Module10HW

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# Stat 6021: Homework Set 9

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**Attended group with**: Wright, Nam, Barbre

## Question 1.

For this question, you will use a data set Boston, which comes from the MASS package in R. This is the same data set that you saw in the live session. The purpose of this question is to classify a town as being a high- or low-crime town based on some predictors. The governor of Massachusetts is most interested in identifying towns that have a high crime rate.

### Question 1 (a) Before fitting your logistic regression model …

you will need to create a new variable. The variable crim is the per capita crime rate of the town. Create a new variable that classifies crim in the following manner:

Define a town to have a: \* low crime rate, if its crime rate is less than 1 per capita. \* high crime rate, otherwise

Using the ifelse() function will be very helpful for this.

I highly recommend to add this newly created variable to the existing data frame.

Also, use the contrasts() function to see which class is the reference class for this newly created variable. What is the reference class?

**Work on Q1a**

library(MASS)  
library(Hmisc)

## Loading required package: lattice

## Loading required package: survival

## Loading required package: Formula

## Warning: package 'Formula' was built under R version 4.0.3

## Loading required package: ggplot2

##   
## Attaching package: 'Hmisc'

## The following objects are masked from 'package:base':  
##   
## format.pval, units

library(dplyr)

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:Hmisc':  
##   
## src, summarize

## The following object is masked from 'package:MASS':  
##   
## select

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

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

library(nnet)  
library(ROCR)

## Warning: package 'ROCR' was built under R version 4.0.3

#?Boston  
  
  
# even though we dont need it, here is the summary  
aboutBoston <- summary(Boston$crim)  
aboutBoston

## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 0.00632 0.08204 0.25651 3.61352 3.67708 88.97620

Boston <- Boston %>%  
 mutate(crimHigh = (crim >= 1.0) \* 1)

