package: 'DAAG'
```

```
## The following object is masked from 'package:car':
##
##     vif
```

```
select.myd <- sample(1:nrow(college_data), 0.75*nrow(college_data))
#Selecting 75% of the data for training purpose
train.myd <- college_data[select.myd,]
#Selecting 25% (remaining) of the data for testing
test.myd <- college_data[-select.myd,]

model1 <- lm(Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend + Elite10:Acc
ept.pct + Elite10:Outstate + Elite10:perc.alumni + Elite10 : Expend,data=train.myd)
# Summary of the model
summary(model1)
```

```
##
## Call:
## lm(formula = Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend + Elite10:Accept.pct + Elite10:Outstate + Elite10:perc.alumni +
##     Elite10:Expend, data = train.myd)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -50.067  -7.820  -0.362   7.731  57.204
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)          5.373e+01  4.074e+00  13.190  < 2e-16 ***
## Elite10              3.056e+01  1.178e+01   2.595 0.009706 **
## Accept.pct          -1.562e+01  4.667e+00  -3.348 0.000869 ***
## Outstate             2.316e-03  2.284e-04  10.141  < 2e-16 ***
## perc.alumni          3.331e-01  5.753e-02   5.791 1.16e-08 ***
## Expend              -9.592e-04  2.307e-04  -4.158 3.70e-05 ***
## Elite10:Accept.pct  -1.743e+01  1.148e+01  -1.518 0.129486
## Elite10:Outstate    -1.814e-03  6.396e-04  -2.836 0.004730 **
## Elite10:perc.alumni -1.075e-01  1.482e-01  -0.725 0.468477
## Elite10:Expend       1.048e-03  3.325e-04   3.150 0.001718 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.17 on 572 degrees of freedom
## Multiple R-squared:  0.415,  Adjusted R-squared:  0.4058
## F-statistic: 45.09 on 9 and 572 DF,  p-value: < 2.2e-16
```

```
#5-fold cross validation
cv.lm(data=college_data, form.lm=model1, m= 5, plotit= T)
```

```
## Warning in cv.lm(data = college_data, form.lm = model1, m = 5, plotit = T):
##
##  As there is >1 explanatory variable, cross-validation
##  predicted values for a fold are not a linear function
##  of corresponding overall predicted values.  Lines that
##  are shown for the different folds are approximate
```

Small symbols show cross-validation predicted values

Legend:
- Fold 1
- Fold 2
- Fold 3
- Fold 4
- Fold 5

X-axis: Predicted (fit to all data)
Y-axis: Grad.Rate
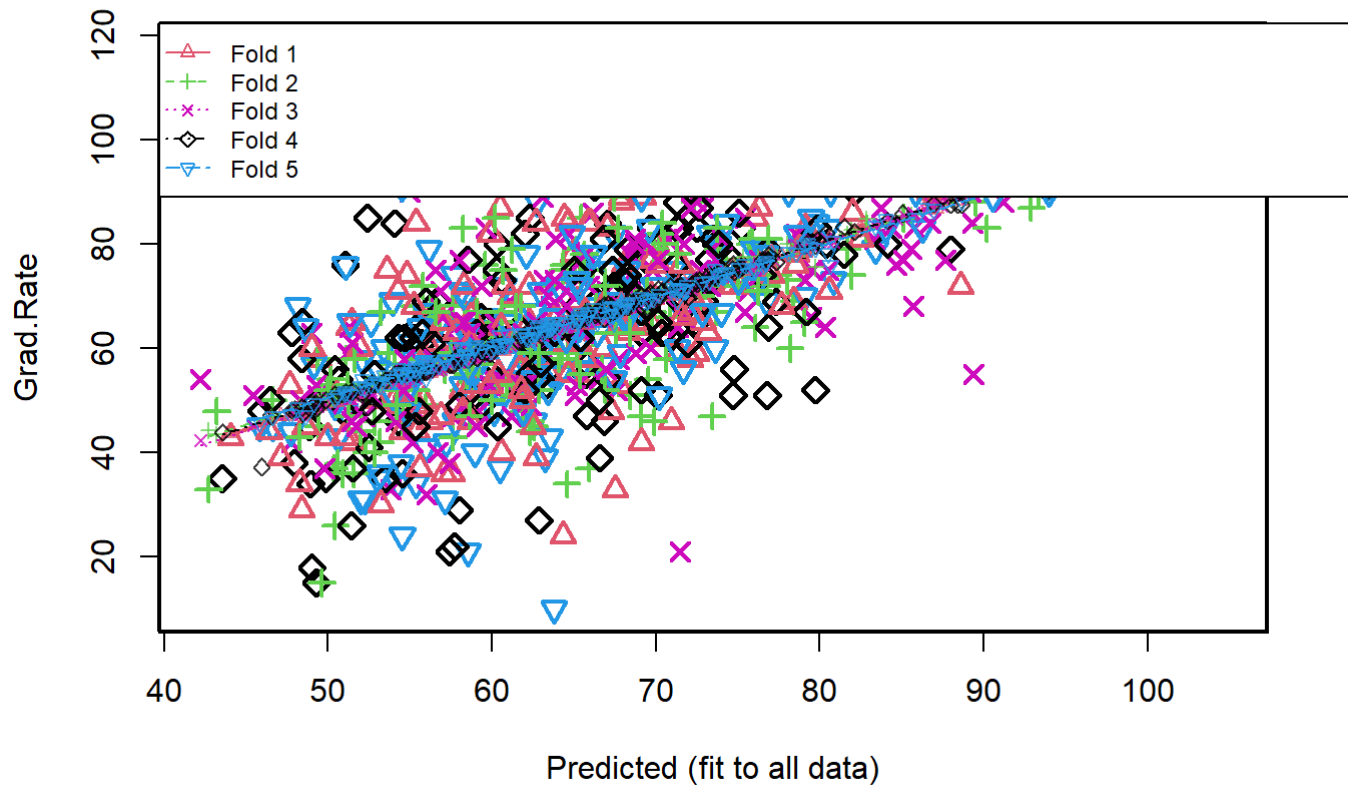
```
##
## fold 1
## Observations in test set: 155
##                         4         6        13       22        23        29
## Predicted      72.44995  66.34431 65.150306 58.42528 68.718211  72.11213
## cvpred         73.70815  66.79988 64.745485 57.71203 68.462072  71.82693
## Grad.Rate      59.00000  55.00000 74.000000 70.00000 65.000000  58.00000
## CV residual   -14.70815 -11.79988  9.254515 12.28797 -3.462072 -13.82693
##                        34        38        39       42        55        60
## Predicted      62.275851 82.557498 62.248758 64.65842 74.489477 75.225409
## cvpred         61.831772 82.440629 62.456459 64.20865 75.329273 76.377575
## Grad.Rate      65.000000 91.000000 72.000000 84.00000 72.000000 72.000000
## CV residual     3.168228  8.559371  9.543541 19.79135 -3.329273 -4.377575
##                        61        62        64        72       76         79
## Predicted      97.6995499 56.54135 64.39957 87.063824 70.61613 59.1790694
## cvpred         96.9416256 56.21915 64.42137 86.881198 70.14865 58.5608877
## Grad.Rate      96.0000000 67.00000 85.00000 89.000000 71.00000 59.0000000
## CV residual    -0.9416256 10.78085 20.57863  2.118802  0.85135  0.4391123
##                        84        90        91        94        99       102
## Predicted      67.679798 57.898148 70.573859 63.533267  64.36575 67.2117843
## cvpred         67.418222 57.678583 70.656367 63.270743  64.54497 67.1070616
## Grad.Rate      64.000000 67.000000 62.000000 55.000000  24.00000 67.0000000
## CV residual   -3.418222  9.321417 -8.656367 -8.270743 -40.54497 -0.1070616
##                       103       106       120      125       133       134       142
## Predicted      54.329761 62.57364 56.194246 68.53451 64.96032 69.851247 58.379490
## cvpred         53.607152 61.93554 55.722608 68.17298 64.97919 69.163416 58.096405
## Grad.Rate      49.000000 58.00000 46.000000 96.00000 78.00000 64.000000 59.000000
## CV residual   -4.607152 -3.93554 -9.722608 27.82702 13.02081 -5.163416  0.903595
##                       144       147       148       156       162       170
## Predicted      68.071207 51.460854 63.518658  70.92818 49.445945 60.50343
## cvpred         67.811301 51.405987 63.480213  70.05095 48.993223 60.53243
## Grad.Rate      76.000000 42.000000 55.000000  46.00000 58.000000 87.00000
## CV residual     8.188699 -9.405987 -8.480213 -24.05095  9.006777 26.46757
##                       176       181       184       185       189       195
## Predicted      78.6019937 55.862415 61.085127  71.39044 68.260196  67.75772
## cvpred         78.8882677 55.156642 60.741809  72.17391 67.570187  67.64331
## Grad.Rate      78.0000000 50.000000 70.000000  59.00000 63.000000  53.00000
## CV residual    -0.8882677 -5.156642  9.258191 -13.17391 -4.570187 -14.64331
##                       206       210       220       228       235       244
## Predicted      70.000044 66.840766 74.662315 72.843350 70.148680 72.881435
## cvpred         70.361326 66.765521 75.551771 72.839542 69.891612 72.970541
## Grad.Rate      80.000000 60.000000 72.000000 69.000000 76.000000 65.000000
## CV residual     9.638674 -6.765521 -3.551771 -3.839542  6.108388 -7.970541
##                       245       262       263       273       277       284       286
## Predicted      78.421078 64.123811  54.53168 62.89984 63.922379 69.22909  57.53911
## cvpred         78.284609 63.964504  54.52257 62.45779 63.824803 69.12560  57.19087
## Grad.Rate      69.000000 67.000000  44.00000 95.00000 66.000000 89.00000  36.00000
## CV residual   -9.284609  3.035496 -10.52257 32.54221  2.175197 19.87440 -21.19087
##                       298       301       309       312       313       328       334
## Predicted      58.167863 53.62279 76.04530 65.718543 61.696916 66.00932 54.189722
## cvpred         58.096011 53.43885 75.92771 65.810682 61.415463 66.52243 54.084924
## Grad.Rate      52.000000 75.00000 85.00000 58.000000 56.000000 84.00000 51.000000
## CV residual   -6.096011 21.56115  9.07229 -7.810682 -5.415463 17.47757 -3.084924
##                       348       349       351       359      362       365       369
## Predicted      65.86257 69.698790 64.634085  67.28963 59.91268 67.87394 55.419329
```

```
## cvpred        64.56391 69.542422 64.726341   66.56123 59.34694 67.52382 55.119558
## Grad.Rate     84.00000 77.000000 55.000000   48.00000 82.00000 89.00000 49.000000
## CV residual   19.43609  7.457578 -9.726341 -18.56123 22.65306 21.47618 -6.119558
##                       375       378        386        390        394        402
## Predicted     56.55313  48.37374 51.949957 56.207133 68.316731 54.769208
## cvpred        55.73301  47.70143 51.260574 55.377052 67.974346 54.028051
## Grad.Rate     61.00000 100.00000 60.000000 60.000000 64.000000 52.000000
## CV residual    5.26699  52.29857  8.739426  4.622948 -3.974346 -2.028051
##                       405       406        408       410       412        427         432
## Predicted     65.297862 58.32237 80.570107 67.91303  55.42481  67.50875 79.109917
## cvpred        65.279986 58.35147 80.932082 69.22268  54.94078  67.01792 79.348174
## Grad.Rate     61.000000 72.00000 71.000000 65.00000  44.00000  33.00000 83.000000
## CV residual   -4.279986 13.64853 -9.932082 -4.22268 -10.94078 -34.01792  3.651826
##                       435       443       444       449       451        456
## Predicted     52.944089 65.222260  69.12979  58.47631  62.71397 58.726283
## cvpred        52.429429 65.334713  69.70797  58.30015  62.77174 58.791069
## Grad.Rate     50.000000 69.000000  42.00000  48.00000  39.00000 66.000000
## CV residual   -2.429429  3.665287 -27.70797 -10.30015 -23.77174  7.208931
##                        472        480        485       486        493       496
## Predicted     69.6926611 64.234357 56.8133920 57.393077 72.181063 67.05500
## cvpred        70.4798022 64.549993 56.4389842 57.037772 72.122011 67.23828
## Grad.Rate     70.0000000 61.000000 57.0000000 58.000000 70.000000 83.00000
## CV residual   -0.4798022 -3.549993  0.5610158  0.962228 -2.122011 15.76172
##                       497       499       505       517       521        528       529
## Predicted     71.576332 70.05449 67.89065 66.329027 60.75477 82.486261 86.695051
## cvpred        71.456715 70.24715 67.72474 66.692744 60.10370 83.191813 86.617378
## Grad.Rate     76.000000 98.00000 88.00000 66.000000 72.00000 81.000000 90.000000
## CV residual    4.543285 27.75285 20.27526 -0.692744 11.89630 -2.191813  3.382622
##                       531       532       536       549       559       560       561
## Predicted     48.616436 47.661819 54.26255  60.58222 51.28679 74.89076 54.82677
## cvpred        48.164886 47.033148 54.02663  60.98743 50.05586 74.38444 54.45705
## Grad.Rate     45.000000 53.000000 71.00000  40.00000 64.00000 97.00000 74.00000
## CV residual   -3.164886  5.966852 16.97337 -20.98743 13.94414 22.61556 19.54295
##                       570       573       578       581       583       584
## Predicted     78.498350 57.649659 58.729678  57.09220 49.999354 60.562673
## cvpred        79.509892 57.079255 58.322822  56.62935 49.598046 60.306978
## Grad.Rate     76.000000 59.000000 53.000000  36.00000 43.000000 64.000000
## CV residual   -3.509892  1.920745 -5.322822 -20.62935 -6.598046  3.693022
##                       587       588       594       598       605       608
## Predicted     50.938734 55.39146 87.048031 77.037406 47.114071  58.64779
## cvpred        50.811328 55.12757 87.658642 78.274705 46.958275  57.77810
## Grad.Rate     43.000000 84.00000 91.000000 74.000000 39.000000  46.00000
## CV residual   -7.811328 28.87243  3.341358 -4.274705 -7.958275 -11.77810
##                       620       625       634       635       638        641       645
## Predicted     71.557081  48.25048 57.830952 55.22799 76.32935  62.51343 58.209962
## cvpred        73.285126  48.61587 57.737472 55.41032 76.88912  62.47619 57.670386
## Grad.Rate     66.000000  34.00000 63.000000 68.00000 87.00000  45.00000 48.000000
## CV residual   -7.285126 -14.61587  5.262528 12.58968 10.11088 -17.47619 -9.670386
##                       647       651       654       655       657       662
## Predicted     50.520317  55.57918 59.897410 60.398306 56.905818 46.41161
## cvpred        49.803599  54.86348 59.653245 59.726824 56.297163 46.40956
## Grad.Rate     51.000000  37.00000 53.000000 55.000000 47.000000 44.00000
## CV residual    1.196401 -17.86348 -6.653245 -4.726824 -9.297163 -2.40956
##                       664       667       673       674       685       686
## Predicted     90.043351  73.17068 44.0702849 75.42764  48.39094 51.46595
## cvpred        90.146171  73.70000 43.6870321 74.88645  47.81046 50.92205
```

