STAT S4240 002, Homework 1

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Problem 1: James 2.4, Exercise 8

Part a

```
> college <- read.csv(file="datasets/College.csv")
> head(college)
                           X Private Apps Accept Enroll Top10perc Top25perc F.Undergrad P.Undergrad Outstate Room.Board Books
1 Abilene Christian University     Yes 1660   1232    721        23        52        2885         537     7440       3300   450
2           Adelphi University     Yes 2186   1924    512        16        29        2683        1227    12280       6450   750
3              Adrian College     Yes 1428   1097    336        22        50        1036          99    11250       3750   400
4          Agnes Scott College     Yes  417    349    137        60        89         510          63    12960       5450   450
5    Alaska Pacific University     Yes  193    146     55        16        44         249         869     7560       4120   800
6            Albertson College     Yes  587    479    158        38        62         678          41    13500       3335   500
  Personal PhD Terminal S.F.Ratio perc.alumni Expend Grad.Rate
1     2200  70       78      18.1          12   7041        60
2     1500  29       30      12.2          16  10527        56
3     1165  53       66      12.9          30   8735        54
4      875  92       97       7.7          37  19016        59
5     1500  76       72      11.9           2  10922        15
6      675  67       73       9.4          11   9727        55
```

Part b

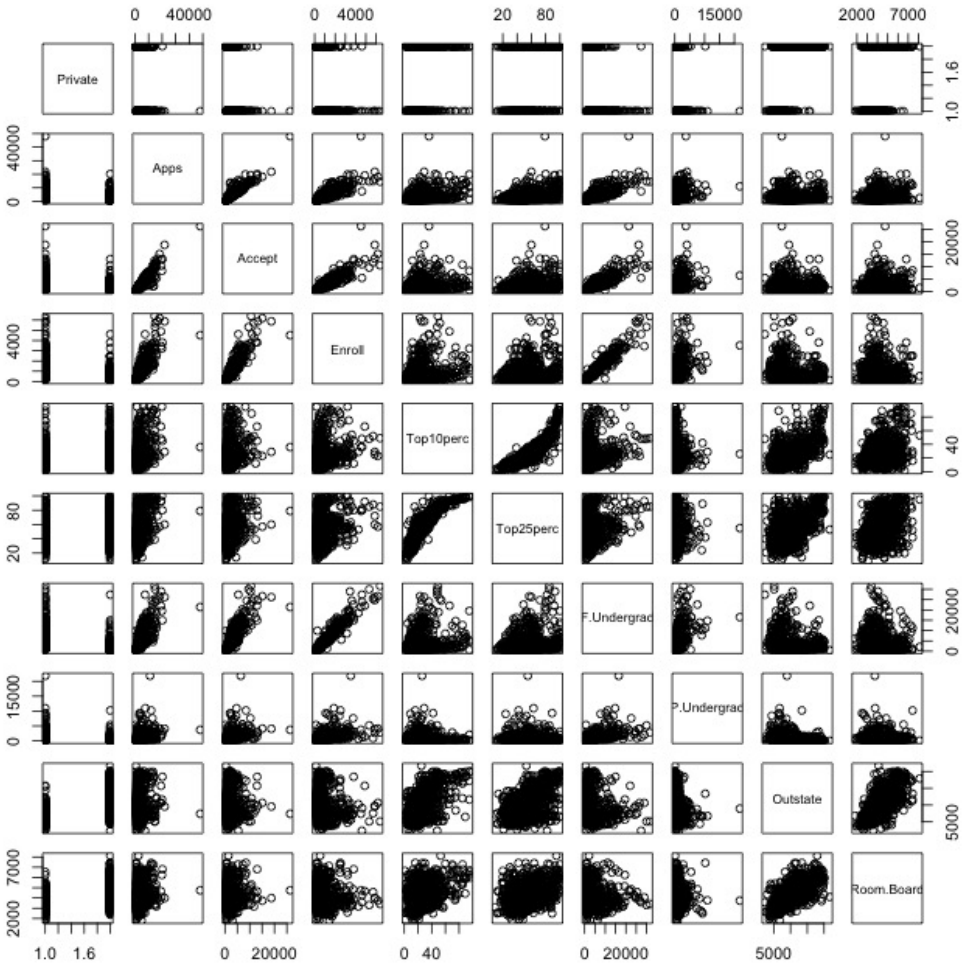
	row.names	Private	Apps	Accept	Enroll	Top10perc	Top25perc
1	Abilene Christian University	Yes	1660	1232	721	23	52
2	Adelphi University	Yes	2186	1924	512	16	29
3	Adrian College	Yes	1428	1097	336	22	50
4	Agnes Scott College	Yes	417	349	137	60	89
5	Alaska Pacific University	Yes	193	146	55	16	44
6	Albertson College	Yes	587	479	158	38	62
7	Albertus Magnus College	Yes	353	340	103	17	45
8	Albion College	Yes	1899	1720	489	37	68
9	Albright College	Yes	1038	839	227	30	63
10	Alderson-Broaddus College	Yes	582	498	172	21	44