Boston

## crim zn indus chas nox rm age dis rad tax ptratio black  
## 1 0.00632 18.0 2.31 0 0.5380 6.575 65.2 4.0900 1 296 15.3 396.90  
## 2 0.02731 0.0 7.07 0 0.4690 6.421 78.9 4.9671 2 242 17.8 396.90  
## 3 0.02729 0.0 7.07 0 0.4690 7.185 61.1 4.9671 2 242 17.8 392.83  
## 4 0.03237 0.0 2.18 0 0.4580 6.998 45.8 6.0622 3 222 18.7 394.63  
## 5 0.06905 0.0 2.18 0 0.4580 7.147 54.2 6.0622 3 222 18.7 396.90  
## 6 0.02985 0.0 2.18 0 0.4580 6.430 58.7 6.0622 3 222 18.7 394.12  
## 7 0.08829 12.5 7.87 0 0.5240 6.012 66.6 5.5605 5 311 15.2 395.60  
## 8 0.14455 12.5 7.87 0 0.5240 6.172 96.1 5.9505 5 311 15.2 396.90  
## 9 0.21124 12.5 7.87 0 0.5240 5.631 100.0 6.0821 5 311 15.2 386.63  
## 10 0.17004 12.5 7.87 0 0.5240 6.004 85.9 6.5921 5 311 15.2 386.71  
## 11 0.22489 12.5 7.87 0 0.5240 6.377 94.3 6.3467 5 311 15.2 392.52  
## 12 0.11747 12.5 7.87 0 0.5240 6.009 82.9 6.2267 5 311 15.2 396.90  
## 13 0.09378 12.5 7.87 0 0.5240 5.889 39.0 5.4509 5 311 15.2 390.50  
## 14 0.62976 0.0 8.14 0 0.5380 5.949 61.8 4.7075 4 307 21.0 396.90  
## 15 0.63796 0.0 8.14 0 0.5380 6.096 84.5 4.4619 4 307 21.0 380.02  
## 16 0.62739 0.0 8.14 0 0.5380 5.834 56.5 4.4986 4 307 21.0 395.62  
## 17 1.05393 0.0 8.14 0 0.5380 5.935 29.3 4.4986 4 307 21.0 386.85  
## 18 0.78420 0.0 8.14 0 0.5380 5.990 81.7 4.2579 4 307 21.0 386.75  
## 19 0.80271 0.0 8.14 0 0.5380 5.456 36.6 3.7965 4 307 21.0 288.99  
## 20 0.72580 0.0 8.14 0 0.5380 5.727 69.5 3.7965 4 307 21.0 390.95  
## 21 1.25179 0.0 8.14 0 0.5380 5.570 98.1 3.7979 4 307 21.0 376.57  
## 22 0.85204 0.0 8.14 0 0.5380 5.965 89.2 4.0123 4 307 21.0 392.53  
## 23 1.23247 0.0 8.14 0 0.5380 6.142 91.7 3.9769 4 307 21.0 396.90  
## 24 0.98843 0.0 8.14 0 0.5380 5.813 100.0 4.0952 4 307 21.0 394.54  
## 25 0.75026 0.0 8.14 0 0.5380 5.924 94.1 4.3996 4 307 21.0 394.33  
## 26 0.84054 0.0 8.14 0 0.5380 5.599 85.7 4.4546 4 307 21.0 303.42  
## 27 0.67191 0.0 8.14 0 0.5380 5.813 90.3 4.6820 4 307 21.0 376.88  
## 28 0.95577 0.0 8.14 0 0.5380 6.047 88.8 4.4534 4 307 21.0 306.38  
## 29 0.77299 0.0 8.14 0 0.5380 6.495 94.4 4.4547 4 307 21.0 387.94  
## 30 1.00245 0.0 8.14 0 0.5380 6.674 87.3 4.2390 4 307 21.0 380.23  
## 31 1.13081 0.0 8.14 0 0.5380 5.713 94.1 4.2330 4 307 21.0 360.17  
## 32 1.35472 0.0 8.14 0 0.5380 6.072 100.0 4.1750 4 307 21.0 376.73  
## 33 1.38799 0.0 8.14 0 0.5380 5.950 82.0 3.9900 4 307 21.0 232.60  
## 34 1.15172 0.0 8.14 0 0.5380 5.701 95.0 3.7872 4 307 21.0 358.77  
## 35 1.61282 0.0 8.14 0 0.5380 6.096 96.9 3.7598 4 307 21.0 248.31  
## 36 0.06417 0.0 5.96 0 0.4990 5.933 68.2 3.3603 5 279 19.2 396.90  
## 37 0.09744 0.0 5.96 0 0.4990 5.841 61.4 3.3779 5 279 19.2 377.56  
## 