```
## Grad.Rate    93.000000  63.00000 43.0000000 92.00000  29.00000 65.00000
## CV residual  2.853829 -10.70000 -0.6870321 17.11355 -18.81046 14.07795
##                      697        705        715       722        724        725
## Predicted    57.032058 78.7328226   53.23568 66.78335 72.136538 82.022925
## cvpred       56.482588 78.8482457   53.12755 66.09440 71.858336 82.197551
## Grad.Rate    65.000000 79.0000000   30.00000 68.00000 67.000000 86.000000
## CV residual  8.517412  0.1517543  -23.12755  1.90560 -4.858336  3.802449
##                      737        740        747       756        760        761        763
## Predicted    62.66590 49.01905 58.695852   88.58218 65.701673 77.676874 61.777830
## cvpred       62.46167 48.48644 58.290454   88.41681 65.730659 77.811013 61.880802
## Grad.Rate    84.00000 60.00000 61.000000   72.00000 67.000000 68.000000 52.000000
## CV residual  21.53833 11.51356  2.709546  -16.41681  1.269341 -9.811013 -9.880802
##                      769        777
## Predicted    61.83348 60.70546
## cvpred       61.67962 59.44384
## Grad.Rate    50.00000 99.00000
## CV residual -11.67962 39.55616
##
## Sum of squares = 29255.46    Mean square = 188.74    n = 155
##
## fold 2
## Observations in test set: 156
##                        3         7         17         18         26        27        35
## Predicted    69.50927 69.71023 103.246484 62.293767 43.193006 72.36454 65.42894
## cvpred       69.56527 69.74598 104.260841 62.416737 43.518401 72.17002 65.49334
## Grad.Rate    54.00000 63.00000 100.000000 59.000000 48.000000 88.00000 85.00000
## CV residual -15.56527 -6.74598  -4.260841 -3.416737  4.481599 15.82998 19.50666
##                       43        51         54         56        57        58
## Predicted    58.258719  61.91702 51.114353   68.46624 64.32576 50.237313
## cvpred       58.438977  62.09159 51.436542   68.63535 64.32748 50.491997
## Grad.Rate    52.000000  48.00000 58.000000   51.00000 75.00000 53.000000
## CV residual -6.438977 -14.09159  6.563458  -17.63535 10.67252  2.508003
##                       68        74         83         86        88        95
## Predicted    64.264420 69.027944 55.976325 59.584117 81.938885 66.109100
## cvpred       64.417533 68.759374 56.028883 59.831546 82.738326 66.606576
## Grad.Rate    58.000000 78.000000 49.000000 52.000000 74.000000 75.000000
## CV residual -6.417533  9.240626 -7.028883 -7.831546 -8.738326  8.393424
##                       97        104        107        108       112        115
## Predicted    77.423655 46.617623 75.346012   69.12095 66.199381 92.890989
## cvpred       77.505009 46.914278 77.481017   69.46291 66.272168 93.542809
## Grad.Rate    74.000000 50.000000 74.000000   47.00000 63.000000 87.000000
## CV residual -3.505009  3.085722 -3.481017  -22.46291 -3.272168 -6.542809
##                      118        127        131       136        140        146
## Predicted    76.260694  69.55983 67.967507 59.55241 78.418791  62.56872
## cvpred       76.408147  69.45486 68.056268 59.67476 78.802215  62.59254
## Grad.Rate    77.000000 100.00000 72.000000 76.00000 69.000000  45.00000
## CV residual  0.591853  30.54514  3.943732 16.32524 -9.802215 -17.59254
##                      152        158        160       166        169        171
## Predicted    76.05300 63.458343 91.872727 54.540518 54.8871638  53.16548
## cvpred       76.07168 63.586493 92.243587 54.615435 54.9342423  53.84549
## Grad.Rate    64.00000 72.000000 94.000000 46.000000 54.0000000  42.00000
## CV residual -12.07168  8.413507  1.756413 -8.615435 -0.9342423 -11.84549
##                      191       192        194       196       203        204       205
## Predicted    70.21898 85.59204 73.693307 55.27326 57.60857 55.522706 63.655762
## cvpred       70.28739 85.57922 73.583251 55.65015 57.68898 55.782166 63.446127
## Grad.Rate    82.00000 96.00000 67.000000 68.00000 68.00000 58.000000 62.000000
```

```
## CV residual 11.71261 10.42078 -6.583251 12.34985 10.31102  2.217834 -1.446127
##                     207        217        219        225        227        229
## Predicted   52.870423 65.418499  62.35123 64.36196  51.58601 70.859206
## cvpred      52.875653 65.383733  62.31341 64.41989  51.79443 70.930506
## Grad.Rate   46.000000 74.000000  46.00000 76.00000  36.00000 66.000000
## CV residual -6.875653  8.616267 -16.31341 11.58011 -15.79443 -4.930506
##                     231        234        238        239        242        248        255
## Predicted   74.290206 54.080737 82.884547  79.73261 69.52016  50.61396 65.13822
## cvpred      75.008531 54.136274 84.724444  75.50513 69.41674  50.97245 65.71918
## Grad.Rate   77.000000 57.000000 83.000000 100.00000 96.00000  38.00000 79.00000
## CV residual  1.991469  2.863726 -1.724444  24.49487 26.58326 -12.97245 13.28082
##                     256        258        259        260        274        276
## Predicted   73.767791 61.693701 75.039682 72.997893  52.33930  64.56636
## cvpred      74.055034 62.022651 75.534657 73.334675  52.63211  64.48875
## Grad.Rate   79.000000 60.000000 72.000000 72.000000  40.00000  34.00000
## CV residual  4.944966 -2.022651 -3.534657 -1.334675 -12.63211 -30.48875
##                     282        287        288        290        293        296        308
## Predicted    50.43736  66.75093 75.73780 56.29542 89.486984 60.442521 68.19390
## cvpred       50.94712  66.80296 75.96802 56.44707 89.549058 60.768174 68.21682
## Grad.Rate    26.00000  56.00000 80.00000 68.00000 88.000000 65.000000 94.00000
## CV residual -24.94712 -10.80296  4.03198 11.55293 -1.549058  4.231826 25.78318
##                     315        318        319        324        329        332
## Predicted   59.749191  65.04484 75.899457 53.698501 60.899003 76.771436
## cvpred      59.894678  64.61534 75.782648 54.031046 61.204544 76.545541
## Grad.Rate   61.000000 100.00000 81.000000 59.000000 53.000000 72.000000
## CV residual  1.105322  35.38466  5.217352  4.968954 -8.204544 -4.545541
##                     336        339        340        342        350        366
## Predicted   65.214451 69.926768 72.717526 64.650743 61.769966 60.21969
## cvpred      65.606087 70.079544 72.900589 64.471285 62.199383 60.41713
## Grad.Rate   59.000000 79.000000 70.000000 59.000000 68.000000 85.00000
## CV residual -6.606087  8.920456 -2.900589 -5.471285  5.800617 24.58287
##                     383        385        388        392        400        413
## Predicted    50.37443  49.62600 58.23428  62.33081 51.610748 60.497417
## cvpred       50.66109  50.47842 58.48393  62.27178 51.904198 60.879357
## Grad.Rate    37.00000  15.00000 83.00000  44.00000 58.000000 62.000000
## CV residual -13.66109 -35.47842 24.51607 -18.27178  6.095802  1.120643
##                     414        419        423        424        429        430
## Predicted   53.430902  69.88432 64.12015 67.4237685 90.180828 81.670591
## cvpred      54.013258  69.94907 64.04163 67.3198334 90.482455 81.892138
## Grad.Rate   52.000000  46.00000 58.00000 68.0000000 83.000000 79.000000
## CV residual -2.013258 -23.94907 -6.04163  0.6801666 -7.482455 -2.892138
##                     431        436        440        446        448        462
## Predicted   69.811629 49.413286  65.93271 67.553319 51.996370 59.09796
## cvpred      70.214801 49.748181  65.91789 67.648193 52.171454 59.37964
## Grad.Rate   67.000000 45.000000  37.00000 63.000000 44.000000 67.00000
## CV residual -3.214801 -4.748181 -28.91789 -4.648193 -8.171454  7.62036
##                     463        464        471        478        490        503        509
## Predicted    70.66042 70.530003 70.38305 61.20325 49.384755 73.750361 58.110754
## cvpred       70.76918 70.382948 70.74342 61.34056 49.541755 74.058516 58.102021
## Grad.Rate    58.00000 80.000000 84.00000 79.00000 58.000000 83.000000 56.000000
## CV residual -12.76918  9.617052 13.25658 17.65944  8.458245  8.941484 -2.102021
##                     514        515        516        518        520        530        533
## Predicted    65.41068  62.89387 78.041603 67.45441 69.455222 53.21768  57.62414
## cvpred       65.39128  63.09938 79.950957 67.64843 69.677059 53.39433  57.89163
## Grad.Rate    55.00000  52.00000 73.000000 89.00000 71.000000 67.00000  43.00000
## CV residual -10.39128 -11.09938 -6.950957 21.35157  1.322941 13.60567 -14.89163
```

```
##                      534        540        545         548         550        552
## Predicted     48.252799 55.390312 65.61955 85.1378425 71.300568 55.77996
## cvpred        48.718869 55.696152 65.90834 85.3845643 71.331593 56.02933
## Grad.Rate     43.000000 52.000000 78.00000 85.0000000 78.000000 72.00000
## CV residual   -5.718869 -3.696152 12.09166 -0.3845643  6.668407 15.97067
##                      555        569        577        585        592         599
## Predicted     60.604269 56.847660 68.408415  59.99257 76.891299  66.92426
## cvpred        60.629599 56.967808 68.963805  60.13234 72.154988  66.67641
## Grad.Rate     67.000000 66.000000 67.000000  50.00000 81.000000  52.00000
## CV residual    6.370401  9.032192 -1.963805 -10.13234  8.845012 -14.67641
##                      604        609        611       615        617         628
## Predicted     42.72003 59.237297 50.166927 60.67206  61.26071   73.42741
## cvpred        44.28114 59.400988 51.203362 61.11438  61.70206   73.47539
## Grad.Rate     33.00000 57.000000 54.000000 75.00000  51.00000   47.00000
## CV residual  -11.28114 -2.400988  2.796638 13.88562 -10.70206 -26.47539
##                      630        633        636       643        646         677
## Predicted     62.366249 58.502528 57.156144 58.82633 52.3996882 51.268372
## cvpred        62.321986 58.668566 57.410743 59.27520 52.5170283 51.997485
## Grad.Rate     59.000000 55.000000 56.000000 58.00000 52.0000000 47.000000
## CV residual   -3.321986 -3.668566 -1.410743 -1.27520 -0.5170283 -4.997485
##                      679        691        696       699        706         707       716
## Predicted     50.89140   58.63373 51.218706 56.58729 61.478232   52.83752 66.35422
## cvpred        51.02707   59.21562 51.715188 56.64742 61.546358   52.99296 66.33976
## Grad.Rate     36.00000   47.00000 53.000000 67.00000 68.000000   40.00000 68.00000
## CV residual  -15.02707  -12.21562  1.284812 10.35258  6.453642  -12.99296  1.66024
##                      726        727        730       743        745         754
## Predicted     93.348590   79.04332 49.996216  78.18340 57.509585 76.269388
## cvpred        92.287031   79.05267 50.214741  78.14735 57.818942 77.564821
## Grad.Rate     90.000000   65.00000 52.000000  60.00000 59.000000 71.000000
## CV residual   -2.287031  -14.05267  1.785259 -18.14735  1.181058 -6.564821
##                      755        759        762       774        775
## Predicted     66.88778 68.425550 62.868682 67.72027 54.206293
## cvpred        66.88255 68.549035 62.985271 67.87530 54.631324
## Grad.Rate     72.00000 63.000000 59.000000 83.00000 49.000000
## CV residual    5.11745 -5.549035 -3.985271 15.12470 -5.631324
##
## Sum of squares = 22614.14    Mean square = 144.96    n = 156
##
## fold 3
## Observations in test set: 156
##                       8         11         12        16        24         30
## Predicted     73.2611680 79.101781 84.700143 61.091417 55.370584 75.646553
## cvpred        73.4860098 78.837266 84.741524 60.589636 54.219217 75.705965
## Grad.Rate     73.0000000 73.000000 76.000000 69.000000 48.000000 71.000000
## CV residual   -0.4860098 -5.837266 -8.741524  8.410364 -6.219217 -4.705965
##                      32         44        48        49        66         69         70
## Predicted     67.008278 58.342821  89.37980 71.21362  62.39144 64.69080   53.86350
## cvpred        67.263362 57.954653  89.37412 70.75888  61.42539 64.39804   54.52151
## Grad.Rate     71.000000 49.000000  55.00000 82.00000  49.00000 82.00000   33.00000
## CV residual    3.736638 -8.954653 -34.37412 11.24112 -12.42539 17.60196 -21.52151
##                      71         73        81        89        96         98
## Predicted     96.6136216 86.487447 70.72268 69.649794  60.82333 62.696030
## cvpred        97.3256854 86.451087 70.85232 69.141388  60.39981 62.717182
## Grad.Rate     97.0000000 93.000000 81.00000 79.000000 118.00000 64.000000
## CV residual   -0.3256854  6.548913 10.14768  9.858612  57.60019  1.282818
##                     101        109        113       117        121        122
```