Part c

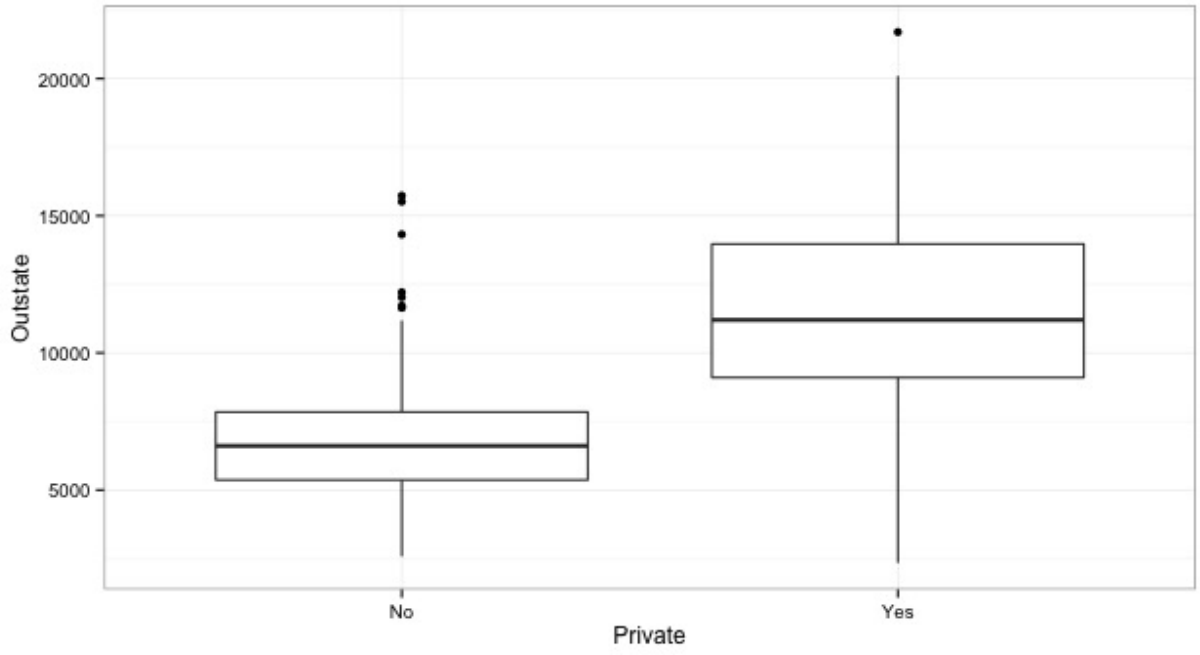
Part i

```
> summary(college)
 Private        Apps           Accept          Enroll       Top10perc       Top25perc      F.Undergrad     P.Undergrad         Outstate    
 No :212   Min.   :   81   Min.   :   72   Min.   :  35   Min.   :  1.00   Min.   :  9.0   Min.   :  139   Min.   :    1.0   Min.   : 2340  
 Yes:565   1st Qu.:  776   1st Qu.:  604   1st Qu.: 242   1st Qu.: 15.00   1st Qu.: 41.0   1st Qu.:  992   1st Qu.:   95.0   1st Qu.: 7320  
           Median : 1558   Median : 1110   Median : 434   Median : 23.00   Median : 54.0   Median : 1707   Median :  353.0   Median : 9990  
           Mean   : 3002   Mean   : 2019   Mean   : 780   Mean   : 27.56   Mean   : 55.8   Mean   : 3700   Mean   :  855.3   Mean   :10441  
           3rd Qu.: 3624   3rd Qu.: 2424   3rd Qu.: 902   3rd Qu.: 35.00   3rd Qu.: 69.0   3rd Qu.: 4005   3rd Qu.:  967.0   3rd Qu.:12925  
           Max.   :48094   Max.   :26330   Max.   :6392   Max.   : 96.00   Max.   :100.0   Max.   :31643   Max.   :21836.0   Max.   :21700  
   Room.Board       Books           Personal         PhD            Terminal       S.F.Ratio      perc.alumni        Expend        Grad.Rate     
 Min.   :1780   Min.   :  96.0   Min.   : 250   Min.   :  8.00   Min.   : 24.0   Min.   : 2.50   Min.   : 0.00   Min.   : 3186   Min.   : 10.00  
 1st Qu.:3597   1st Qu.: 470.0   1st Qu.: 850   1st Qu.: 62.00   1st Qu.: 71.0   1st Qu.:11.50   1st Qu.:13.00   1st Qu.: 6751   1st Qu.: 53.00  
 Median :4200   Median : 500.0   Median :1200   Median : 75.00   Median : 82.0   Median :13.60   Median :21.00   Median : 8377   Median : 65.00  
 Mean   :4358   Mean   : 549.4   Mean   :1341   Mean   : 72.66   Mean   : 79.7   Mean   :14.09   Mean   :22.74   Mean   : 9660   Mean   : 65.46  
 3rd Qu.:5050   3rd Qu.: 600.0   3rd Qu.:1700   3rd Qu.: 85.00   3rd Qu.: 92.0   3rd Qu.:16.50   3rd Qu.:31.00   3rd Qu.:10830   3rd Qu.: 78.00  
 Max.   :8124   Max.   :2340.0   Max.   :6800   Max.   :103.00   Max.   :100.0   Max.   :39.80   Max.   :64.00   Max.   :56233   Max.   :118.00  
```