38 0.08014 0.0 5.96 0 0.4990 5.850 41.5 3.9342 5 279 19.2 396.90  
## 39 0.17505 0.0 5.96 0 0.4990 5.966 30.2 3.8473 5 279 19.2 393.43  
## 40 0.02763 75.0 2.95 0 0.4280 6.595 21.8 5.4011 3 252 18.3 395.63  
## 41 0.03359 75.0 2.95 0 0.4280 7.024 15.8 5.4011 3 252 18.3 395.62  
## 42 0.12744 0.0 6.91 0 0.4480 6.770 2.9 5.7209 3 233 17.9 385.41  
## 43 0.14150 0.0 6.91 0 0.4480 6.169 6.6 5.7209 3 233 17.9 383.37  
## 44 0.15936 0.0 6.91 0 0.4480 6.211 6.5 5.7209 3 233 17.9 394.46  
## 45 0.12269 0.0 6.91 0 0.4480 6.069 40.0 5.7209 3 233 17.9 389.39  
## 46 0.17142 0.0 6.91 0 0.4480 5.682 33.8 5.1004 3 233 17.9 396.90  
## 47 0.18836 0.0 6.91 0 0.4480 5.786 33.3 5.1004 3 233 17.9 396.90  
## 48 0.22927 0.0 6.91 0 0.4480 6.030 85.5 5.6894 3 233 17.9 392.74  
## 49 0.25387 0.0 6.91 0 0.4480 5.399 95.3 5.8700 3 233 17.9 396.90  
## 50 0.21977 0.0 6.91 0 0.4480 5.602 62.0 6.0877 3 233 17.9 396.90  
## 51 0.08873 21.0 5.64 0 0.4390 5.963 45.7 6.8147 4 243 16.8 395.56  
## 52 0.04337 21.0 5.64 0 0.4390 6.115 63.0 6.8147 4 243 16.8 393.97  
## 53 0.05360 21.0 5.64 0 0.4390 6.511 21.1 6.8147 4 243 16.8 396.90  
## 54 0.04981 21.0 5.64 0 0.4390 5.998 21.4 6.8147 4 243 16.8 396.90  
## 55 0.01360 75.0 4.00 0 0.4100 5.888 47.6 7.3197 3 469 21.1 396.90  
## 56 0.01311 90.0 1.22 0 0.4030 7.249 21.9 8.6966 5 226 17.9 395.93  
## 57 0.02055 85.0 0.74 0 0.4100 6.383 35.7 9.1876 2 313 17.3 396.90  
## 58 0.01432 100.0 1.32 0 0.4110 6.816 40.5 8.3248 5 256 15.1 392.90  
## 59 0.15445 25.0 5.13 0 0.4530 6.145 29.2 7.8148 8 284 19.7 390.68  
## 60 0.10328 25.0 5.13 0 0.4530 5.927 47.2 6.9320 8 284 19.7 396.90  
## 61 0.14932 25.0 5.13 0 0.4530 5.741 66.2 7.2254 8 284 19.7 395.11  
## 62 0.17171 25.0 5.13 0 0.4530 5.966 93.4 6.8185 8 284 19.7 378.08  
## 63 0.11027 25.0 5.13 0 0.4530 6.456 67.8 7.2255 8 284 19.7 396.90  
## 64 0.12650 25.0 5.13 0 0.4530 6.762 43.4 7.9809 8 284 19.7 395.58  
## 65 0.01951 17.5 1.38 0 0.4161 7.104 59.5 9.2229 3 216 18.6 393.24  
## 66 0.03584 80.0 3.37 0 0.3980 6.290 17.8 6.6115 4 337 16.1 396.90  
## 67 0.04379 80.0 3.37 0 0.3980 5.787 31.1 6.6115 4 337 16.1 396.90  
## 68 0.05789 12.5 6.07 0 0.4090 5.878 21.4 6.4980 4 345 18.9 396.21  
## 69 0.13554 12.5 6.07 0 0.4090 5.594 36.8 6.4980 4 345 18.9 396.90  
## 70 0.12816 12.5 6.07 0 0.4090 5.885 33.0 6.4980 4 345 18.9 396.90  
## 71 0.08826 0.0 10.81 0 0.4130 6.417 6.6 5.2873 4 305 19.2 383.73  
## 72 0.15876 0.0 10.81 0 0.4130 5.961 17.5 5.2873 4 305 19.2 376.94  
## 73 0.09164 0.0 10.81 0 0.4130 6.065 7.8 5.2873 4 305 19.2 390.91  
## 74 0.19539 0.0 10.81 0 0.4130 6.245 6.2 5.2873 4 305 19.2 377.17  
## 75 0.07896 0.0 12.83 0 0.4370 6.273 6.0 4.2515 5 