```
## Predicted      57.91984   67.66516   59.21588 68.464486 75.477204 69.83225
## cvpred         57.43524   68.50383   58.39467 68.109171 75.301919 70.00082
## Grad.Rate      47.00000   52.00000   48.00000 74.000000 67.000000 75.00000
## CV residual -10.43524 -16.50383 -10.39467  5.890829 -8.301919  4.99918
##                     124        138        141        154        155        157        163
## Predicted      91.161811 87.426504 89.32243  65.10801 49.01397 60.077979 83.359117
## cvpred         91.516369 87.369034 89.31942  64.70393 48.36575 59.976188 83.673133
## Grad.Rate      93.000000 95.000000 84.00000  51.00000 63.00000 54.000000 81.000000
## CV residual  1.483631   7.630966 -5.31942 -13.70393 14.63425 -5.976188 -2.673133
##                     165        168        178        180        188        197        209
## Predicted      83.755732 69.741443 47.811177  66.57057 66.18401 76.79534 59.66545
## cvpred         83.942374 69.855918 47.561369  66.08461 65.74439 76.59607 58.65873
## Grad.Rate      87.000000 60.000000 42.000000  54.00000 86.00000 94.00000 83.00000
## CV residual  3.057626 -9.855918 -5.561369 -12.08461 20.25561 17.40393 24.34127
##                     215        226        237        249        257        261
## Predicted      65.5435130 85.764668 63.075578 63.174663 85.629221 73.355431
## cvpred         64.8872043 85.680985 62.465882 63.270666 85.596995 73.496618
## Grad.Rate      65.0000000 83.000000 60.000000 73.000000 79.000000 72.000000
## CV residual  0.1127957 -2.680985 -2.465882  9.729334 -6.596995 -1.496618
##                     264        275        283        289        291        295        300
## Predicted      61.22916 63.586911 56.60129 60.568397 57.975997 72.90096 85.736794
## cvpred         61.16247 63.333462 56.32154 60.095086 57.219515 72.78470 85.965263
## Grad.Rate      47.00000 68.000000 75.00000 54.000000 61.000000 87.00000 92.000000
## CV residual -14.16247  4.666538 18.67846 -6.095086  3.780485 14.21530  6.034737
##                     302        306        307        321        323        327
## Predicted      73.72215 49.375166  87.65940 59.446232 68.187688 71.751752
## cvpred         73.58786 48.808868  88.47465 58.704713 67.680029 71.426256
## Grad.Rate      77.00000 51.000000  77.00000 63.000000 70.000000 80.000000
## CV residual  3.41214  2.191132 -11.47465  4.295287  2.319971  8.573744
##                     335        338        345        347        355        356
## Predicted      85.136075 64.4377284 65.50112 72.66201 94.2068512 45.479766
## cvpred         85.484405 63.9211164 65.34429 73.38256 94.9614035 45.116831
## Grad.Rate      77.000000 64.0000000 77.00000 90.00000 94.0000000 51.000000
## CV residual -8.484405  0.0788836 11.65571 16.61744 -0.9614035  5.883169
##                     358        361        363        364        368        373        376
## Predicted      56.04073 68.411845 69.45521 51.230625 60.18305  67.77732  65.19213
## cvpred         55.28498 68.081242 68.92882 50.432906 59.96704  68.19808  64.49116
## Grad.Rate      32.00000 78.000000 80.00000 59.000000 65.00000  58.00000  53.00000
## CV residual -23.28498  9.918758 11.07118  8.567094  5.03296 -10.19808 -11.49116
##                     389        391        395        398        399        401
## Predicted      66.98220 86.757507  71.46872 65.927185 74.083927 84.354185
## cvpred         66.89085 87.765897  71.53788 65.569516 73.802139 84.246882
## Grad.Rate      56.00000 84.000000  21.00000 72.000000 81.000000 83.000000
## CV residual -10.89085 -3.765897 -50.53788  6.430484  7.197861 -1.246882
##                     404        411        434        447        453        459
## Predicted      56.92119 55.819860 79.552035  79.50068 51.50644 75.465703
## cvpred         55.90757 55.338455 79.416416  80.89649 50.93773 75.536443
## Grad.Rate      71.00000 57.000000 75.000000  66.00000 61.00000 85.000000
## CV residual 15.09243  1.661545 -4.416416 -14.89649 10.06227  9.463557
##                     460        461        467        468        469        470
## Predicted      104.782612 80.84564 52.225117 76.328762 64.608279  85.71788
## cvpred         104.982708 80.43331 51.567443 76.461128 65.035606  85.95014
## Grad.Rate      99.000000 96.00000 47.000000 74.000000 68.000000  68.00000
## CV residual  -5.982708 15.56669 -4.567443 -2.461128  2.964394 -17.95014
##                     473        474        475        476        482        483
## Predicted      76.3016763 70.6043581  80.37998 63.93835 68.74999 52.6594689
```

```
## cvpred       76.1136347 70.3270726  80.96103 63.28503 68.63098 51.8998714
## Grad.Rate    77.0000000 70.0000000  64.00000 81.00000 81.00000 51.0000000
## CV residual  0.8863653 -0.3270726 -16.96103 17.71497 12.36902 -0.8998714
##                      488        492        504          519        522        524
## Predicted     63.506745 67.586077 61.796869 64.526551466 56.493031   57.62621
## cvpred        62.808844 67.076127 61.421868 64.000832948 56.099348   57.34537
## Grad.Rate     70.000000 69.000000 53.000000 64.000000000 58.000000   47.00000
## CV residual   7.191156  1.923873 -8.421868 -0.000832948  1.900652 -10.34537
##                      544        546        566        567        568        572
## Predicted     50.850937 71.387082 61.875147   55.20413 62.077225 58.112808
## cvpred        50.600419 71.606384 61.242746   54.62425 61.303079 57.478342
## Grad.Rate     49.000000 64.000000 63.000000   42.00000 53.000000 65.000000
## CV residual  -1.600419 -7.606384  1.757254 -12.62425 -8.303079  7.521658
##                      574       580        593       596        602        607
## Predicted     54.152710 72.26842 62.771388 65.75556 91.210931 71.712444
## cvpred        53.505552 72.02974 62.441139 65.59660 91.722325 72.457278
## Grad.Rate     46.000000 98.00000 65.000000 78.00000 88.000000 66.000000
## CV residual  -7.505552 25.97026  2.558861 12.40340 -3.722325 -6.457278
##                      610      612       613       614        619         622
## Predicted     89.2138056 64.61339 65.53959 66.93323 70.166092 66.75765146
## cvpred        89.7186056 64.13664 65.30686 66.62957 69.695232 65.96085324
## Grad.Rate     90.0000000 71.00000 63.00000 93.00000 77.000000 66.00000000
## CV residual   0.2813944  6.86336 -2.30686 26.37043  7.304768  0.03914676
##                      623       631       637       639       642       648       659
## Predicted     42.22278 51.34810 68.831666 59.863391 49.340116 61.80828   56.69372
## cvpred        42.31659 50.41112 68.941475 58.981871 48.978238 62.42601   55.78507
## Grad.Rate     54.00000 64.00000 59.000000 53.000000 53.000000 53.00000   40.00000
## CV residual  11.68341 13.58888 -9.941475 -5.981871  4.021762 -9.42601 -15.78507
##                      660       661       665       676       682       683       687
## Predicted     58.07823 88.467926 56.991102 58.664018 63.11730 60.478305 48.341019
## cvpred        57.86805 88.618983 56.853951 58.284348 62.40863 59.903573 47.314587
## Grad.Rate     77.00000 97.000000 66.000000 63.000000 89.00000 62.000000 50.000000
## CV residual  19.13195  8.381017  9.146049  4.715652 26.59137  2.096427  2.685413
##                      690       692       694       700       701       702
## Predicted     78.566573  49.82664 87.186006 51.437555 59.41771   57.46559
## cvpred        79.927141  49.45725 87.738981 50.377625 59.35468   56.69852
## Grad.Rate     82.000000  37.00000 95.000000 46.000000 72.00000   38.00000
## CV residual   2.072859 -12.45725  7.261019 -4.377625 12.64532 -18.69852
##                      703       708       711       712       714       720       732
## Predicted     51.778179 66.44336 77.22735   59.10941 63.871131 72.74454 55.02572
## cvpred        51.464847 66.14661 76.69380   58.70168 63.468655 72.18132 53.87578
## Grad.Rate     45.000000 95.00000 96.00000   45.00000 73.000000 75.00000 90.00000
## CV residual  -6.464847 28.85339 19.30620 -13.70168  9.531345  2.81868 36.12422
##                      734       738       746       748       752       758
## Predicted     92.552103 90.193491 54.641514 58.334845 72.17349 68.75157
## cvpred        92.638654 90.836524 53.478923 57.674586 71.36397 68.12862
## Grad.Rate     91.000000 92.000000 52.000000 65.000000 87.00000 80.00000
## CV residual  -1.638654  1.163476 -1.478923  7.325414 15.63603 11.87138
##                      764       767       768       771
## Predicted     100.965025 54.690536 58.7344692 80.561487
## cvpred        100.788555 54.172198 58.5409264 80.404434
## Grad.Rate      99.000000 58.000000 59.0000000 75.000000
## CV residual   -1.788555  3.827802  0.4590736 -5.404434
##
## Sum of squares = 25065.53    Mean square = 160.68    n = 156
##
```

```
## fold 4
## Observations in test set: 155
##                      2        5        9       21       36       37
## Predicted     63.55849 49.31507 73.650252 45.94962 67.600370 87.995749
## cvpred        63.45067 48.46732 73.577941 37.22906 67.415567 87.502307
## Grad.Rate     56.00000 15.00000 80.000000 48.00000 71.000000 79.000000
## CV residual  -7.45067 -33.46732  6.422059 10.77094  3.584433 -8.502307
##                     41       46       50       63       67       75
## Predicted     73.5415049 54.323373 57.598047 66.86371 49.04000 71.30501
## cvpred        73.8390859 55.070194 56.853248 65.53211 49.54413 71.56269
## Grad.Rate     73.0000000 46.000000 63.000000 46.00000 18.00000 83.00000
## CV residual  -0.8390859 -9.070194  6.146752 -19.53211 -31.54413 11.43731
##                     77       80       82       85       87       92
## Predicted     65.72976 55.707309 69.102313 71.45990 88.631888 72.228639
## cvpred        65.76487 55.870804 70.162433 71.65238 87.515257 72.369087
## Grad.Rate     55.00000 61.000000 63.000000 83.00000 91.000000 67.000000
## CV residual  -10.76487  5.129196 -7.162433 11.34762  3.484743 -5.369087
##                    105      110      119      126      128      132      135
## Predicted     52.705860 68.404578 60.60921 58.972638 72.54509 73.252567 60.34302
## cvpred        53.054294 68.751479 60.67947 59.593268 72.39034 73.975709 60.54122
## Grad.Rate     51.000000 73.000000 73.00000 51.000000 83.00000 77.000000 80.00000
## CV residual  -2.054294  4.248521 12.32053 -8.593268 10.60966  3.024291 19.45878
##                    139      149      150      153      172      173      179
## Predicted     85.05667 60.31528 88.386308 52.41920 69.391178 75.236593 47.95527
## cvpred        85.87302 60.66750 87.624016 48.70951 69.731803 75.477112 48.35750
## Grad.Rate     93.00000 75.00000 91.000000 85.00000 77.000000 83.000000 38.00000
## CV residual   7.12698 14.33250  3.375984 36.29049  7.268197  7.522888 -10.35750
##                    182      183      186      187      193      199      200
## Predicted     51.06364 62.01635 73.564278 76.89270 46.504271 57.74422 56.65872
## cvpred        51.45361 61.69815 73.804148 77.84539 47.049282 57.97672 57.30607
## Grad.Rate     76.00000 82.00000 81.000000 64.00000 50.000000 22.00000 69.00000
## CV residual  24.54639 20.30185  7.195852 -13.84539  2.950718 -35.97672 11.69393
##                    202      211      212      213      216      218
## Predicted     59.356016 70.14091 55.249294 67.12288 58.02176 69.13804
## cvpred        59.473049 71.28848 55.408619 68.35542 58.75481 70.00684
## Grad.Rate     66.000000 51.00000 62.000000 54.00000 29.00000 52.00000
## CV residual   6.526951 -20.28848  6.591381 -14.35542 -29.75481 -18.00684
##                    221      222      230      232      233      240
## Predicted     59.934992 93.4350423 67.449713 61.63609 65.78836 72.443499
## cvpred        60.207868 94.2801514 67.068519 61.26901 66.58277 72.852563
## Grad.Rate     55.000000 95.0000000 72.000000 64.00000 47.00000 65.000000
## CV residual  -5.207868  0.7198486  4.931481  2.73099 -19.58277 -7.852563
##                    241      243      247      251      265      266
## Predicted     84.166153 93.863705 59.645622 104.780974 57.42526 54.08037
## cvpred        84.383767 92.409422 59.372779 104.383592 56.74191 55.01824
## Grad.Rate     80.000000 91.000000 64.000000 100.000000 21.00000 84.00000
## CV residual  -4.383767 -1.409422  4.627221  -4.383592 -35.74191 28.98176
##                    267      268      270      272      280      292      299
## Predicted     65.534063 61.78126 59.651215 66.383632 69.55714 63.088776 67.07353
## cvpred        65.844038 62.04659 60.322024 66.930565 70.15791 63.409625 67.25237
## Grad.Rate     75.000000 52.00000 54.000000 69.000000 98.00000 62.000000 84.00000
## CV residual   9.155962 -10.04659 -6.322024  2.069435 27.84209 -1.409625 16.74763
##                    303      304      314      316      320      325
## Predicted     65.82706 51.45496 72.950199 63.30629 52.05045 51.54401
## cvpred        67.18997 51.65902 72.493129 63.82024 51.13645 51.70660
## Grad.Rate     57.00000 26.00000 69.000000 53.00000 92.00000 37.00000
```