Part ii

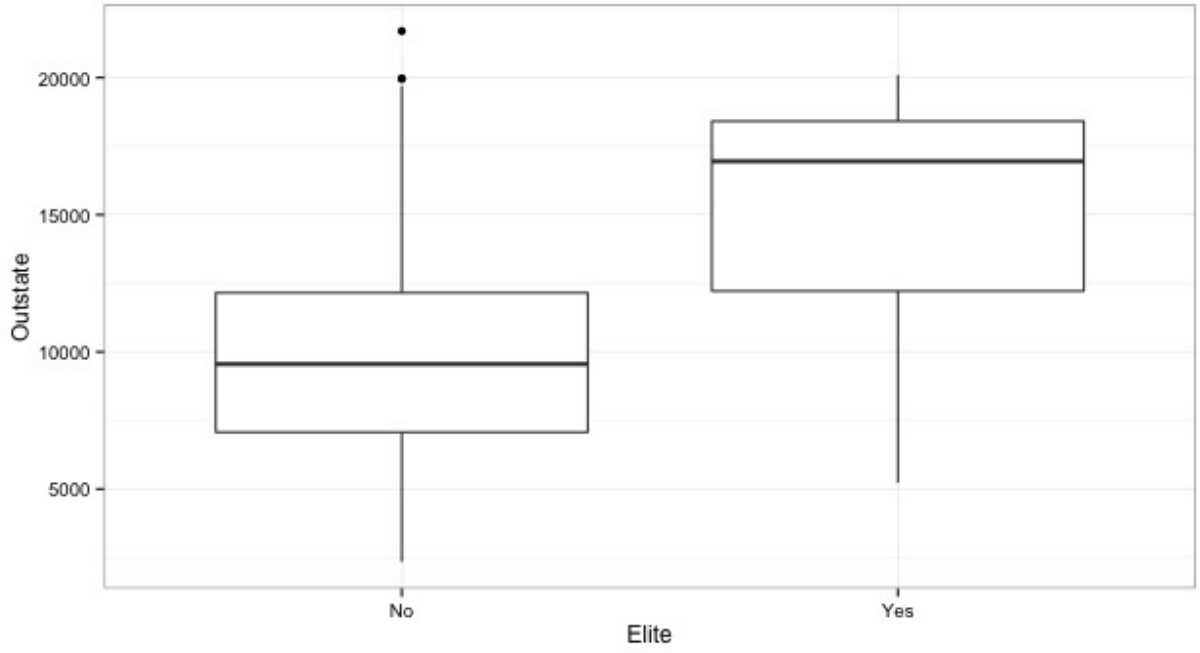


Part iii

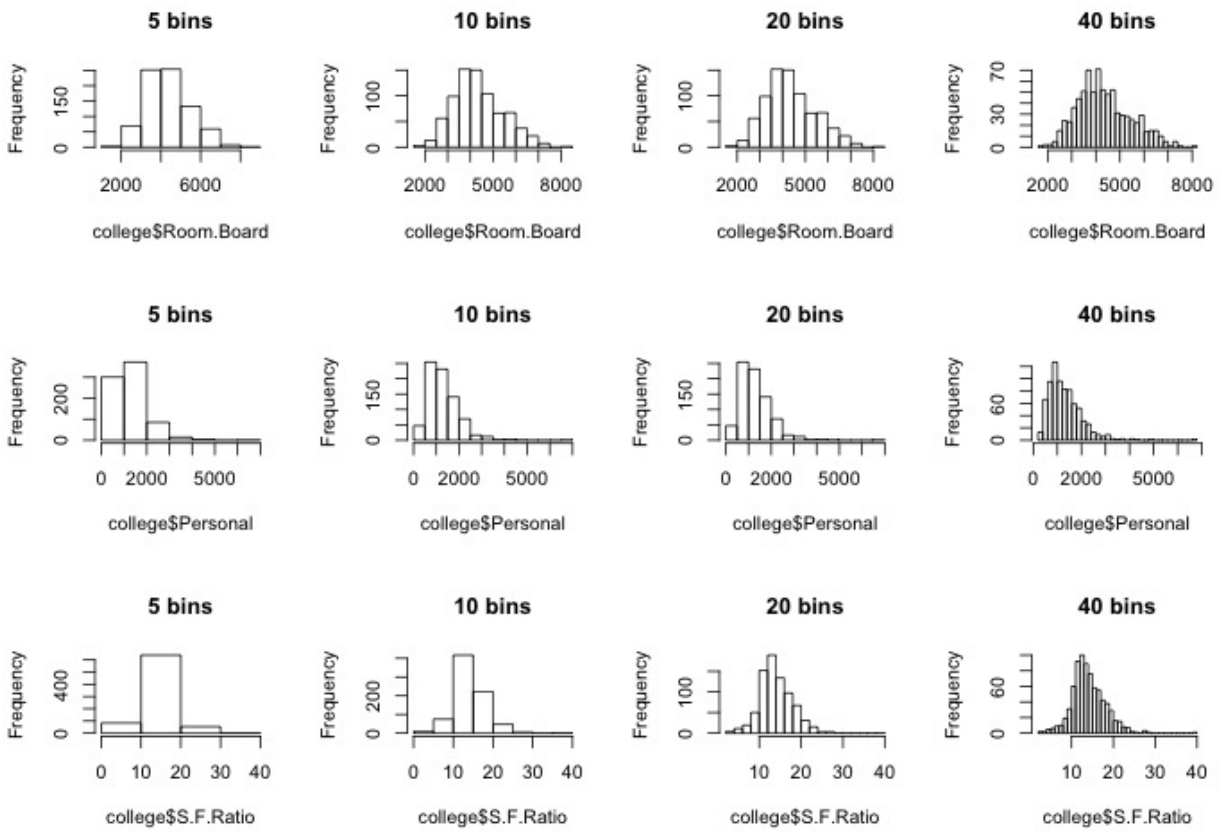


Part iv

There are 78 colleges categorized as "Elite".

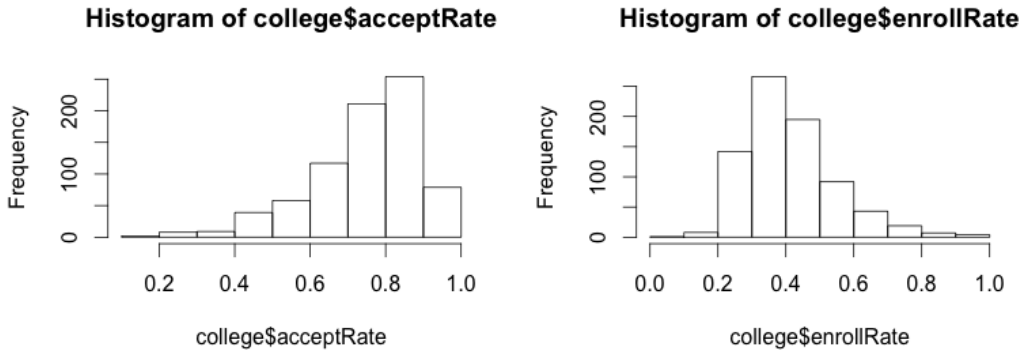


Part v



Part vi

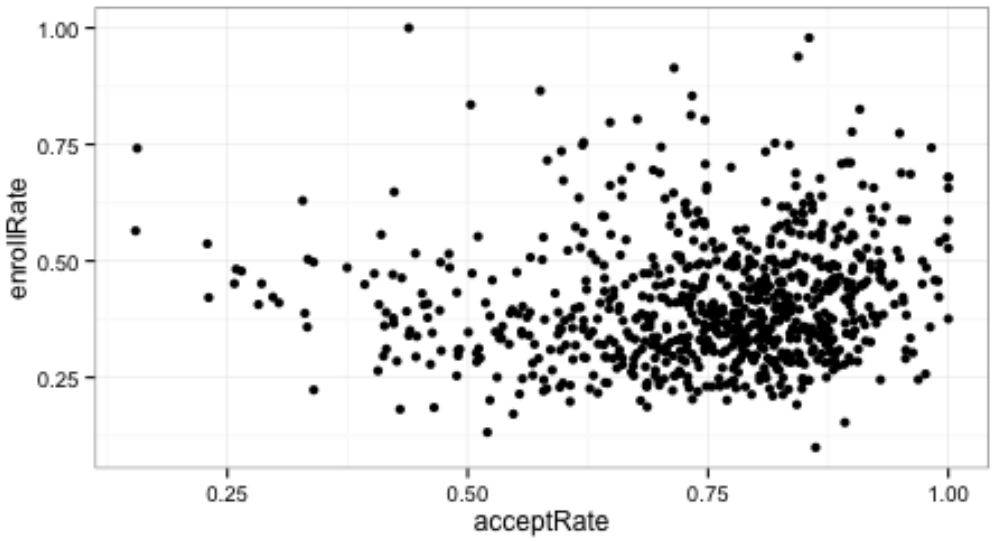
I chose to explore acceptance and enrollment rates, with acceptance rate defined as the number of students accepted per application received (`college$Accept/college$Apps`), and enrollment rate defined as the number of students enrolled per applicant accepted (`college$Enroll/college$Accept`).



Somewhat surprisingly, there's little correlation between acceptance and enrollment rate.

```
> cor(college$acceptRate, college$enrollRate)
```