398 18.7 394.92  
## 76 0.09512 0.0 12.83 0 0.4370 6.286 45.0 4.5026 5 398 18.7 383.23  
## 77 0.10153 0.0 12.83 0 0.4370 6.279 74.5 4.0522 5 398 18.7 373.66  
## 78 0.08707 0.0 12.83 0 0.4370 6.140 45.8 4.0905 5 398 18.7 386.96  
## 79 0.05646 0.0 12.83 0 0.4370 6.232 53.7 5.0141 5 398 18.7 386.40  
## 80 0.08387 0.0 12.83 0 0.4370 5.874 36.6 4.5026 5 398 18.7 396.06  
## 81 0.04113 25.0 4.86 0 0.4260 6.727 33.5 5.4007 4 281 19.0 396.90  
## 82 0.04462 25.0 4.86 0 0.4260 6.619 70.4 5.4007 4 281 19.0 395.63  
## 83 0.03659 25.0 4.86 0 0.4260 6.302 32.2 5.4007 4 281 19.0 396.90  
## 84 0.03551 25.0 4.86 0 0.4260 6.167 46.7 5.4007 4 281 19.0 390.64  
## 85 0.05059 0.0 4.49 0 0.4490 6.389 48.0 4.7794 3 247 18.5 396.90  
## 86 0.05735 0.0 4.49 0 0.4490 6.630 56.1 4.4377 3 247 18.5 392.30  
## 87 0.05188 0.0 4.49 0 0.4490 6.015 45.1 4.4272 3 247 18.5 395.99  
## 88 0.07151 0.0 4.49 0 0.4490 6.121 56.8 3.7476 3 247 18.5 395.15  
## 89 0.05660 0.0 3.41 0 0.4890 7.007 86.3 3.4217 2 270 17.8 396.90  
## 90 0.05302 0.0 3.41 0 0.4890 7.079 63.1 3.4145 2 270 17.8 396.06  
## 91 0.04684 0.0 3.41 0 0.4890 6.417 66.1 3.0923 2 270 17.8 392.18  
## 92 0.03932 0.0 3.41 0 0.4890 6.405 73.9 3.0921 2 270 17.8 393.55  
## 93 0.04203 28.0 15.04 0 0.4640 6.442 53.6 3.6659 4 270 18.2 395.01  
## 94 0.02875 28.0 15.04 0 0.4640 6.211 28.9 3.6659 4 270 18.2 396.33  
## 95 0.04294 28.0 15.04 0 0.4640 6.249 77.3 3.6150 4 270 18.2 396.90  
## 96 0.12204 0.0 2.89 0 0.4450 6.625 57.8 3.4952 2 276 18.0 357.98  
## 97 0.11504 0.0 2.89 0 0.4450 6.163 69.6 3.4952 2 276 18.0 391.83  
## 98 0.12083 0.0 2.89 0 0.4450 8.069 76.0 3.4952 2 276 18.0 396.90  
## 99 0.08187 0.0 2.89 0 0.4450 7.820 36.9 3.4952 2 276 18.0 393.53  
## 100 0.06860 0.0 2.89 0 0.4450 7.416 62.5 3.4952 2 276 18.0 396.90  
## 101 0.14866 0.0 8.56 0 0.5200 6.727 79.9 2.7778 5 384 20.9 394.76  
## 102 0.11432 0.0 8.56 0 0.5200 6.781 71.3 2.8561 5 384 20.9 395.58  
## 103 0.22876 0.0 8.56 0 0.5200 6.405 85.4 2.7147 5 384 20.9 70.80  
## 104 0.21161 0.0 8.56 0 0.5200 6.137 87.4 2.7147 5 384 20.9 394.47  
## 105 0.13960 0.0 8.56 0 0.5200 6.167 90.0 2.4210 5 384 20.9 392.69  
## 106 0.13262 0.0 8.56 0 0.5200 5.851 96.7 2.1069 5 384 20.9 394.05  
## 107 0.17120 0.0 8.56 0 0.5200 5.836 91.9 2.2110 5 384 20.9 395.67  
## 108 0.13117 0.0 8.56 0 0.5200 6.127 85.2 2.1224 5 384 20.9 387.69  
## 109 0.12802 0.0 8.56 0 0.5200 6.474 97.1 2.4329 5 384 20.9 395.24  
## 110 0.26363 0.0 8.56 0 0.5200 6.229 91.2 2.5451 5 384 20.9 391.23  
## 111 0.10793 0.0 8.56 0 0.5200 6.195 54.4 2.7778 5 384 20.9 393.49  
## 112 0.10084 0.0 10.01 0 0.5470 6.715 81.6 2.6775 6 432 17.8 395.59  
## 113 0.12329 0.0 10.01 0 