```
## CV residual -10.18997 -25.65902 -3.493129 -10.82024 40.86355 -14.70660
##                      326        330       331       333       343        344
## Predicted     48.881540 59.860949 74.697540 68.7629652 76.67755 71.447801
## cvpred        49.457435 58.937618 75.141934 69.1263348 76.65790 71.601796
## Grad.Rate     45.000000 65.000000 77.000000 70.0000000 96.00000 69.000000
## CV residual   -4.457435   6.062382  1.858066  0.8736652 19.34210 -2.601796
##                      346        352       353       360       374        377
## Predicted     49.270349   76.80468 62.322500 66.27711 67.2516592 47.77998
## cvpred        49.505706   76.99914 63.038955 66.46802 67.9982974 48.05637
## Grad.Rate     50.000000   51.00000 61.000000 91.00000 67.0000000 63.00000
## CV residual    0.494294  -25.99914 -2.038955 24.53198 -0.9982974 14.94363
##                      379        380       387       407       409        415        417
## Predicted      62.87084   74.79743 76.49809   48.94843 69.68772 71.260020 68.282716
## cvpred         63.96193   74.57774 76.90853   48.30775 70.60864 71.477327 68.041392
## Grad.Rate      27.00000   56.00000 74.00000   34.00000 83.00000 76.000000 74.000000
## CV residual   -36.96193  -18.57774 -2.90853  -14.30775 12.39136  4.522673  5.958608
##                      420        422       425       426       433        438        445
## Predicted      52.51852 50.649622 86.95489 70.383313 55.39793 72.64046 50.918559
## cvpred         52.94614 51.009496 87.67388 70.891488 55.13710 73.03087 51.211254
## Grad.Rate      41.00000 54.000000 92.00000 63.000000 64.00000 87.00000 48.000000
## CV residual   -11.94614  2.990504  4.32612 -7.891488  8.86290 13.96913 -3.211254
##                      450        455       457       458       465        466        484
## Predicted     65.171019 62.763169 70.906372 43.56203 75.10339 54.316238 58.53072
## cvpred        65.650649 63.116521 71.869567 43.81029 75.23843 55.204053 57.65128
## Grad.Rate     68.000000 54.000000 62.000000 35.00000 86.00000 62.000000 77.00000
## CV residual    2.349351 -9.116521 -9.869567 -8.81029 10.76157  6.795947 19.34872
##                      491        495       501       506       507        510        512
## Predicted      55.53786 62.33438 67.386703 62.297937 60.13846 56.327129   70.14101
## cvpred         55.80364 63.64591 67.259351 62.424992 60.21290 55.983323   69.97431
## Grad.Rate      48.00000 85.00000 75.000000 55.000000 98.00000 61.000000 100.00000
## CV residual   -7.80364 21.35409  7.740649 -7.424992 37.78710  5.016677   30.02569
##                      513        523       526       537       539        541
## Predicted     79.882061   74.96023 71.506897 50.438308   54.56049 69.110256
## cvpred        80.779285   75.17159 72.118494 51.062563   55.40992 68.163492
## Grad.Rate     83.000000 100.00000 70.000000 56.000000   36.00000 67.000000
## CV residual    2.220715   24.82841 -2.118494  4.937437 -19.40992 -1.163492
##                      551        553       557       558       562        565        575
## Predicted     59.081200 71.30493 68.05134 76.84433 80.400457   59.36088 82.145085
## cvpred        58.141702 71.73846 67.94758 76.97544 82.190554   59.41420 82.378145
## Grad.Rate     63.000000 88.00000 73.00000 79.00000 80.000000   49.00000 90.000000
## CV residual    4.858298 16.26154  5.05242  2.02456 -2.190554 -10.41420  7.621855
##                      576        582       590       591       600        606        618
## Predicted     71.989424 55.98730   66.57765 67.327363 48.47003 81.482656   60.34400
## cvpred        69.778078 55.49867   67.40299 67.032029 47.56572 83.244208   60.55912
## Grad.Rate     61.000000 69.00000   39.00000 70.000000 65.00000 78.000000   45.00000
## CV residual   -8.778078 13.50133 -28.40299  2.967971 17.43428 -5.244208 -15.55912
##                      621        624       632       640       644        650
## Predicted     55.781679 66.82613 53.50654   74.73038 57.993108 65.047088
## cvpred        55.512967 68.20714 53.83820   76.13748 57.785347 65.491998
## Grad.Rate     63.000000 81.00000 35.00000   51.00000 49.000000 75.000000
## CV residual    7.487033 12.79286 -18.83820 -25.13748 -8.785347  9.508002
##                      653        658       670       672       675         678
## Predicted     54.694168   49.88208 79.0745772 65.391391 52.697402 69.45622684
## cvpred        55.117785   50.00077 79.5705626 65.444048 53.217784 68.02415436
## Grad.Rate     62.000000   35.00000 80.0000000 62.000000 48.000000 68.00000000
## CV residual    6.882215 -15.00077  0.4294374 -3.444048 -5.217784 -0.02415436
```

```
##                      681         688         689         693          718          731
## Predicted       55.36730 62.983780 70.136082 68.32537 48.410233 63.829808
## cvpred          55.52961 62.501524 69.583925 67.95729 48.556475 64.373643
## Grad.Rate       45.00000 57.000000 65.000000 79.00000 58.000000 63.000000
## CV residual    -10.52961 -5.501524 -4.583925 11.04271  9.443525 -1.373643
##                      735         739         741         742          750          751
## Predicted       77.342814  62.05314  79.20311 52.869667 73.83057  66.56614
## cvpred          76.506912  62.25444  79.99833 53.109014 74.21366  66.91166
## Grad.Rate       69.000000  52.00000  67.00000 55.000000 80.00000  50.00000
## CV residual     -7.506912 -10.25444 -12.99833  1.890986  5.78634 -16.91166
##                      757
## Predicted       79.74494
## cvpred          79.60350
## Grad.Rate       52.00000
## CV residual    -27.60350
##
## Sum of squares = 32345.81    Mean square = 208.68    n = 155
##
## fold 5
## Observations in test set: 155
##                        1          10          14          15          19          20
## Predicted       56.462558 60.883665 71.423483 64.077014  62.55709  54.28208
## cvpred          57.138416 60.833314 71.271055 64.905538  63.01517  56.14127
## Grad.Rate       60.000000 52.000000 68.000000 55.000000  46.00000  34.00000
## CV residual      2.861584 -8.833314 -3.271055 -9.905538 -17.01517 -22.14127
##                       25          28          31          33          40          45          47
## Predicted       60.352410 53.93556 67.887654  60.11598 60.76074 76.733909 60.849957
## cvpred          60.681257 54.04255 67.768858  60.39073 60.68116 76.613655 60.833211
## Grad.Rate       54.000000 69.00000 69.000000  48.00000 72.00000 69.000000 58.000000
## CV residual     -6.681257 14.95745  1.231142 -12.39073 11.31884 -7.613655 -2.833211
##                       52          53          59          65          78          93         100
## Predicted       62.21230  53.06491 62.617895 79.765536  73.62233 56.16026 59.920762
## cvpred          61.94557  53.52922 62.941359 79.144659  75.15303 56.96620 59.590963
## Grad.Rate       56.00000  35.00000 58.000000 84.000000  60.00000 79.00000 66.000000
## CV residual     -5.94557 -18.52922 -4.941359  4.855341 -15.15303 22.03380  6.409037
##                      111         114         116         123         129         130
## Predicted       55.247972  58.54989 83.381985 88.686835  63.56959 71.085282
## cvpred          54.699798  59.65507 83.353757 88.295447  63.79167 71.499294
## Grad.Rate       58.000000  21.00000 79.000000 91.000000  43.00000 75.000000
## CV residual      3.300202 -38.65507 -4.353757  2.704553 -20.79167  3.500706
##                      137         143         145         151         159         161
## Predicted       69.873024  60.48023 92.205596 67.188895 99.503261 65.313609
## cvpred          69.628236  62.46523 90.806085 66.476045 99.336028 65.684265
## Grad.Rate       72.000000  37.00000 99.000000 75.000000 98.000000 56.000000
## CV residual      2.371764 -25.46523  8.193915  8.523955 -1.336028 -9.684265
##                      164         167         174         175          177         190
## Predicted       73.256816 55.075007 62.498004 97.23171278 57.1077798 47.736315
## cvpred          72.835592 55.846508 61.982442 97.09636463 57.6162382 47.162287
## Grad.Rate       82.000000 61.000000 67.000000 97.00000000 58.0000000 44.000000
## CV residual      9.164408  5.153492  5.017558 -0.09636463  0.3837618 -3.162287
##                      198         201         208         214         223         224
## Predicted        54.53707 66.695953 50.610887 67.43027 79.057780  55.37410
## cvpred           55.26603 66.922956 50.972088 64.86366 79.722417  56.38933
## Grad.Rate        24.00000 57.000000 43.000000 82.00000 70.000000  34.00000
## CV residual     -31.26603 -9.922956 -7.972088 17.13634 -9.722417 -22.38933
##                      236         246         250         252         253         254
```

```
## Predicted       63.23158 58.33569 80.849760  91.766960 60.490500 66.446023
## cvpred          63.39765 59.88124 80.467082  91.593688 60.657133 64.962235
## Grad.Rate       39.00000 70.00000 73.000000 100.000000 52.000000 63.000000
## CV residual -24.39765 10.11876 -7.467082   8.406312 -8.657133 -1.962235
##                      269      271      278      279      281        285
## Predicted       71.66458 86.250161 56.796874 74.1234945 61.785366 94.0041892
## cvpred          71.25390 86.884434 56.664017 74.2917594 62.611506 90.2735601
## Grad.Rate       56.00000 83.000000 65.000000 75.0000000 54.000000 90.0000000
## CV residual -15.25390 -3.884434  8.335983  0.7082406 -8.611506 -0.2735601
##                      294      297      305      310      311      317
## Predicted       70.22364 75.933600 53.428203 86.966788 63.691345 46.63875
## cvpred          70.30690 75.297856 54.691368 86.593996 64.044942 46.93886
## Grad.Rate       51.00000 79.000000 60.000000 91.000000 66.000000 45.00000
## CV residual -19.30690  3.702144  5.308632  4.406004  1.955058 -1.93886
##                      322      337      341      354      357      367      370
## Predicted       63.772052 63.657358 48.15027 68.62403  63.39865 58.09740 62.942453
## cvpred          64.880647 64.274672 48.52104 68.78846  64.79566 57.90165 64.300764
## Grad.Rate       62.000000 55.000000 68.00000 66.00000  52.00000 71.00000 71.000000
## CV residual -2.880647 -9.274672 19.47896 -2.78846 -12.79566 13.09835  6.699236
##                      371      372      381      382      384      393      396
## Predicted       58.36706 68.23538  67.46828 57.69638 52.09333 62.10798 73.818028
## cvpred          58.79454 68.23361  67.96229 57.62814 54.02276 62.06145 73.688318
## Grad.Rate       64.00000 75.00000  54.00000 74.00000 58.00000 78.00000 80.000000
## CV residual  5.20546  6.76639 -13.96229 16.37186  3.97724 15.93855  6.311682
##                      397      403      416      418      421      428      437
## Predicted       62.77343 71.497550  57.19556 51.06206 58.877940 59.423617 51.04154
## cvpred          63.96406 71.457353  57.78654 51.70771 59.983025 59.795429 51.31886
## Grad.Rate       88.00000 73.000000  42.00000 76.00000 56.000000 53.000000 48.00000
## CV residual 24.03594  1.542647 -15.78654 24.29229 -3.983025 -6.795429 -3.31886
##                      439      441      442      452      454      477
## Predicted       52.64141 65.431785 69.60560  52.22403 75.052863 71.92251262
## cvpred          53.02327 66.725576 69.43438  52.40364 75.248778 71.98111336
## Grad.Rate       65.00000 62.000000 83.00000  31.00000 73.000000 72.00000000
## CV residual 11.97673 -4.725576 13.56562 -21.40364 -2.248778  0.01888664
##                      479      481      487      489      494      498      500
## Predicted       65.922030 78.07395 64.91431 75.39357 67.2257371 55.98312 65.86731
## cvpred          66.799746 78.40570 65.31812 76.12504 67.8647694 54.26590 66.25480
## Grad.Rate       68.000000 90.00000 82.00000 97.00000 67.0000000 67.00000 78.00000
## CV residual  1.200254 11.59430 16.68188 20.87496 -0.8647694 12.73410 11.74520
##                      502      508      511      525      527      535
## Predicted       74.305114  71.30548  55.96194 76.558739 54.838175 64.108992
## cvpred          74.478762  71.00671  56.51066 75.902636 54.778331 63.633522
## Grad.Rate       84.000000  60.00000  41.00000 79.000000 48.000000 72.000000
## CV residual  9.521238 -11.00671 -15.51066  3.097364 -6.778331  8.366478
##                      538      542      543      547      554      556
## Predicted       53.971708 69.13824 60.957297 68.240580 45.8542549 67.834611
## cvpred          53.995953 69.82408 62.602642 68.591076 45.7133593 67.491289
## Grad.Rate       51.000000 89.00000 65.000000 66.000000 45.0000000 59.000000
## CV residual -2.995953 19.17592  2.397358 -2.591076 -0.7133593 -8.491289
##                      563      564      571      579      586      589
## Predicted       53.053983 49.124547 58.175784  57.76871  63.78698 63.144401
## cvpred          53.356005 49.347883 60.095815  60.12425  64.99737 63.183771
## Grad.Rate       56.000000 57.000000 53.000000  46.00000  10.00000 60.000000
## CV residual  2.643995  7.652117 -7.095815 -14.12425 -54.99737 -3.183771
##                      595      597      601      603      616      626
## Predicted       69.45230 71.29533 55.628548 59.046961 73.968677 67.299037
```

```
## cvpred        69.14396 69.32760 56.167314 60.412765 74.162987 67.596576
## Grad.Rate    96.00000 93.00000 64.000000 56.000000 67.000000 69.000000
## CV residual  26.85604 23.67240  7.832686 -4.412765 -7.162987  1.403424
##                    627       629       649       652       656       663
## Predicted     56.1234763  57.13561 65.318471 84.045210 50.41702 62.565887
## cvpred        56.6603641  57.56149 66.044451 84.647061 50.37634 62.978437
## Grad.Rate     57.0000000  31.00000 64.000000 83.000000 49.00000 54.000000
## CV residual    0.3396359 -26.56149 -2.044451 -1.647061 -1.37634 -8.978437
##                    666       668       669       671       680       684
## Predicted     65.294984 58.391459  79.23621 68.073990  54.43217 54.975119
## cvpred        65.288325 58.547302  80.10572 68.367596  54.95609 55.382139
## Grad.Rate     72.000000 63.000000 100.00000 66.000000  38.00000 53.000000
## CV residual    6.711675  4.452698  19.89428 -2.367596 -16.95609 -2.382139
##                    695       698       704       709       710       713       717
## Predicted     51.36211  53.18658 66.20277 80.509199 85.850569  52.00706 65.17567
## cvpred        51.12950  52.97589 67.66032 78.114047 84.883982  52.61572 65.38184
## Grad.Rate     65.00000  36.00000 78.00000 83.000000 90.000000  31.00000 73.00000
## CV residual  13.87050 -16.97589 10.33968  4.885953  5.116018 -21.61572  7.61816
##                    719       721       723       728       729       733
## Predicted     76.075214 90.5784604 63.4037089 58.537355 80.64808  61.91927
## cvpred        75.104745 88.6536289 63.7951059 57.895149 75.94072  62.80440
## Grad.Rate     72.000000 89.0000000 63.0000000 56.000000 90.00000  48.00000
## CV residual  -3.104745  0.3463711 -0.7951059 -1.895149 14.05928 -14.80440
##                    736       744       749       753       765       766       770
## Predicted     48.65231 55.330725 64.53995 79.464673 72.835247 54.52586 76.666786
## cvpred        47.11872 56.029932 64.72609 79.303151 72.706828 54.89927 76.297076
## Grad.Rate     64.00000 55.000000 62.00000 85.000000 67.000000 91.00000 78.000000
## CV residual  16.88128 -1.029932 -2.72609  5.696849 -5.706828 36.10073  1.702924
##                    772       773       776
## Predicted     78.57824  58.93842 101.96310
## cvpred        78.27618  60.23342 101.01505
## Grad.Rate     82.00000  40.00000  99.00000
## CV residual   3.72382 -20.23342  -2.01505
##
## Sum of squares = 25761.17    Mean square = 166.2    n = 155
##
## Overall (Sum over all 155 folds)
##       ms
## 173.7994
```