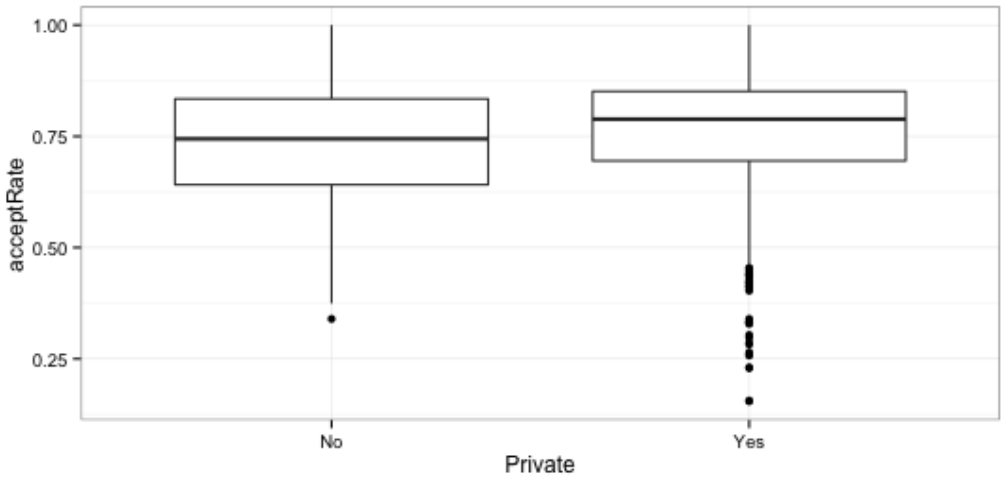
```
[1] 0.0824304
```

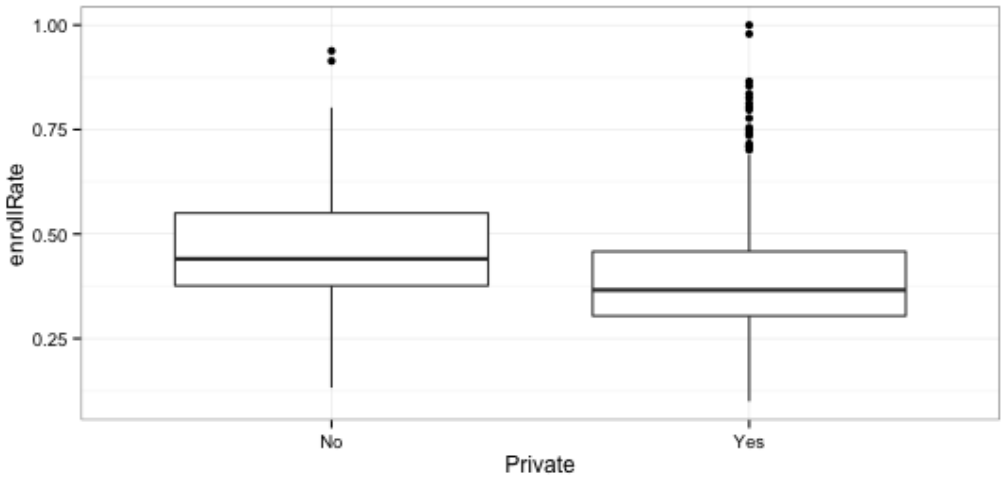


I also looked at summary statistics by public vs private schools.

```
> college %>%
+   group_by(Private) %>%
+   summarize(min.acceptRate=min(acceptRate),
+             median.acceptRate=median(acceptRate),
+             mean.acceptRate=mean(acceptRate),
+             max.acceptRate=max(acceptRate),
+             min.enrollRate=min(enrollRate),
+             median.enrollRate=median(enrollRate),
+             mean.enrollRate=mean(enrollRate),
+             max.enrollRate=max(enrollRate)) %>%
+   as.data.frame()
```

```
  Private min.acceptRate median.acceptRate mean.acceptRate max.acceptRate min.enrollRate
1      No      0.3397060         0.7443387       0.7265305              1     0.13242009
2     Yes      0.1544863         0.7885653       0.7545812              1     0.09975397
  median.enrollRate mean.enrollRate max.enrollRate
1         0.4405908       0.4620216      0.9382716
2         0.3660934       0.3932510      1.0000000
```





Problem 2: James 2.4, Exercise 9

Part a

Quantitative predictors: `mpg`, `cylinders`, `displacement`, `horsepower`, `weight`, `acceleration`, `year`
Qualitative predictors: `origin`, `name`

Part b

```
  statistic  mpg cylinders displacement horsepower weight acceleration year origin name
1       min  9.0         3           68         46   1613          8.0   70     NA   NA
2       max 46.6         8          455        230   5140         24.8   82     NA   NA
```

Part c

```
  statistic       mpg cylinders displacement horsepower    weight acceleration      year origi
```

```
1      mean 23.445918  5.471939      194.412  104.46939 2977.5842    15.541327 75.979592     NA
2        sd  7.805007  1.705783      104.644   38.49116  849.4026     2.758864  3.683737     NA
```

Part d

```
  statistic       mpg cylinders displacement horsepower    weight acceleration      year origin
1       min 11.000000  3.000000     68.00000   46.00000 1649.0000     8.500000 70.000000     NA
2       max 46.600000  8.000000    455.00000  230.00000 4997.0000    24.800000 82.000000     NA
3      mean 24.404430  5.373418    187.24051  100.72152 2935.9715    15.726899 77.145570     NA
4        sd  7.867283  1.654179     99.67837   35.70885  811.3002     2.693721  3.106217     NA
```

Part e

MPG generally increased between 1970 and 1982.

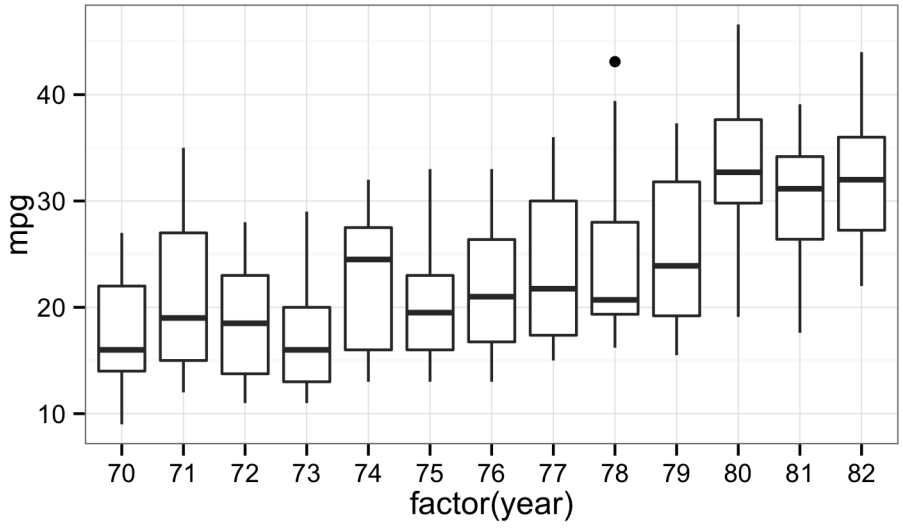


Figure 1: MPG vs year

As the number of cylinders increases, MPG generally decreases.