0.5470 5.913 92.9 2.3534 6 432 17.8 394.95  
## 114 0.22212 0.0 10.01 0 0.5470 6.092 95.4 2.5480 6 432 17.8 396.90  
## 115 0.14231 0.0 10.01 0 0.5470 6.254 84.2 2.2565 6 432 17.8 388.74  
## 116 0.17134 0.0 10.01 0 0.5470 5.928 88.2 2.4631 6 432 17.8 344.91  
## 117 0.13158 0.0 10.01 0 0.5470 6.176 72.5 2.7301 6 432 17.8 393.30  
## 118 0.15098 0.0 10.01 0 0.5470 6.021 82.6 2.7474 6 432 17.8 394.51  
## 119 0.13058 0.0 10.01 0 0.5470 5.872 73.1 2.4775 6 432 17.8 338.63  
## 120 0.14476 0.0 10.01 0 0.5470 5.731 65.2 2.7592 6 432 17.8 391.50  
## 121 0.06899 0.0 25.65 0 0.5810 5.870 69.7 2.2577 2 188 19.1 389.15  
## 122 0.07165 0.0 25.65 0 0.5810 6.004 84.1 2.1974 2 188 19.1 377.67  
## 123 0.09299 0.0 25.65 0 0.5810 5.961 92.9 2.0869 2 188 19.1 378.09  
## 124 0.15038 0.0 25.65 0 0.5810 5.856 97.0 1.9444 2 188 19.1 370.31  
## 125 0.09849 0.0 25.65 0 0.5810 5.879 95.8 2.0063 2 188 19.1 379.38  
## 126 0.16902 0.0 25.65 0 0.5810 5.986 88.4 1.9929 2 188 19.1 385.02  
## 127 0.38735 0.0 25.65 0 0.5810 5.613 95.6 1.7572 2 188 19.1 359.29  
## 128 0.25915 0.0 21.89 0 0.6240 5.693 96.0 1.7883 4 437 21.2 392.11  
## 129 0.32543 0.0 21.89 0 0.6240 6.431 98.8 1.8125 4 437 21.2 396.90  
## 130 0.88125 0.0 21.89 0 0.6240 5.637 94.7 1.9799 4 437 21.2 396.90  
## 131 0.34006 0.0 21.89 0 0.6240 6.458 98.9 2.1185 4 437 21.2 395.04  
## 132 1.19294 0.0 21.89 0 0.6240 6.326 97.7 2.2710 4 437 21.2 396.90  
## 133 0.59005 0.0 21.89 0 0.6240 6.372 97.9 2.3274 4 437 21.2 385.76  
## 134 0.32982 0.0 21.89 0 0.6240 5.822 95.4 2.4699 4 437 21.2 388.69  
## 135 0.97617 0.0 21.89 0 0.6240 5.757 98.4 2.3460 4 437 21.2 262.76  
## 136 0.55778 0.0 21.89 0 0.6240 6.335 98.2 2.1107 4 437 21.2 394.67  
## 137 0.32264 0.0 21.89 0 0.6240 5.942 93.5 1.9669 4 437 21.2 378.25  
## 138 0.35233 0.0 21.89 0 0.6240 6.454 98.4 1.8498 4 437 21.2 394.08  
## 139 0.24980 0.0 21.89 0 0.6240 5.857 98.2 1.6686 4 437 21.2 392.04  
## 140 0.54452 0.0 21.89 0 0.6240 6.151 97.9 1.6687 4 437 21.2 396.90  
## 141 0.29090 0.0 21.89 0 0.6240 6.174 93.6 1.6119 4 437 21.2 388.08  
## 142 1.62864 0.0 21.89 0 0.6240 5.019 100.0 1.4394 4 437 21.2 396.90  
## 143 3.32105 0.0 19.58 1 0.8710 5.403 100.0 1.3216 5 403 14.7 396.90  
## 144 4.09740 0.0 19.58 0 0.8710 5.468 100.0 1.4118 5 403 14.7 396.90  
## 145 2.77974 0.0 19.58 0 0.8710 4.903 97.8 1.3459 5 403 14.7 396.90  
## 146 2.37934 0.0 19.58 0 0.8710 6.130 100.0 1.4191 5 403 14.7 172.91  
## 147 2.15505 0.0 19.58 0 0.8710 5.628 100.0 1.5166 5 403 14.7 169.27  
## 148 2.36862 0.0 19.58 0 0.8710 4.926 95.7 1.4608 5 403 14.7 391.71  
## 149 2.33099 0.0 19.58 0 0.8710 5.186 93.8 1.5296 5 403 14.7 356.99  
## 150 2.73397 0.0 