```
y_pred <- predict.lm(model1, test.myd)
y_obs<-test.myd[,"Grad.Rate"]
#Mean absolute percentage error(MAPE)
mape_m1<-mean(abs((y_obs - y_pred)/y_obs))*100
mape_m1
```

```
## [1] 20.3047
```

#Problem2(E)

```
#5-fold cross validation for model2
model2 <- lm(Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni + Expend + Elite10:Acc
ept.pct + Elite10:Outstate + Elite10:Expend,data=train.myd)
summary(model2)
```

```
## 
## Call:
## lm(formula = Grad.Rate ~ Elite10 + Accept.pct + Outstate + perc.alumni +
##     Expend + Elite10:Accept.pct + Elite10:Outstate + Elite10:Expend,
##     data = train.myd)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max
## -49.723  -7.901  -0.414   7.805  57.179
## 
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        5.371e+01  4.072e+00  13.190  < 2e-16 ***
## Elite10            2.929e+01  1.164e+01   2.516 0.012131 *
## Accept.pct        -1.550e+01  4.662e+00  -3.324 0.000943 ***
## Outstate           2.339e-03  2.260e-04  10.352  < 2e-16 ***
## perc.alumni        3.169e-01  5.299e-02   5.980 3.92e-09 ***
## Expend            -9.544e-04  2.305e-04  -4.141 3.98e-05 ***
## Elite10:Accept.pct -1.675e+01  1.144e+01  -1.464 0.143634
## Elite10:Outstate  -2.002e-03  5.842e-04  -3.427 0.000653 ***
## Elite10:Expend     1.055e-03  3.322e-04   3.176 0.001572 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 13.16 on 573 degrees of freedom
## Multiple R-squared:  0.4145, Adjusted R-squared:  0.4063
## F-statistic: 50.71 on 8 and 573 DF,  p-value: < 2.2e-16
```

```
cv.lm(data=college_data, form.lm=model2, m= 5, plotit= T)
```

```
## Warning in cv.lm(data = college_data, form.lm = model2, m = 5, plotit = T):
## 
##   As there is >1 explanatory variable, cross-validation
##   predicted values for a fold are not a linear function
##   of corresponding overall predicted values.  Lines that
##   are shown for the different folds are approximate
```

Small symbols show cross-validation predicted values

Legend:
- Fold 1
- Fold 2
- Fold 3
- Fold 4
- Fold 5

Y-axis: Grad.Rate

X-axis: Predicted (fit to all data)
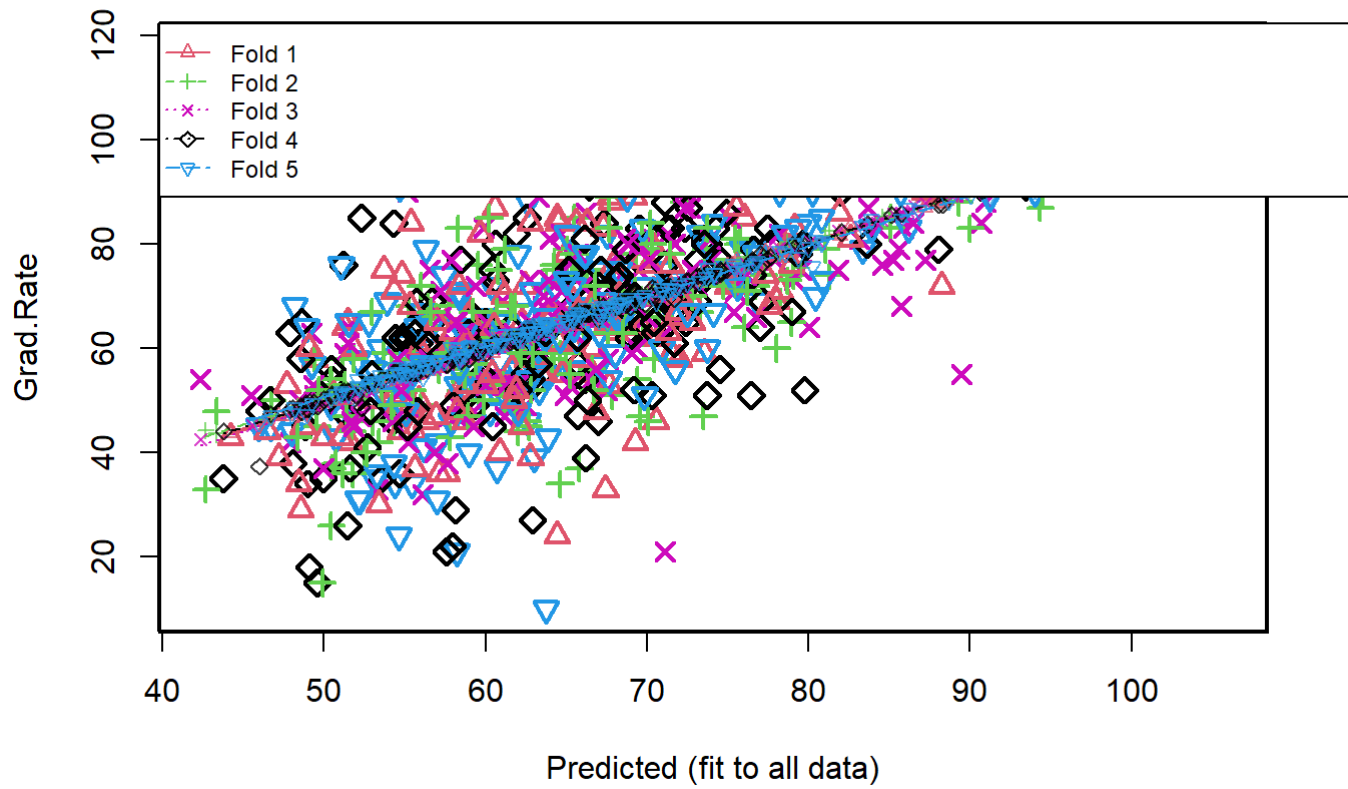
```
## 
## fold 1
## Observations in test set: 155
##                          4         6        13        22         23         29
## Predicted     73.53733  66.62707 65.135741 58.44602 68.694808  71.99951
## cvpred        74.63982  67.07923 64.728448 57.72867 68.440691  71.71661
## Grad.Rate     59.00000  55.00000 74.000000 70.00000 65.000000  58.00000
## CV residual  -15.63982 -12.07923  9.271552 12.27133 -3.440691 -13.71661
##                         34        38        39        42         55        60
## Predicted     62.247906 81.955566 62.468753 64.47695 75.248050 75.547459
## cvpred        61.804567 81.736809 62.673047 64.03209 75.973049 76.692163
## Grad.Rate     65.000000 91.000000 72.000000 84.00000 72.000000 72.000000
## CV residual   3.195433  9.263191  9.326953 19.96791 -3.973049 -4.692163
##                         61       62        64        72        76         79
## Predicted     98.672594 56.60385 64.44932 88.148477 70.386785 59.2186009
## cvpred        97.818433 56.28017 64.47317 87.781287 69.924367 58.5925653
## Grad.Rate     96.000000 67.00000 85.00000 89.000000 71.000000 59.0000000
## CV residual  -1.818433 10.71983 20.52683  1.218713  1.075633  0.4074347
##                         84        90        91        94        99        102
## Predicted     67.622355 57.954513 70.660943 63.427745  64.44354 67.12318022
## cvpred        67.361635 57.735412 70.745081 63.167325  64.62288 67.02193532
## Grad.Rate     64.000000 67.000000 62.000000 55.000000  24.00000 67.00000000
## CV residual  -3.361635  9.264588 -8.745081 -8.167325 -40.62288 -0.02193532
##                        103       106       120      125       133       134
## Predicted     54.492869 62.585666 56.330559 68.51226 64.96815 69.721070
## cvpred        53.763023 61.948765 55.856962 68.14774 64.98741 69.033429
## Grad.Rate     49.000000 58.000000 46.000000 96.00000 78.00000 64.000000
## CV residual  -4.763023 -3.948765 -9.856962 27.85226 13.01259 -5.033429
##                        142       144       147       148       156       162
## Predicted     58.5203764 67.879560 51.613951 63.679894  70.53844 49.41878
## cvpred        58.2318956 67.623964 51.558854 63.637524  69.66622 48.96948
## Grad.Rate     59.0000000 76.000000 42.000000 55.000000  46.00000 58.00000
## CV residual   0.7681044  8.376036 -9.558854 -8.637524 -23.66622  9.03052
##                        170       176       181       184       185       189
## Predicted     60.59622 78.3294696 55.867788 61.129076  71.47536 68.018008
## cvpred        60.62679 78.6198603 55.159014 60.785061  72.25771 67.331792
## Grad.Rate     87.00000 78.0000000 50.000000 70.000000  59.00000 63.000000
## CV residual  26.37321 -0.6198603 -5.159014  9.214939 -13.25771 -4.331792
##                        195       206       210       220       228       235
## Predicted     67.63062 70.235398 66.599323 74.969851 72.751933 70.152160
## cvpred        67.51896 70.591292 66.527728 75.852117 72.750809 69.896224
## Grad.Rate     53.00000 80.000000 60.000000 72.000000 69.000000 76.000000
## CV residual  -14.51896  9.408708 -6.527728 -3.852117 -3.750809  6.103776
##                        244       245       262       263      273       277        284
## Predicted     72.783350 77.981060 64.089874  54.70726 62.87675 64.062605 69.17583
## cvpred        72.875466 77.852431 63.932034  54.69613 62.43532 63.961464 69.07563
## Grad.Rate     65.000000 69.000000 67.000000  44.00000 95.00000 66.000000 89.00000
## CV residual  -7.875466 -8.852431  3.067966 -10.69613 32.56468  2.038536 19.92437
##                        286       298       301       309       312       313       328
## Predicted     57.59021 58.280399 53.70550 76.000098 65.830944 61.652728 66.30198
## cvpred        57.24103 58.208665 53.51798 75.883952 65.922115 61.373775 66.80888
## Grad.Rate     36.00000 52.000000 75.00000 85.000000 58.000000 56.000000 84.00000
## CV residual  -21.24103 -6.208665 21.48202  9.116048 -7.922115 -5.373775 17.19112
##                        334       348       349       351       359       362      365
## Predicted     54.25275 65.58039 69.588250 64.756449  66.82939 59.64595 67.73916
```

```
## cvpred       54.14950 64.27987 69.431651 64.847685  66.10608 59.08646 67.39164
## Grad.Rate    51.00000 84.00000 77.000000 55.000000  48.00000 82.00000 89.00000
## CV residual -3.14950 19.72013  7.568349 -9.847685 -18.10608 22.91354 21.60836
##                   369        375       378       386       390       394
## Predicted    55.38822 56.475904  48.42661 51.855011 55.855983 68.193558
## cvpred       55.09304 55.653172  47.75341 51.168284 55.031353 67.855266
## Grad.Rate    49.00000 61.000000 100.00000 60.000000 60.000000 64.000000
## CV residual -6.09304  5.346828  52.24659  8.831716  4.968647 -3.855266
##                   402        405       406       408       410       412
## Predicted    54.545005 65.290130 58.33136 78.256076 67.514157  55.53547
## cvpred       53.808019 65.273736 58.35628 78.673928 68.779044  55.04571
## Grad.Rate    52.000000 61.000000 72.00000 71.000000 65.000000  44.00000
## CV residual -1.808019 -4.273736 13.64372 -7.673928 -3.779044 -11.04571
##                   427        432       435       443       444       449
## Predicted    67.43468 79.113173 52.895185 65.430424  69.25898  58.58673
## cvpred       66.94710 79.353089 52.382824 65.538111  69.83813  58.40816
## Grad.Rate    33.00000 83.000000 50.000000 69.000000  42.00000  48.00000
## CV residual -33.94710  3.646911 -2.382824  3.461889 -27.83813 -10.40816
##                   451        456       472       480       485       486
## Predicted    62.78187 58.926010 68.269596 64.542332 56.8803310 57.3888823
## cvpred       62.83947 58.988746 68.932852 64.854816 56.4980172 57.0254175
## Grad.Rate    39.00000 66.000000 70.000000 61.000000 57.0000000 58.0000000
## CV residual -23.83947  7.011254  1.067148 -3.854816  0.5019828  0.9745825
##                   493        496       497       499       505       517       521
## Predicted    71.975182 67.27667 71.463948 69.98058 67.76333 66.4440255 60.8118
## cvpred       71.921554 67.45715 71.347649 70.17567 67.60114 66.8077567 60.1546
## Grad.Rate    70.000000 83.00000 76.000000 98.00000 88.00000 66.0000000 72.0000
## CV residual -1.921554 15.54285  4.652351 27.82433 20.39886 -0.8077567 11.8454
##                   528        529       531       532       536       549       559
## Predicted    82.586104 87.168193 48.710424 47.714871 54.35488  60.87083 51.29423
## cvpred       83.288214 86.947112 48.256779 47.085532 54.12164  61.27306 50.05313
## Grad.Rate    81.000000 90.000000 45.000000 53.000000 71.00000  40.00000 64.00000
## CV residual -2.288214  3.052888 -3.256779  5.914468 16.87836 -21.27306 13.94687
##                   560        561       570       573       578       581       583
## Predicted    74.78093 54.82213 78.914523 57.634160 58.774998  57.10749 49.975127
## cvpred       74.27392 54.44904 80.009543 57.062093 58.365298  56.64378 49.575625
## Grad.Rate    97.00000 74.00000 76.000000 59.000000 53.000000  36.00000 43.000000
## CV residual 22.72608 19.55096 -4.009543  1.937907 -5.365298 -20.64378 -6.575625
##                   584        587       588       594       598       605       608
## Predicted    60.498998 51.052937 55.40009 86.82800 77.302119 47.205388  58.72174
## cvpred       60.243046 50.923836 55.13615 87.43913 78.534911 47.050509  57.84227
## Grad.Rate    64.000000 43.000000 84.00000 91.00000 74.000000 39.000000  46.00000
## CV residual  3.756954 -7.923836 28.86385  3.56087 -4.534911 -8.050509 -11.84227
##                   620        625       634       635       638       641       645
## Predicted    71.665727  48.44947 57.957015 55.32177 75.53269  62.21834 58.23623
## cvpred       73.460883  48.80751 57.859485 55.50331 76.02400  62.18010 57.69394
## Grad.Rate    66.000000  34.00000 63.000000 68.00000 87.00000  45.00000 48.00000
## CV residual -7.460883 -14.80751  5.140515 12.49669 10.97600 -17.18010 -9.69394
##                   647        651       654       655       657       662
## Predicted    50.585511  55.62170 59.942330 60.421556 56.931037 46.482354
## cvpred       49.863715  54.89938 59.697348 59.746077 56.319365 46.478413
## Grad.Rate    51.000000  37.00000 53.000000 55.000000 47.000000 44.000000
## CV residual  1.136285 -17.89938 -6.697348 -4.746077 -9.319365 -2.478413
##                   664        667       673       674       685       686       697
## Predicted    90.087283 71.32926 44.2408440 75.12294  48.53746 51.50193 57.016918
## cvpred       90.179851 71.81707 43.8577022 74.58453  47.95326 50.95310 56.466442
```