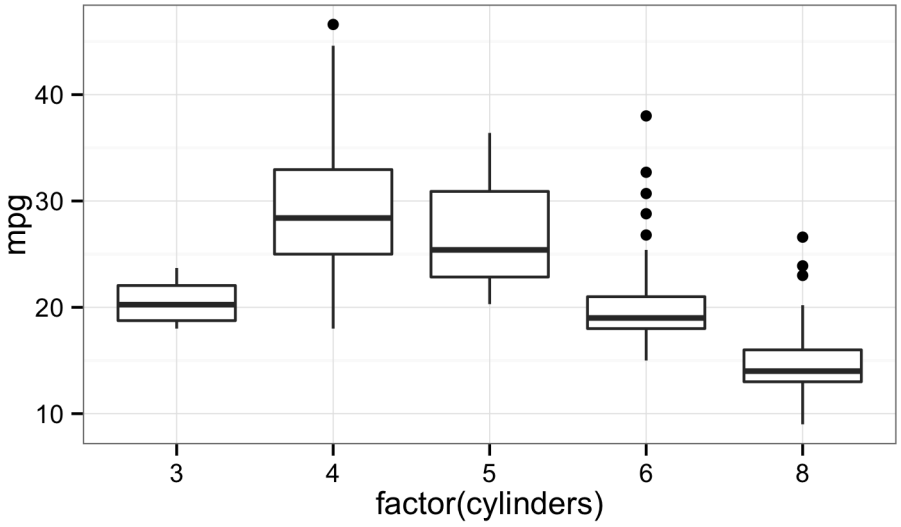
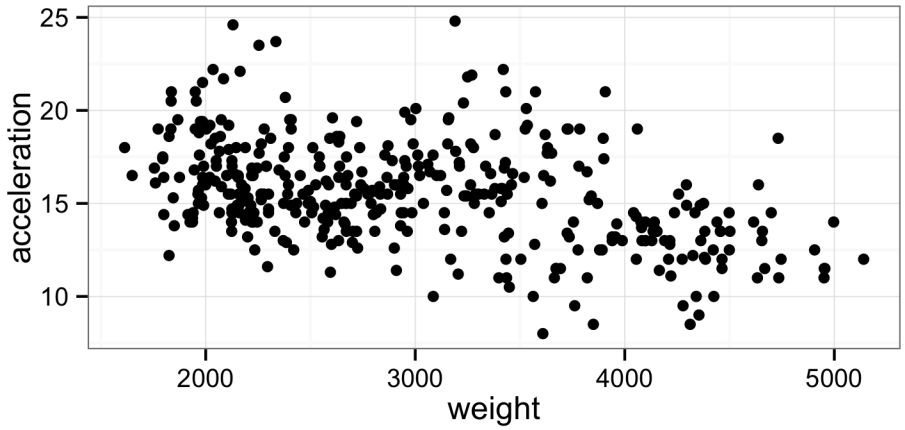
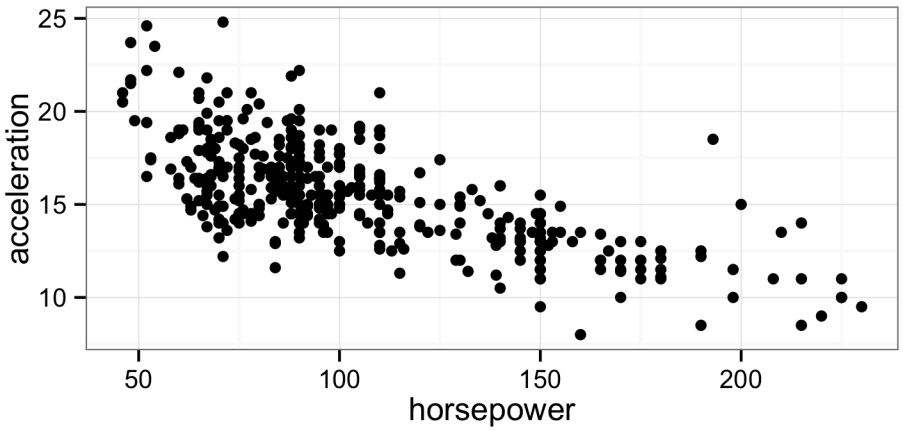


Figure 2: MPG vs number of cylinders

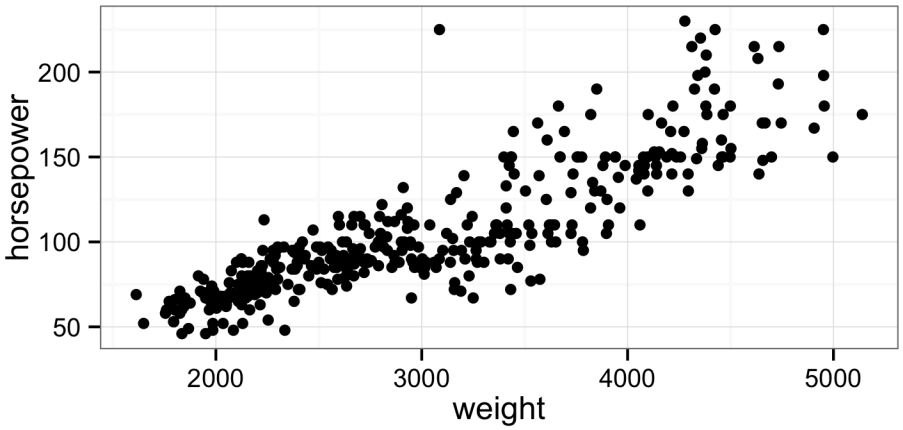
There isn't a particularly strong relationship between weight and acceleration (at least not one that is easily seen graphically).



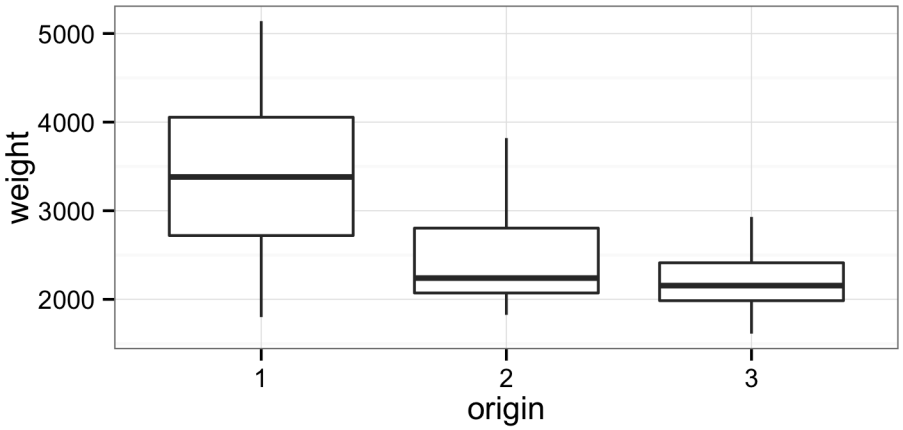
But there is a strong negative relationship between horsepower and acceleration.



And unsurprisingly, as the weight of a car increases, so does its horsepower.



Japanese cars (3) are usually lighter than American (1) and European (2) cars.



Japanese cars also have higher MPG.