```
## Grad.Rate    93.000000 63.00000 43.0000000 92.00000  29.00000 65.00000 65.000000
## CV residual  2.820149 -8.81707 -0.8577022 17.41547 -18.95326 14.04690  8.533558
##                      705         715        722        724        725        737        740
## Predicted     78.5508532    53.40978 66.551856 71.92677 81.886021 62.77700 49.08140
## cvpred        78.6690624    53.29996 65.867471 71.65453 82.065716 62.57194 48.54943
## Grad.Rate     79.0000000    30.00000 68.000000 67.00000 86.000000 84.00000 60.00000
## CV residual    0.3309376 -23.29996  2.132529 -4.65453  3.934284 21.42806 11.45057
##                      747         756        760        761        763        769        777
## Predicted     58.82398    88.23348 65.705871 77.549218  61.90677  61.74641 60.43286
## cvpred        58.41292    88.06988 65.737007 77.686828  62.01083  61.59484 59.17148
## Grad.Rate     61.00000    72.00000 67.000000 68.000000  52.00000  50.00000 99.00000
## CV residual    2.58708 -16.06988  1.262993 -9.686828 -10.01083 -11.59484 39.82852
##
## Sum of squares = 29290.98    Mean square = 188.97    n = 155
##
## fold 2
## Observations in test set: 156
##                        3          7        17        18        26        27        35
## Predicted     69.39855 69.748853 105.17393 62.421852 43.328087 72.2724 65.48651
## cvpred        69.51032 69.767148 105.33833 62.482071 43.589083 72.1246 65.52342
## Grad.Rate     54.00000 63.000000 100.00000 59.000000 48.000000 88.0000 85.00000
## CV residual -15.51032 -6.767148  -5.33833 -3.482071  4.410917 15.8754 19.47658
##                       43         51        54        56        57        58        68
## Predicted     58.430282    61.77782 51.190059  67.82363 64.26457 50.50042 64.213213
## cvpred        58.526477    62.02333 51.475583  68.31228 64.29609 50.62664 64.393303
## Grad.Rate     52.000000    48.00000 58.000000  51.00000 75.00000 53.00000 58.000000
## CV residual  -6.526477 -14.02333  6.524417 -17.31228 10.70391  2.37336 -6.393303
##                       74         83        86        88        95        97
## Predicted     69.310433 56.001071 59.518308 81.292566 66.289229 77.247784
## cvpred        68.902626 56.042218 59.800112 82.489939 66.698196 77.417052
## Grad.Rate     78.000000 49.000000 52.000000 74.000000 75.000000 74.000000
## CV residual  9.097374 -7.042218 -7.800112 -8.489939  8.301804 -3.417052
##                      104        107       108       112       115        118
## Predicted     46.785222 79.043579  69.57767 66.113928 94.330180 76.2652123
## cvpred        47.000612 79.553267  69.69352 66.229171 94.368216 76.4115374
## Grad.Rate     50.000000 74.000000  47.00000 63.000000 87.000000 77.0000000
## CV residual  2.999388 -5.553267 -22.69352 -3.229171 -7.368216  0.5884626
##                      127        131       136       140       146       152
## Predicted     69.32154 67.973046 59.55763 78.249403  62.66376  76.04739
## cvpred        69.33586 68.060618 59.67882 78.717889  62.64228  76.06988
## Grad.Rate    100.00000 72.000000 76.00000 69.000000  45.00000  64.00000
## CV residual  30.66414  3.939382 16.32118 -9.717889 -17.64228 -12.06988
##                      158        160       166       169       171       191       192
## Predicted     63.730961 92.606731 54.301127 55.138844  53.40460 69.68797 84.59102
## cvpred        63.725108 92.696475 54.497181 55.062903  53.96709 70.02132 85.10637
## Grad.Rate     72.000000 94.000000 46.000000 54.000000  42.00000 82.00000 96.00000
## CV residual  8.274892  1.303525 -8.497181 -1.062903 -11.96709 11.97868 10.89363
##                      194        196       203       204       205       207       217
## Predicted     73.278881 55.28448 57.74715 55.542327 63.571497 53.033617 65.328727
## cvpred        73.375814 55.65613 57.75983 55.793091 63.405216 52.959425 65.339682
## Grad.Rate     67.000000 68.00000 68.00000 58.000000 62.000000 46.000000 74.000000
## CV residual  -6.375814 12.34387 10.24017  2.206909 -1.405216 -6.959425  8.660318
##                      219       225       227       229       231       234       238
## Predicted     62.61627 64.2494  51.77509 70.750267 74.238556 54.182733 85.100917
## cvpred        62.44783 64.3644  51.89076 70.876749 74.982475 54.188844 86.003466
## Grad.Rate     46.00000 76.0000  36.00000 66.000000 77.000000 57.000000 83.000000
```

```
## CV residual -16.44783 11.6356 -15.89076 -4.876749  2.017525  2.811156 -3.003466
##                   239       242       248       255       256       258       259
## Predicted      79.52636 69.51584  50.73161 65.02369 73.675199 61.941456 74.702349
## cvpred         75.33111 69.41470  51.03364 65.66240 74.009045 62.148318 75.365548
## Grad.Rate     100.00000 96.00000  38.00000 79.00000 79.000000 60.000000 72.000000
## CV residual    24.66889 26.58530 -13.03364 13.33760  4.990955 -2.148318 -3.365548
##                   260       274       276       282       287       288
## Predicted      72.905799  52.49704  64.62583  50.43766  66.58421 75.622925
## cvpred         73.289025  52.71311  64.51873  50.94707  66.71975 75.911096
## Grad.Rate      72.000000  40.00000  34.00000  26.00000  56.00000 80.000000
## CV residual    -1.289025 -12.71311 -30.51873 -24.94707 -10.71975  4.088904
##                   290       293       296       308       315       318       319
## Predicted      56.40726 89.31568 60.361634 68.1168 59.9798130  65.20070 75.774664
## cvpred         56.50557 89.46254 60.728808 68.1791 60.0124931  64.69411 75.720449
## Grad.Rate      68.00000 88.00000 65.000000 94.0000 61.0000000 100.00000 81.000000
## CV residual    11.49443 -1.46254  4.271192 25.8209  0.9875069  35.30589  5.279551
##                   324       329       332       336       339       340       342
## Predicted      53.716441 61.07872 76.695132 65.013666 69.926721 72.808448 64.64226
## cvpred         54.040051 61.29656 76.507867 65.505733 70.079938 72.946976 64.46831
## Grad.Rate      59.000000 53.00000 72.000000 59.000000 79.000000 70.000000 59.00000
## CV residual    4.959949 -8.29656 -4.507867 -6.505733  8.920062 -2.946976 -5.46831
##                   350       366       383       385       388       392       400
## Predicted      61.808990 60.22580  50.49097  49.90821 58.31053  61.98878 51.81388
## cvpred         62.219874 60.42161  50.72127  50.62187 58.52181  62.10186 52.00860
## Grad.Rate      68.000000 85.00000  37.00000  15.00000 83.00000  44.00000 58.00000
## CV residual    5.780126 24.57839 -13.72127 -35.62187 24.47819 -18.10186  5.99140
##                   413       414       419       423       424       429
## Predicted      60.454837 53.582603  70.04633 64.145940 67.2269896 89.994748
## cvpred         60.858338 54.091055  70.03107 64.055967 67.2226166 90.387773
## Grad.Rate      62.000000 52.000000  46.00000 58.000000 68.0000000 83.000000
## CV residual    1.141662 -2.091055 -24.03107 -6.055967  0.7773834 -7.387773
##                   430       431       436       440       446       448
## Predicted      81.032554 69.725715 49.577330  65.80540 67.583220 51.743911
## cvpred         81.641422 70.279827 49.833149  65.85383 67.662901 52.045502
## Grad.Rate      79.000000 67.000000 45.000000  37.00000 63.000000 44.000000
## CV residual   -2.641422 -3.279827 -4.833149 -28.85383 -4.662901 -8.045502
##                   462       463       464       471       478       490       503
## Predicted      59.212489  70.44152 70.33858 70.21796 61.21827 49.431516 73.710954
## cvpred         59.438744  70.65969 70.28708 70.66158 61.34988 49.567047 74.039047
## Grad.Rate      67.000000  58.00000 80.00000 84.00000 79.00000 58.000000 83.000000
## CV residual    7.561256 -12.65969  9.71292 13.33842 17.65012  8.432953  8.960953
##                   509       514       515       516       518       520       530
## Predicted      58.00395  65.26605  62.83417 78.682407 67.62299 69.239621 52.94149
## cvpred         58.04838  65.31873  63.06997 80.423757 67.73382 69.569653 53.25742
## Grad.Rate      56.00000  55.00000  52.00000 73.000000 89.00000 71.000000 67.00000
## CV residual   -2.04838 -10.31873 -11.06997 -7.423757 21.26618  1.430347 13.74258
##                   533       534       540       545       548       550
## Predicted      57.80838 48.378330 55.474035 65.47318 85.0878902 71.446856
## cvpred         57.98598 48.783827 55.739224 65.83604 85.3589953 71.405127
## Grad.Rate      43.00000 43.000000 52.000000 78.00000 85.0000000 78.000000
## CV residual  -14.98598 -5.783827 -3.739224 12.16396 -0.3589953  6.594873
##                   552       555       569       577       585       592
## Predicted      56.00029 60.701885 56.922960 68.695917  59.90268 75.441091
## cvpred         56.14161 60.679521 57.005924 69.108631  60.08859 71.314858
## Grad.Rate      72.00000 67.000000 66.000000 67.000000  50.00000 81.000000
## CV residual   15.85839  6.320479  8.994076 -2.108631 -10.08859  9.685142
```

```
##                      599        604        609        611        615        617
## Predicted       66.71968   42.68515  59.422652  50.427414  60.79141   61.43009
## cvpred          66.57364   44.26419  59.495414  51.335581  61.17511   61.78824
## Grad.Rate       52.00000   33.00000  57.000000  54.000000  75.00000   51.00000
## CV residual    -14.57364  -11.26419  -2.495414   2.664419  13.82489  -10.78824
##                      628        630        633        636        643         646
## Predicted       73.47754  62.185010  58.707731  57.101319  58.910755  52.5865679
## cvpred          73.50044  62.231361  58.772128  57.384305  59.318312  52.6122366
## Grad.Rate       47.00000  59.000000  55.000000  56.000000  58.000000  52.0000000
## CV residual    -26.50044  -3.231361  -3.772128  -1.384305  -1.318312  -0.6122366
##                      677        679        691        696        699        706        707
## Predicted       51.420087   51.1928   58.90726   51.28855   56.60584   61.58123   52.64354
## cvpred          52.074138   51.1807   59.35483   51.75171   56.65837   61.59939   52.89750
## Grad.Rate       47.000000   36.0000   47.00000   53.00000   67.00000   68.00000   40.00000
## CV residual    -5.074138  -15.1807  -12.35483   1.24829   10.34163    6.40061  -12.89750
##                      716        726        727        730        743        745
## Predicted       66.483617  94.482955   78.92521  49.700473   78.01401  57.613405
## cvpred          66.405013  92.894649   78.99374  50.068473   78.06286  57.872859
## Grad.Rate       68.000000  90.000000   65.00000  52.000000   60.00000  59.000000
## CV residual     1.594987  -2.894649  -13.99374   1.931527  -18.06286   1.127141
##                      754        755        759        762        774        775
## Predicted       76.202430  66.814787  68.52440  62.920820  67.62236  54.172857
## cvpred          77.531095  66.847053  68.59919  63.012762  67.82757  54.616344
## Grad.Rate       71.000000  72.000000  63.00000  59.000000  83.00000  49.000000
## CV residual    -6.531095   5.152947  -5.59919  -4.012762  15.17243  -5.616344
##
## Sum of squares = 22706.26    Mean square = 145.55     n = 156
##
## fold 3
## Observations in test set: 156
##                       8         11         12         16         24         30
## Predicted       73.1262150  79.125908  84.554249  61.098832  55.581515  75.436814
## cvpred          73.2719054  78.852356  84.509903  60.596143  54.524261  75.383927
## Grad.Rate       73.0000000  73.000000  76.000000  69.000000  48.000000  71.000000
## CV residual    -0.2719054  -5.852356  -8.509903   8.403857  -6.524261  -4.383927
##                      32         44         48         49         66         69         70
## Predicted       66.865140  58.331635   89.49269  71.33348   62.53442  64.66187   53.34257
## cvpred          67.043751  57.935044   89.51427  70.92263   61.62861  64.34781   53.76933
## Grad.Rate       71.000000  49.000000   55.00000  82.00000   49.00000  82.00000   33.00000
## CV residual     3.956249  -8.935044  -34.51427  11.07737  -12.62861  17.65219  -20.76933
##                      71         73         81         89         96         98
## Predicted       96.0702591  86.452347  70.40545  69.658318   60.84969  62.41905
## cvpred          96.8629838  86.381933  70.37990  69.140855   60.42977  62.30928
## Grad.Rate       97.0000000  93.000000  81.00000  79.000000  118.00000  64.00000
## CV residual     0.1370162   6.618067  10.62010   9.859145   57.57023   1.69072
##                      101        109        113        117        121        122
## Predicted       58.25113   67.53765   59.25849  68.385479  75.401667  69.529248
## cvpred          57.91326   68.30122   58.45155  67.986367  75.178393  69.552324
## Grad.Rate       47.00000   52.00000   48.00000  74.000000  67.000000  75.000000
## CV residual    -10.91326  -16.30122  -10.45155   6.013633  -8.178393   5.447676
##                      124        138        141        154        155        157
## Predicted       90.993265  89.134095  90.691421   64.92932  49.21973  60.024072
## cvpred          91.252329  90.365033  91.726249   64.44136  48.66619  59.887964
## Grad.Rate       93.000000  95.000000  84.000000   51.00000  63.00000  54.000000
## CV residual     1.747671   4.634967  -7.726249  -13.44136  14.33381  -5.887964
##                      163        165        168        178        180        188        197
```

```
## Predicted      83.157471 83.710326 69.39370 47.928796   66.59874 66.25369 76.77984
## cvpred         83.357885 83.851646 69.33897 47.733421   66.11593 65.83421 76.55922
## Grad.Rate      81.000000 87.000000 60.00000 42.000000   54.00000 86.00000 94.00000
## CV residual    -2.357885  3.148354 -9.33897 -5.733421 -12.11593 20.16579 17.44078
##                        209        215        226        237        249        257
## Predicted      59.88957 65.628783104 85.852486 63.177265 62.76716 85.614567
## cvpred         58.97871 65.003037596 85.786302 62.607377 62.68071 85.552113
## Grad.Rate      83.00000 65.000000000 83.000000 60.000000 73.00000 79.000000
## CV residual    24.02129 -0.003037596 -2.786302 -2.607377 10.31929 -6.552113
##                        261        264        275        283        289        291        295
## Predicted      73.115580   61.19878 63.544433 56.53701 60.465654 58.063076 72.65199
## cvpred         73.133045   61.10716 63.264519 56.23020 59.945652 57.343503 72.41366
## Grad.Rate      72.000000   47.00000 68.000000 75.00000 54.000000 61.000000 87.00000
## CV residual    -1.133045 -14.10716  4.735481 18.76980 -5.945652  3.656497 14.58634
##                        300        302        306        307        321        323
## Predicted      85.67951 73.950437 49.431512   87.25483 59.480275 68.176870
## cvpred         85.86314 73.905137 48.891574   87.86418 58.756167 67.654881
## Grad.Rate      92.00000 77.000000 51.000000   77.00000 63.000000 70.000000
## CV residual    6.13686   3.094863  2.108426 -10.86418  4.243833  2.345119
##                        327        335        338        345        347        355
## Predicted      71.739958 85.257276 64.47909821 65.50662 72.23003 93.3698263
## cvpred         71.396769 85.919782 63.97327235 65.33977 72.74015 93.7743742
## Grad.Rate      80.000000 77.000000 64.00000000 77.00000 90.00000 94.0000000
## CV residual    8.603231 -8.919782  0.02672765 11.66023 17.25985  0.2256258
##                        356        358        361        363        364        368        373
## Predicted      45.545844   56.12794 68.2656 69.51524 51.272768 60.087856 67.560422
## cvpred         45.211464   55.41272 67.8631 69.00490 50.493184 59.822274 67.868716
## Grad.Rate      51.000000   32.00000 78.0000 80.00000 59.000000 65.000000 58.000000
## CV residual    5.788536 -23.41272 10.1369 10.99510  8.506816  5.177726 -9.868716
##                        376        389        391        395        398        399
## Predicted      65.20944   66.83629 86.519811   71.10861 66.049125 73.917637
## cvpred         64.50976   66.66667 87.396344   71.00270 65.735324 73.546734
## Grad.Rate      53.00000   56.00000 84.000000   21.00000 72.000000 81.000000
## CV residual   -11.50976 -10.66667 -3.396344 -50.00270  6.264676  7.453266
##                        401        404        411        434        447        453
## Predicted      84.239101 57.21831 55.759210 79.560492   76.74064 51.554921
## cvpred         84.060079 56.33879 55.254517 79.409501   76.96288 51.003868
## Grad.Rate      83.000000 71.00000 57.000000 75.000000   66.00000 61.000000
## CV residual    -1.060079 14.66121  1.745483 -4.409501 -10.96288  9.996132
##                        459        460        461        467        468        469
## Predicted      75.164335 105.711189 80.71296 52.266441 76.152573 64.71013
## cvpred         75.086047 106.668256 80.22727 51.639056 76.190592 65.16821
## Grad.Rate      85.000000  99.000000 96.00000 47.000000 74.000000 68.00000
## CV residual    9.913953  -7.668256 15.77273 -4.639056 -2.190592  2.83179
##                        470        473        474        475        476        482
## Predicted      85.72974 77.948203 70.6601341   80.06979 63.97828 68.62902
## cvpred         85.94357 78.781519 70.3982353   80.48979 63.33607 68.44661
## Grad.Rate      68.00000 77.000000 70.0000000   64.00000 81.00000 81.00000
## CV residual   -17.94357 -1.781519 -0.3982353 -16.48979 17.66393 12.55339
##                        483        488        492        504        519        522
## Predicted      52.720593 63.615614 67.567076 61.787760 64.6976776 56.486477
## cvpred         52.002587 62.959481 67.039468 61.400278 64.2402489 56.086981
## Grad.Rate      51.000000 70.000000 69.000000 53.000000 64.0000000 58.000000
## CV residual    -1.002587  7.040519  1.960532 -8.400278 -0.2402489  1.913019
##                        524        544        546        566        567        568
## Predicted      57.70685 51.066247 71.505756 61.758064   55.26065 62.012105
```

```
## cvpred          57.45481 50.906264 71.759917 61.076096   54.70920 61.215324
## Grad.Rate      47.00000 49.000000 64.000000 63.000000   42.00000 53.000000
## CV residual -10.45481 -1.906264 -7.759917  1.923904 -12.70920 -8.215324
##                        572         574        580        593        596        602        607
## Predicted   58.094715 54.270601 72.09349 62.728157 65.71878 90.950140 69.998761
## cvpred      57.454541 53.681768 71.76938 62.369772 65.53287 91.325581 69.795897
## Grad.Rate   65.000000 46.000000 98.00000 65.000000 78.00000 88.000000 66.000000
## CV residual  7.545459 -7.681768 26.23062  2.630228 12.46713 -3.325581 -3.795897
##                        610        612        613        614        619        622
## Predicted   88.8905670 64.753002 65.498004 66.92096 70.136379 67.0931086
## cvpred      89.1505994 64.331669 65.235767 66.60089 69.641512 66.4357438
## Grad.Rate   90.0000000 71.000000 63.000000 93.00000 77.000000 66.0000000
## CV residual  0.8494006  6.668331 -2.235767 26.39911  7.358488 -0.4357438
##                        623        631        637        639        642        648        659
## Predicted   42.35282 51.56294  69.10442 60.004861 49.349134 61.263104  56.85481
## cvpred      42.51188 50.72283  69.32211 59.184416 48.991593 61.626744  56.01885
## Grad.Rate   54.00000 64.00000  59.00000 53.000000 53.000000 53.000000  40.00000
## CV residual 11.48812 13.27717 -10.32211 -6.184416  4.008407 -8.626744 -16.01885
##                        660        661        665        676        682        683        687
## Predicted   57.90410 89.338264 57.22229 58.672980 63.32461 60.512746 48.48900
## cvpred      57.61295 90.264886 57.18465 58.294734 62.69888 59.950337 47.53566
## Grad.Rate   77.00000 97.000000 66.00000 63.000000 89.00000 62.000000 50.00000
## CV residual 19.38705  6.735114  8.81535  4.705266 26.30112  2.049663  2.46434
##                        690        692        694        700        701        702
## Predicted   78.201661  49.97878 86.147812 51.707170 59.42409  57.65894
## cvpred      79.380812  49.67617 86.288609 50.769543 59.36017  56.97769
## Grad.Rate   82.000000  37.00000 95.000000 46.000000 72.00000  38.00000
## CV residual  2.619188 -12.67617  8.711391 -4.769543 12.63983 -18.97769
##                        703        708        711        712        714        720        732
## Predicted   51.818764 66.47862 77.33928  59.29546 63.903356 72.805747 55.16514
## cvpred      51.525656 66.18664 76.84074  58.96820 63.509177 72.258709 54.08700
## Grad.Rate   45.000000 95.00000 96.00000  45.00000 73.000000 75.000000 90.00000
## CV residual -6.525656 28.81336 19.15926 -13.96820  9.490823  2.741291 35.91300
##                        734        738        746        748        752        758
## Predicted   93.706414 89.870141 54.801417 58.222984 72.36299 68.85565
## cvpred      94.650788 90.728834 53.717227 57.514385 71.62635 68.26753
## Grad.Rate   91.000000 92.000000 52.000000 65.000000 87.00000 80.00000
## CV residual -3.650788  1.271166 -1.717227  7.485615 15.37365 11.73247
##                        764        767        768        771
## Predicted   103.109581 54.570319 58.5615375 81.846931
## cvpred      104.414394 54.004336 58.2881254 82.572115
## Grad.Rate    99.000000 58.000000 59.0000000 75.000000
## CV residual  -5.414394  3.995664  0.7118746 -7.572115
##
## Sum of squares = 24936.22    Mean square = 159.85    n = 156
##
## fold 4
## Observations in test set: 155
##                          2          5          9         21         36         37
## Predicted   63.735332  49.59265 73.786651 45.98725 67.360687 88.062387
## cvpred      63.676661  48.82079 73.748403 37.29093 67.111057 87.571022
## Grad.Rate   56.000000  15.00000 80.000000 48.00000 71.000000 79.000000
## CV residual -7.676661 -33.82079  6.251597 10.70907  3.888943 -8.571022
##                         41         46         50         63         67         75
## Predicted   73.4677836 54.254120 57.616350  66.99718  49.09366 71.27586
## cvpred      73.7420373 54.982964 56.874735  65.69955  49.61709 71.52619
```

```
## Grad.Rate    73.0000000 46.000000 63.000000  46.00000  18.00000 83.00000
## CV residual -0.7420373 -8.982964  6.125265 -19.69955 -31.61709 11.47381
##                      77        80        82        85        87        92
## Predicted     65.61709 55.870734 68.794220 71.45301 90.7291249 71.975437
## cvpred        65.61692 56.077152 69.767715 71.64193 90.1844789 71.878471
## Grad.Rate     55.00000 61.000000 63.000000 83.00000 91.0000000 67.000000
## CV residual -10.61692  4.922848 -6.767715 11.35807  0.8155211 -4.878471
##                     105       110       119       126       128        132       135
## Predicted     52.99116 68.280603 60.61981 58.906694 72.35490 73.133786 60.63052
## cvpred        53.41488 68.592577 60.68980 59.507233 72.14561 73.823697 60.90562
## Grad.Rate     51.00000 73.000000 73.00000 51.000000 83.00000 77.000000 80.00000
## CV residual  -2.41488  4.407423 12.31020 -8.507233 10.85439  3.176303 19.09438
##                     139       149       150       153       172        173       179
## Predicted     85.132644 60.43779 88.280667 52.32663 69.463061 74.256051  48.08377
## cvpred        85.561692 60.82208 87.477515 48.60296 69.824796 73.874678  48.52647
## Grad.Rate     93.000000 75.00000 91.000000 85.00000 77.000000 83.000000  38.00000
## CV residual   7.438308 14.17792  3.522485 36.39704  7.175204  9.125322 -10.52647
##                     182       183       186       187       193        199       200
## Predicted     51.22664 61.90477 73.618020  77.02247 46.709692  57.95090 56.69676
## cvpred        51.66137 61.56153 73.868834  78.00340 47.318417  58.23999 57.34736
## Grad.Rate     76.00000 82.00000 81.000000  64.00000 50.000000  22.00000 69.00000
## CV residual 24.33863 20.43847  7.131166 -14.00340  2.681583 -36.23999 11.65264
##                     202       211       212       213       216        218
## Predicted     59.269920  70.33001 55.250274  66.14516  58.14006  69.21021
## cvpred        59.361011  71.52697 55.406914  66.67537  58.90650  70.09927
## Grad.Rate     66.000000  51.00000 62.000000  54.00000  29.00000  52.00000
## CV residual  6.638989 -20.52697  6.593086 -12.67537 -29.90650 -18.09927
##                     221       222       230       232       233        240       241
## Predicted     59.79900 91.831482 67.04059 61.539223  65.71203 72.405206 83.66022
## cvpred        60.04192 91.731793 66.55513 61.147523  66.48439 72.804575 83.74126
## Grad.Rate     55.00000 95.000000 72.00000 64.000000  47.00000 65.000000 80.00000
## CV residual -5.04192  3.268207  5.44487  2.852477 -19.48439 -7.804575 -3.74126
##                     243       247       251       265       266        267
## Predicted     93.457719 59.53459 105.835982  57.59557 54.33255 65.441000
## cvpred        91.884862 59.23529 105.764051  56.94573 55.34146 65.729902
## Grad.Rate     91.000000 64.00000 100.000000  21.00000 84.00000 75.000000
## CV residual -0.884862  4.76471  -5.764051 -35.94573 28.65854  9.270098
##                     268       270       272       280       292        299       303
## Predicted     61.598986 59.681463 66.209537 69.32656 62.865974 67.33850  65.75979
## cvpred        61.819729 60.360378 66.714548 69.85629 63.130452 67.58122  67.10730
## Grad.Rate     52.000000 54.000000 69.000000 98.00000 62.000000 84.00000  57.00000
## CV residual -9.819729 -6.360378  2.285452 28.14371 -1.130452 16.41878 -10.10730
##                     304       314       316       320       325        326
## Predicted     51.47078 73.122582  62.95395 51.96874  51.62328 48.877552
## cvpred        51.68052 72.707868  63.37356 51.02946  51.81086 49.458786
## Grad.Rate     26.00000 69.000000  53.00000 92.00000  37.00000 45.000000
## CV residual -25.68052 -3.707868 -10.37356 40.97054 -14.81086 -4.458786
##                     330       331       333       343       344        346
## Predicted     60.034502 74.520588 68.798566 76.61461 71.239538 49.3484228
## cvpred        59.159383 74.919082 69.171832 76.57006 71.333891 49.6099463
## Grad.Rate     65.000000 77.000000 70.000000 96.00000 69.000000 50.0000000
## CV residual  5.840617  2.080918  0.828168 19.42994 -2.333891  0.3900537
##                     352       353       360       374       377        379       380
## Predicted     76.44610 62.436132 66.43767 67.280375 47.86907  62.91401 74.52630
## cvpred        76.53846 63.180445 66.66830 68.036349 48.17414  64.01491 74.23476
## Grad.Rate     51.00000 61.000000 91.00000 67.000000 63.00000  27.00000 56.00000
```