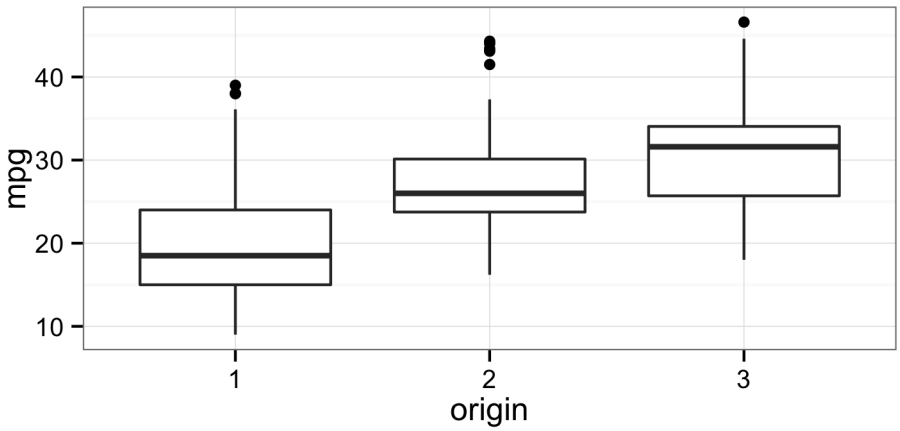


Figure 3: MPG by origin

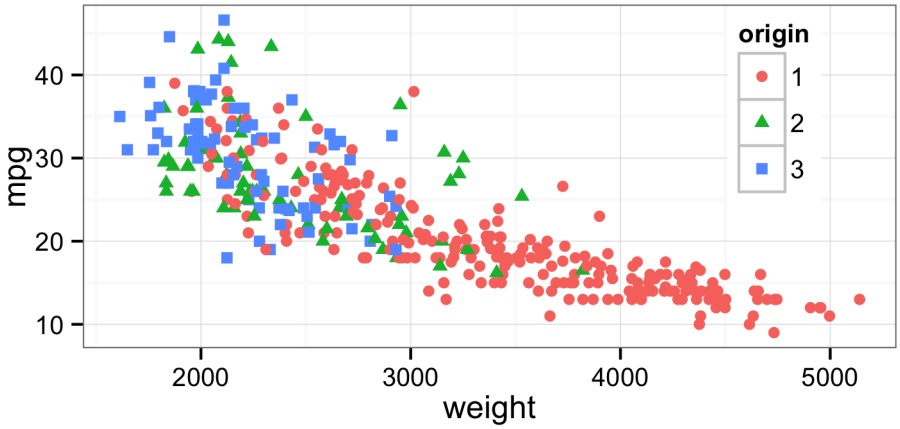


Figure 4: MPG vs weight, by origin

Part f

As shown in **Part e**, the year (Figure 1), number of cylinders (Figure 2), origin (Figure 3), and weight (Figure 4) of a car are all useful in predicting MPG. Displacement is also a useful predictor, but acceleration is not (see Figures 5 and 6 below).

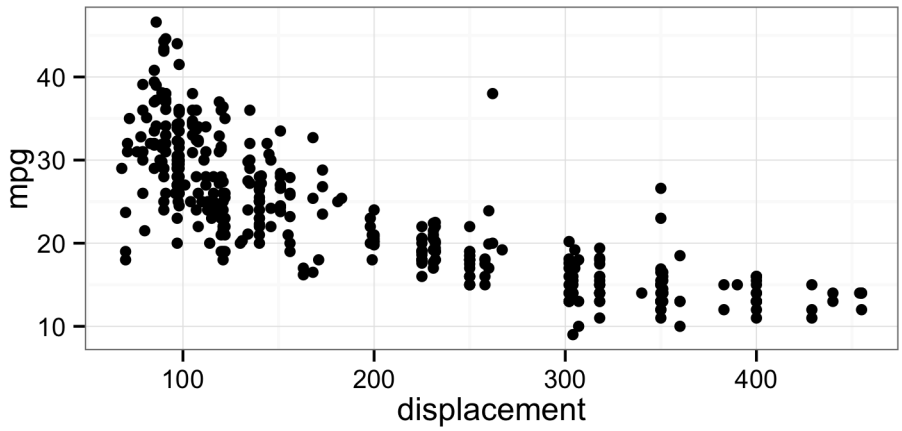


Figure 5: MPG vs displacemet

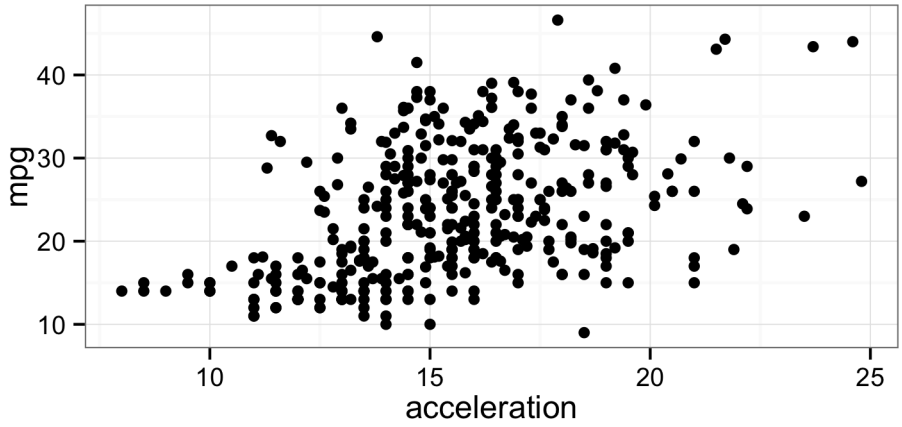


Figure 6: MPG vs acceleration

Problem 3: James 2.4, Exercise 10

Part a

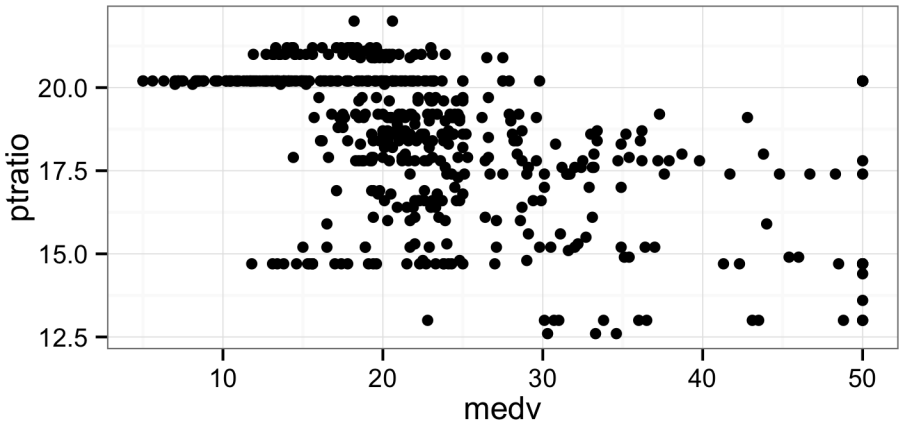
In the `Boston` dataset there are 506 rows and 14 columns. Each row represents a town in Boston. The column definitions, as written in the help file, are:

`crim`: per capita crime rate by town.
`zn`: proportion of residential land zoned for lots over 25,000 sq.ft.
`indus`: proportion of non-retail business acres per town.
`chas`: Charles River dummy variable (= 1 if tract bounds river; 0 otherwise).
`nox`: nitrogen oxides concentration (parts per 10 million).
`rm`: average number of rooms per dwelling.
`age`: proportion of owner-occupied units built prior to 1940.
`dis`: weighted mean of distances to five Boston employment centres.