```
## CV residual -25.53846 -2.180445 24.33170 -1.036349 14.82586 -37.01491 -18.23476
##                    387      407      409      415      417      420      422
## Predicted   76.522313 49.01114 69.51495 71.112786 68.31686 52.68649 50.475697
## cvpred      76.935511 48.39032 70.38992 71.289678 68.08335 53.16199 50.797178
## Grad.Rate   74.000000 34.00000 83.00000 76.000000 74.00000 41.00000 54.000000
## CV residual -2.935511 -14.39032 12.61008 4.710322 5.91665 -12.16199 3.202822
##                    425      426      433      438      445      450
## Predicted   85.740412 70.509054 55.482169 72.57778 51.109176 65.333544
## cvpred      85.824143 71.052442 55.244703 72.95003 51.455669 65.856026
## Grad.Rate   92.000000 63.000000 64.000000 87.00000 48.000000 68.000000
## CV residual 6.175857 -8.052442 8.755297 14.04997 -3.455669 2.143974
##                    455      457      458      465      466      484      491
## Predicted   62.821805 68.846240 43.781232 74.93544 54.446472 58.48260 55.802915
## cvpred      63.192386 68.765305 44.095683 75.01792 55.372168 57.58569 56.139707
## Grad.Rate   54.000000 62.000000 35.000000 86.00000 62.000000 77.00000 48.000000
## CV residual -9.192386 -6.765305 -9.095683 10.98208 6.627832 19.41431 -8.139707
##                    495      501      506      507      510      512      513
## Predicted   62.56141 67.148095 62.442421 60.37276 56.371734 70.27487 77.474114
## cvpred      63.93278 66.959958 62.608706 60.50936 56.042977 70.13914 77.135144
## Grad.Rate   85.00000 75.000000 55.000000 98.00000 61.000000 100.00000 83.000000
## CV residual 21.06722 8.040042 -7.608706 37.49064 4.957023 29.86086 5.864856
##                    523      526      537      539      541      551
## Predicted   74.61445 71.302185 50.484157 54.68249 68.9372662 58.944324
## cvpred      74.72881 71.860122 51.125354 55.57141 67.9432018 57.963242
## Grad.Rate   100.00000 70.000000 56.000000 36.00000 67.0000000 63.000000
## CV residual 25.27119 -1.860122 4.874646 -19.57141 -0.9432018 5.036758
##                    553      557      558      562      565      575
## Predicted   71.13723 68.078504 76.602190 79.6552536 59.35628 82.040225
## cvpred      71.52905 67.981037 76.358161 80.7159532 59.40101 82.239516
## Grad.Rate   88.00000 73.000000 79.000000 80.0000000 49.00000 90.000000
## CV residual 16.47095 5.018963 2.641839 -0.7159532 -10.40101 7.760484
##                    576      582      590      591      600      606      618
## Predicted   71.699771 55.72795 66.20412 69.257822 48.64736 79.371983 60.44573
## cvpred      69.414713 55.17210 66.93299 69.476406 47.79438 79.957946 60.69344
## Grad.Rate   61.000000 69.00000 39.00000 70.000000 65.00000 78.000000 45.00000
## CV residual -8.414713 13.82790 -27.93299 0.523594 17.20562 -1.957946 -15.69344
##                    621      624      632      640      644      650      653
## Predicted   55.651613 66.13818 53.60148 73.72117 57.976879 65.173789 54.86530
## cvpred      55.348665 66.93399 53.96147 74.33002 57.771841 65.651236 55.33506
## Grad.Rate   63.000000 81.00000 35.00000 51.00000 49.000000 75.000000 62.00000
## CV residual 7.651335 14.06601 -18.96147 -23.33002 -8.771841 9.348764 6.66494
##                    658      670      672      675      678      681
## Predicted   49.96637 77.649487 65.709615 52.881059 69.8577106 55.1893
## cvpred      50.10569 77.488461 65.844013 53.448268 68.5277193 55.3051
## Grad.Rate   35.00000 80.000000 62.000000 48.000000 68.0000000 45.0000
## CV residual -15.10569 2.511539 -3.844013 -5.448268 -0.5277193 -10.3051
##                    688      689      693      718      731      735
## Predicted   63.267878 70.452095 68.68186 48.564947 63.725995 77.135118
## cvpred      62.858712 69.982257 68.40618 48.752491 64.243408 76.241399
## Grad.Rate   57.000000 65.000000 79.00000 58.000000 63.000000 69.000000
## CV residual -5.858712 -4.982257 10.59382 9.247509 -1.243408 -7.241399
##                    739      741      742      750      751      757
## Predicted   62.05621 78.97940 52.987479 73.566543 66.32149 79.77176
## cvpred      62.25175 79.71503 53.260048 73.880385 66.60218 79.62937
## Grad.Rate   52.00000 67.00000 55.000000 80.000000 50.00000 52.00000
## CV residual -10.25175 -12.71503 1.739952 6.119615 -16.60218 -27.62937
```

```
## 
## Sum of squares = 32264.9    Mean square = 208.16    n = 155
## 
## fold 5
## Observations in test set: 155
##                         1         10         14         15         19         20
## Predicted    56.552246 61.022498 71.326440 63.938673  62.60525  54.39764
## cvpred       57.198646 60.925925 71.209054 64.818002  63.05321  56.22140
## Grad.Rate    60.000000 52.000000 68.000000 55.000000  46.00000  34.00000
## CV residual   2.801354 -8.925925 -3.209054 -9.818002 -17.05321 -22.22140
##                        25        28        31        33        40        45        47
## Predicted    60.252320 53.91386 67.790591  60.30621 60.40038 76.825940 60.92207
## cvpred       60.623352 54.02350 67.702792  60.51628 60.43774 76.684704 60.87745
## Grad.Rate    54.000000 69.00000 69.000000  48.00000 72.00000 69.000000 58.00000
## CV residual  -6.623352 14.97650  1.297208 -12.51628 11.56226 -7.684704 -2.87745
##                        52        53       59       65        78       93      100
## Predicted    62.015733  53.11017 62.65783 79.978077  73.73276 56.32270 59.853947
## cvpred       61.812091  53.55811 62.97075 79.299625  75.24032 57.07486 59.544903
## Grad.Rate    56.000000  35.00000 58.00000 84.000000  60.00000 79.00000 66.000000
## CV residual  -5.812091 -18.55811 -4.97075  4.700375 -15.24032 21.92514  6.455097
##                       111       114       116       123       129      130
## Predicted    55.317791  58.21324 83.349995 88.667766  63.89073 70.93627
## cvpred       54.743894  59.43346 83.343249 88.238816  64.00974 71.40352
## Grad.Rate    58.000000  21.00000 79.000000 91.000000  43.00000 75.00000
## CV residual   3.256106 -38.43346 -4.343249  2.761184 -21.00974  3.59648
##                       137       143       145       151        159       161
## Predicted    69.743867  60.72368 90.05692 67.110555 100.115194 65.382670
## cvpred       69.543299  62.63494 89.48338 66.423922  99.699032 65.732277
## Grad.Rate    72.000000  37.00000 99.00000 75.000000  98.000000 56.000000
## CV residual   2.456701 -25.63494  9.51662  8.576078  -1.699032 -9.732277
##                       164       167      174       175       177      190
## Predicted    73.225345 55.139490 62.26041 97.4785017 57.0876788 48.00066
## cvpred       72.819253 55.890687 61.82136 97.2450767 57.6047361 47.33644
## Grad.Rate    82.000000 61.000000 67.00000 97.0000000 58.0000000 44.00000
## CV residual   9.180747  5.109313  5.17864 -0.2450767  0.3952639 -3.33644
##                       198       201       208      214       223      224
## Predicted     54.64277  67.05457 50.746378 67.50412  80.44399  55.46449
## cvpred        55.33659  67.16604 51.056601 64.92416  80.73588  56.45266
## Grad.Rate     24.00000  57.00000 43.000000 82.00000  70.00000  34.00000
## CV residual  -31.33659 -10.16604 -8.056601 17.07584 -10.73588 -22.45266
##                       236      246       250       252       253       254
## Predicted     63.03170 58.43792 80.883819  92.568258 60.563306 67.035297
## cvpred        63.26444 59.95542 80.497373  92.087772 60.704648 65.416321
## Grad.Rate     39.00000 70.00000 73.000000 100.000000 52.000000 63.000000
## CV residual  -24.26444 10.04458 -7.497373   7.912228 -8.704648 -2.416321
##                       269       271       278       279       281        285
## Predicted     71.72127 86.190642 56.741849 74.1831352 61.731976 94.0299410
## cvpred        71.29779 86.873101 56.624415 74.3380247 62.573708 90.3307876
## Grad.Rate     56.00000 83.000000 65.000000 75.0000000 54.000000 90.0000000
## CV residual  -15.29779 -3.873101  8.375585  0.6619753 -8.573708 -0.3307876
##                       294        297       305       310      311       317
## Predicted     69.85305 75.908034 53.475282 86.831422 63.72005 46.728311
## cvpred        70.06112 75.287201 54.723754 86.516879 64.06666 46.998536
## Grad.Rate     51.00000 79.000000 60.000000 91.000000 66.00000 45.000000
## CV residual  -19.06112  3.712799  5.276246  4.483121  1.93334 -1.998536
##                       322       337       341       354       357       367       370
```

```
## Predicted       63.672818 63.75236 48.18967 68.509834  63.31283 58.34531 62.875576
## cvpred          64.817571 64.33753 48.54153 68.715662  64.74460 58.06741 64.263504
## Grad.Rate       62.000000 55.00000 68.00000 66.000000  52.00000 71.00000 71.000000
## CV residual     -2.817571 -9.33753 19.45847 -2.715662 -12.74460 12.93259  6.736496
##                        371        372        381      382        384      393        396
## Predicted       58.413169 68.240466  67.63828 57.45185 52.087745 62.02266 73.660954
## cvpred          58.826116 68.238333  68.08181 57.45950 54.025055 62.00201 73.586082
## Grad.Rate       64.000000 75.000000  54.00000 74.00000 58.000000 78.00000 80.000000
## CV residual      5.173884  6.761667 -14.08181 16.54050  3.974945 15.99799  6.413918
##                        397        403        416      418        421        428        437
## Predicted       62.65429 71.500606  57.04033 51.06833 58.981691 59.553507 51.057798
## cvpred          63.88957 71.463048  57.68173 51.70966 60.054817 59.881135 51.325039
## Grad.Rate       88.00000 73.000000  42.00000 76.00000 56.000000 53.000000 48.000000
## CV residual     24.11043  1.536952 -15.68173 24.29034 -4.054817 -6.881135 -3.325039
##                        439        441      442        452        454          477
## Predicted       52.75491 65.616734 69.68451  52.19695 75.423086 71.943828365
## cvpred          53.09561 66.860022 69.48953  52.38174 75.509676 71.999850092
## Grad.Rate       65.00000 62.000000 83.00000  31.00000 73.000000 72.000000000
## CV residual     11.90439 -4.860022 13.51047 -21.38174 -2.509676  0.000149908
##                        479       481      487        489        494       498        500
## Predicted       65.780772 78.20909 65.04135 75.33438 67.2944775 56.11470 65.94309
## cvpred          66.708963 78.50697 65.40450 76.09168 67.9146238 54.35399 66.30447
## Grad.Rate       68.000000 90.00000 82.00000 97.00000 67.0000000 67.00000 78.00000
## CV residual      1.291037 11.49303 16.59550 20.90832 -0.9146238 12.64601 11.69553
##                        502       508      511      525        527        535
## Predicted       74.170090  70.91444  56.16505 76.54185 55.080641 64.277232
## cvpred          74.395394  70.74751  56.64697 75.89897 54.936841 63.749046
## Grad.Rate       84.000000  60.00000  41.00000 79.00000 48.000000 72.000000
## CV residual      9.604606 -10.74751 -15.64697  3.10103 -6.936841  8.250954
##                        538      542        543      547        554        556
## Predicted       53.674356 68.76847 60.884023 68.128186 45.9742568 68.037665
## cvpred          53.791963 69.58088 62.564974 68.519048 45.7872815 67.628594
## Grad.Rate       51.000000 89.00000 65.000000 66.000000 45.0000000 59.000000
## CV residual     -2.791963 19.41912  2.435026 -2.519048 -0.7872815 -8.628594
##                        563        564        571        579        586        589
## Predicted       53.067317 49.270463 58.265551  57.83807  63.72394 63.280554
## cvpred          53.367104 49.449167 60.163645  60.18012  64.95662 63.276109
## Grad.Rate       56.000000 57.000000 53.000000  46.00000  10.00000 60.000000
## CV residual      2.632896  7.550833 -7.163645 -14.18012 -54.95662 -3.276109
##                        595       597        601        603        616        626
## Predicted       69.23465 70.56049 55.785642 59.064877 74.110127 67.311485
## cvpred          69.00292 68.92519 56.271304 60.428543 74.266582 67.605926
## Grad.Rate       96.00000 93.00000 64.000000 56.000000 67.000000 69.000000
## CV residual     26.99708 24.07481  7.728696 -4.428543 -7.266582  1.394074
##                         627        629        649        652        656        663
## Predicted       56.1105217  56.99147 65.486124 83.883603 50.407886 62.72891
## cvpred          56.6543391  57.46807 66.163407 84.693236 50.367232 63.08933
## Grad.Rate       57.0000000  31.00000 64.000000 83.000000 49.000000 54.00000
## CV residual      0.3456609 -26.46807 -2.163407 -1.693236 -1.367232 -9.08933
##                        666      668        669        671        680        684
## Predicted       65.439112 58.656869  79.14222 68.311342  54.31654 54.851410
## cvpred          65.386246 58.725246  80.05791 68.532836  54.87361 55.299535
## Grad.Rate       72.000000 63.000000 100.00000 66.000000  38.00000 53.000000
## CV residual      6.613754  4.274754  19.94209 -2.532836 -16.87361 -2.299535
##                        695       698      704        709        710      713        717
## Predicted       51.50709  53.24895 66.19067 79.343080 85.714886  52.07197 64.995486
```

```
## cvpred        51.23173   53.01070 67.65609 77.374539 84.753128   52.65586 65.262793
## Grad.Rate     65.00000   36.00000 78.00000 83.000000 90.000000   31.00000 73.000000
## CV residual 13.76827 -17.01070 10.34391  5.625461  5.246872 -21.65586  7.737207
##                       719         721        723        728        729        733
## Predicted     75.599856 91.2290623 63.4251249 58.371342 80.25330   62.0125
## cvpred        74.793395 89.1543154 63.8132309 57.781969 75.70549   62.8699
## Grad.Rate     72.000000 89.0000000 63.0000000 56.000000 90.00000   48.0000
## CV residual -2.793395 -0.1543154 -0.8132309 -1.781969 14.29451 -14.8699
##                       736        744        749        753        765        766        770
## Predicted     48.92040 55.427335 64.59370 80.812117 72.512650 54.70565 76.715891
## cvpred        47.29624 56.093214 64.76303 80.200675 72.495818 55.01759 76.334615
## Grad.Rate     64.00000 55.000000 62.00000 85.000000 67.000000 91.00000 78.000000
## CV residual 16.70376 -1.093214 -2.76303  4.799325 -5.495818 35.98241  1.665385
##                       772        773        776
## Predicted     78.535127   58.96209 102.589197
## cvpred        78.253523   60.25075 101.405454
## Grad.Rate     82.000000   40.00000  99.000000
## CV residual  3.746477 -20.25075  -2.405454
##
## Sum of squares = 25837.28    Mean square = 166.69    n = 155
##
## Overall (Sum over all 155 folds)
##       ms
## 173.791
```

```
y_pred <- predict.lm(model2, test.myd)
y_obs<-test.myd[,"Grad.Rate"]
#Mean absolute percentage error(MAPE)
mape_m2<-mean(abs((y_obs - y_pred)/y_obs))*100
mape_m2
```

```
## [1] 20.33806
```