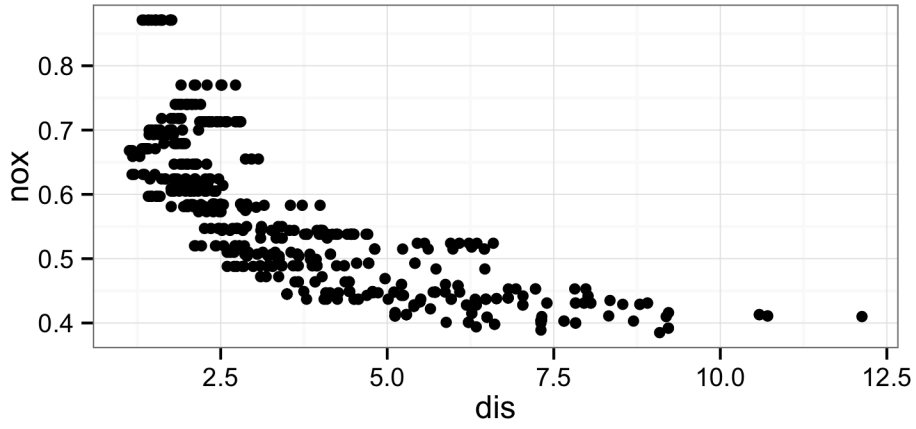
`rad`: index of accessibility to radial highways.
`tax`: full-value property-tax rate per $10,000.
`ptratio`: pupil-teacher ratio by town.
`black`: $1000(Bk - 0.63)^2$ where Bk is the proportion of blacks by town.
`lstat`: lower status of the population (percent).
`medv`: median value of owner-occupied homes in $1000s.

Part b

Pupil-teacher ratio decreases slightly as home value increases.



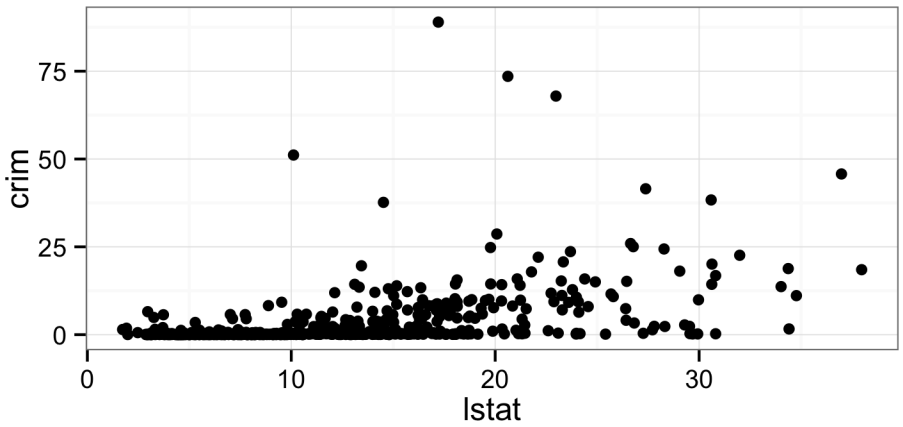
As distance from employment centers increases, nitrogen oxides concentration decreases.



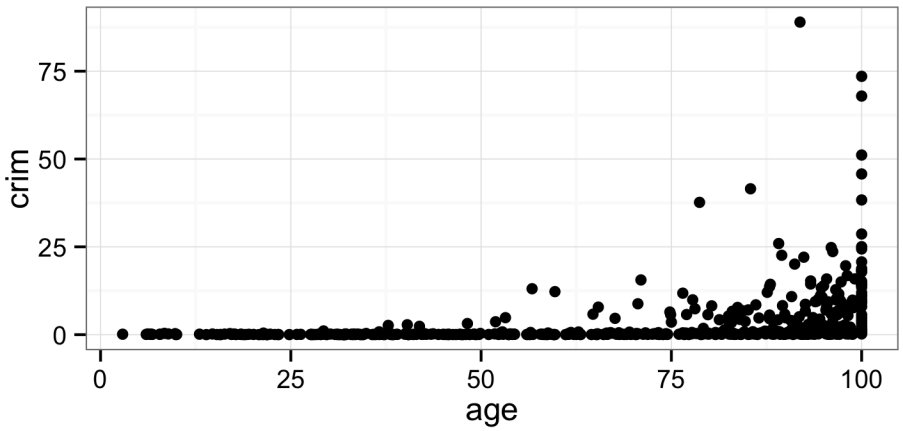
For plots incorporating crime rate (`crim`), see **Part c**.

Part c

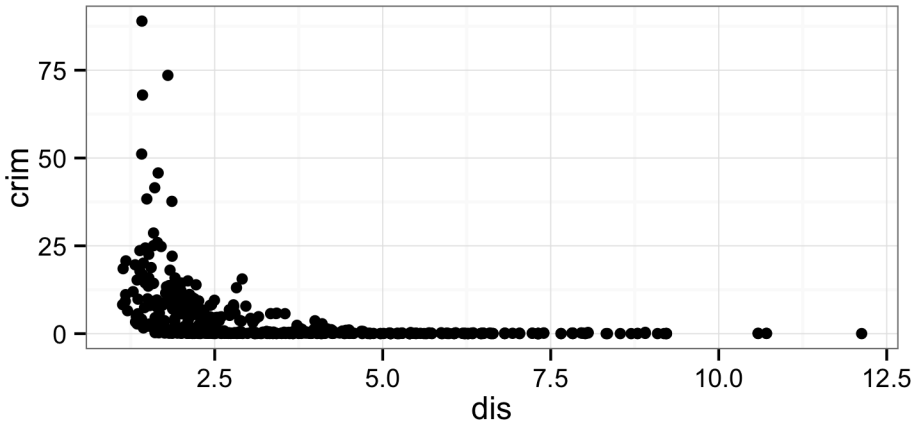
Crime rates are associated with many of the predictors. As "lower status of the population (percent)" increases, crime rates do too.



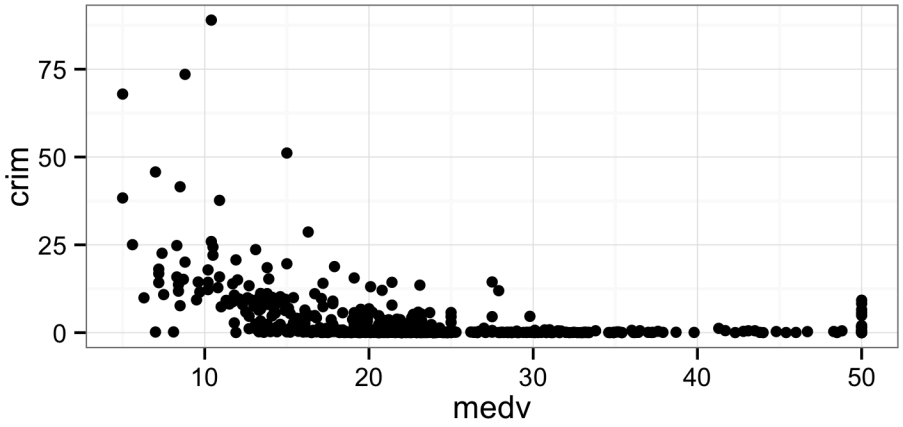
Similarly, towns with a higher proportion of buildings built before 1940 have higher crime rates as well.



Towns further from employment centers have lower crime rates.



And crime rates decrease as the median home value increases.



Part d

Yes, some suburbs of Bostom appear to have particularly high crime rates. The suburbs in rows 381, 399, 401, 405, 406, 411, 414, 415, 418, 419, and 428 each have a per capita crime rate of more than 25. Crime rate ranges from 0.00632 to 88.97620.

There also appear to be some towns with incredibly high tax rates. There are 137 towns with full-value property-tax rate per $10,000 of more than 600. Tax rate ranges from 187 to 711. A subset of the 137 towns are listed below:

```
[1] 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373
...
[121] 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493
```

It doesn't look like any towns have particularly high pupil-teacher ratios. Pupil-teacher ratio ranges from 12.6 to 22.0. 20.2 students/teacher appears to be a very popular ratio.

Range of each predictor:

```
  stat     crim  zn indus chas   nox    rm   age     dis rad tax ptratio  black lstat medv
1  min  0.00632   0  0.46    0 0.385 3.561   2.9  1.1296   1 187    12.6   0.32  1.73    5
2  max 88.97620 100 27.74    1 0.871 8.780 100.0 12.1265  24 711    22.0 396.90 37.97   50
```

Part e

35 town in the dataset bound the Charles river

Part f

Among towns in the dataset, the median pupil-teacher ratio is 19.05.

Part g

The towns in row numbers 399 and 406 have the lowest median values of owner-occupied homes at $5,000.
For those towns:

	rowNum	crim	zn	indus	chas	nox	rm	age	dis	rad	tax	ptratio	black	lstat	medv
1	399	38.3518	0	18.1	0	0.693	5.453	100	1.4896	24	666	20.2	396.90	30.59	5
2	406	67.9208	0	18.1	0	0.693	5.683	100	1.4254	24	666	20.2	384.97	22.98	5

Crime rates here are on the upper end of the range, and the towns have an average number of rooms per dwelling. Neither town borders the Charles river, and 100% of owner-occupied buildings in both towns were built before 1940.

Part h

There are 64 towns that average more than 7 rooms per dwelling, and 13 towns that average more than 8 rooms per dwelling.
Towns with more than 8 rooms per dwelling:

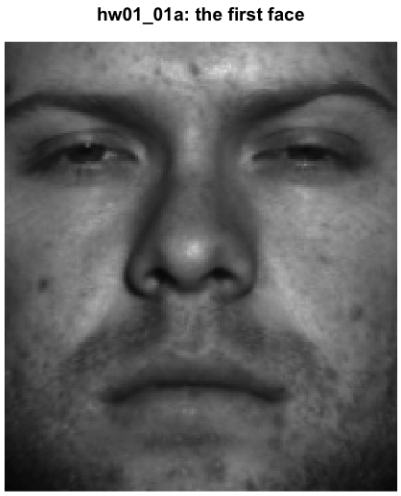
	rowNum	crim	zn	indus	chas	nox	rm	age	dis	rad	tax	ptratio	black	lstat	medv
1	98	0.12083	0	2.89	0	0.4450	8.069	76.0	3.4952	2	276	18.0	396.90	4.21	38.7
2	164	1.51902	0	19.58	1	0.6050	8.375	93.9	2.1620	5	403	14.7	388.45	3.32	50.0
3	205	0.02009	95	2.68	0	0.4161	8.034	31.9	5.1180	4	224	14.7	390.55	2.88	50.0
4	225	0.31533	0	6.20	0	0.5040	8.266	78.3	2.8944	8	307	17.4	385.05	4.14	44.8
5	226	0.52693	0	6.20	0	0.5040	8.725	83.0	2.8944	8	307	17.4	382.00	4.63	50.0
6	227	0.38214	0	6.20	0	0.5040	8.040	86.5	3.2157	8	307	17.4	387.38	3.13	37.6
7	233	0.57529	0	6.20	0	0.5070	8.337	73.3	3.8384	8	307	17.4	385.91	2.47	41.7
8	234	0.33147	0	6.20	0	0.5070	8.247	70.4	3.6519	8	307	17.4	378.95	3.95	48.3
9	254	0.36894	22	5.86	0	0.4310	8.259	8.4	8.9067	7	330	19.1	396.90	3.54	42.8
10	258	0.61154	20	3.97	0	0.6470	8.704	86.9	1.8010	5	264	13.0	389.70	5.12	50.0
11	263	0.52014	20	3.97	0	0.6470	8.398	91.5	2.2885	5	264	13.0	386.86	5.91	48.8
12	268	0.57834	20	3.97	0	0.5750	8.297	67.0	2.4216	5	264	13.0	384.54	7.44	50.0
13	365	3.47428	0	18.10	1	0.7180	8.780	82.9	1.9047	24	666	20.2	354.55	5.29	21.9

These towns all have very low crime rates and have lower values for `lstat`. They generally have `medv` values towards the higher end of the range.

Problem 4: Yale Faces B

Part a

The `CroppedYale/yaleB01/yaleB01_P00A-005E+10.pgm` image is of class `pixmapGrey` (part of the `pixmap` package). The original image is made up of 32,256 pixels (192 x 168).



Part b

A pixel value in a `pixmapGrey`-classed pgm image ranges from 0 to 1. A value of 0 corresponds to a black pixel, and a value of 1 corresponds to a white pixel.

In `faces_matrix`, which combines images 1 and 2, the pixel values range from 0.007843137 to 1.000000000.

Part c

`dir_list_1` lists all of the directories stored in the `CroppedYale/` directory. It has 38 elements, a sample of which is shown below.

```
> dir_list_1
 [1] "yaleB01" "yaleB02" "yaleB03" "yaleB04" "yaleB05" "yaleB06" "yaleB07"
...
[36] "yaleB37" "yaleB38" "yaleB39"
```

`dir_list_2` lists all of the individual files stored in the `CroppedYale/` directory, showing the full file path of each file stored in the directory. It has 2,547 elements, a sample of which is shown below.

```
> head(dir_list_2, 10)
 [1] "yaleB01/DEADJOE"                   "yaleB01/WS_FTP.LOG"
 [3] "yaleB01/yaleB01_P00_Ambient.pgm"   "yaleB01/yaleB01_P00.info"
 [5] "yaleB01/yaleB01_P00A-005E-10.pgm" "yaleB01/yaleB01_P00A-005E+10.pgm"
 [7] "yaleB01/yaleB01_P00A-010E-20.pgm" "yaleB01/yaleB01_P00A-010E+00.pgm"
 [9] "yaleB01/yaleB01_P00A-015E+20.pgm" "yaleB01/yaleB01_P00A-020E-10.pgm"
> tail(dir_list_2, 10)
 [1] "yaleB39/yaleB39_P00A+070E+45.pgm" "yaleB39/yaleB39_P00A+085E-20.pgm"
 [3] "yaleB39/yaleB39_P00A+085E+20.pgm" "yaleB39/yaleB39_P00A+095E+00.pgm"
 [5] "yaleB39/yaleB39_P00A+110E-20.pgm" "yaleB39/yaleB39_P00A+110E+15.pgm"
```

```
 [7] "yaleB39/yaleB39_P00A+110E+40.pgm" "yaleB39/yaleB39_P00A+110E+65.pgm"
 [9] "yaleB39/yaleB39_P00A+120E+00.pgm" "yaleB39/yaleB39_P00A+130E+20.pgm"
```

Part d