19.58 0 0.8710 5.597 94.9 1.5257 5 403 14.7 351.85  
## 151 1.65660 0.0 19.58 0 0.8710 6.122 97.3 1.6180 5 403 14.7 372.80  
## 152 1.49632 0.0 19.58 0 0.8710 5.404 100.0 1.5916 5 403 14.7 341.60  
## 153 1.12658 0.0 19.58 1 0.8710 5.012 88.0 1.6102 5 403 14.7 343.28  
## 154 2.14918 0.0 19.58 0 0.8710 5.709 98.5 1.6232 5 403 14.7 261.95  
## 155 1.41385 0.0 19.58 1 0.8710 6.129 96.0 1.7494 5 403 14.7 321.02  
## 156 3.53501 0.0 19.58 1 0.8710 6.152 82.6 1.7455 5 403 14.7 88.01  
## 157 2.44668 0.0 19.58 0 0.8710 5.272 94.0 1.7364 5 403 14.7 88.63  
## 158 1.22358 0.0 19.58 0 0.6050 6.943 97.4 1.8773 5 403 14.7 363.43  
## 159 1.34284 0.0 19.58 0 0.6050 6.066 100.0 1.7573 5 403 14.7 353.89  
## 160 1.42502 0.0 19.58 0 0.8710 6.510 100.0 1.7659 5 403 14.7 364.31  
## 161 1.27346 0.0 19.58 1 0.6050 6.250 92.6 1.7984 5 403 14.7 338.92  
## 162 1.46336 0.0 19.58 0 0.6050 7.489 90.8 1.9709 5 403 14.7 374.43  
## 163 1.83377 0.0 19.58 1 0.6050 7.802 98.2 2.0407 5 403 14.7 389.61  
## 164 1.51902 0.0 19.58 1 0.6050 8.375 93.9 2.1620 5 403 14.7 388.45  
## 165 2.24236 0.0 19.58 0 0.6050 5.854 91.8 2.4220 5 403 14.7 395.11  
## 166 2.92400 0.0 19.58 0 0.6050 6.101 93.0 2.2834 5 403 14.7 240.16  
## 167 2.01019 0.0 19.58 0 0.6050 7.929 96.2 2.0459 5 403 14.7 369.30  
## 168 1.80028 0.0 19.58 0 0.6050 5.877 79.2 2.4259 5 403 14.7 227.61  
## 169 2.30040 0.0 19.58 0 0.6050 6.319 96.1 2.1000 5 403 14.7 297.09  
## 170 2.44953 0.0 19.58 0 0.6050 6.402 95.2 2.2625 5 403 14.7 330.04  
## 171 1.20742 0.0 19.58 0 0.6050 5.875 94.6 2.4259 5 403 14.7 292.29  
## 172 2.31390 0.0 19.58 0 0.6050 5.880 97.3 2.3887 5 403 14.7 348.13  
## 173 0.13914 0.0 4.05 0 0.5100 5.572 88.5 2.5961 5 296 16.6 396.90  
## 174 0.09178 0.0 4.05 0 0.5100 6.416 84.1 2.6463 5 296 16.6 395.50  
## 175 0.08447 0.0 4.05 0 0.5100 5.859 68.7 2.7019 5 296 16.6 393.23  
## 176 0.06664 0.0 4.05 0 0.5100 6.546 33.1 3.1323 5 296 16.6 390.96  
## 177 0.07022 0.0 4.05 0 0.5100 6.020 47.2 3.5549 5 296 16.6 393.23  
## 178 0.05425 0.0 4.05 0 0.5100 6.315 73.4 3.3175 5 296 16.6 395.60  
## 179 0.06642 0.0 4.05 0 0.5100 6.860 74.4 2.9153 5 296 16.6 391.27  
## 180 0.05780 0.0 2.46 0 0.4880 6.980 58.4 2.8290 3 193 17.8 396.90  
## 181 0.06588 0.0 2.46 0 0.4880 7.765 83.3 2.7410 3 193 17.8 395.56  
## 182 0.06888 0.0 2.46 0 0.4880 6.144 62.2 2.5979 3 193 17.8 396.90  
## 183 0.09103 0.0 2.46 0 0.4880 7.155 92.2 2.7006 3 193 17.8 394.12  
## 184 0.10008 0.0 2.46 0 0.4880 6.563 95.6 2.8470 3 193 17.8 396.90  
## 185 0.08308 0.0 2.46 0 0.4880 5.604 89.8 2.9879 3 193 17.8 391.00  
## 186 0.06047 0.0 2.46 0 0.4880 6.153 68.8 3.2797 3 193 17.8 387.11  
## 187 0.05602 0.0 2.46 0 0.4880 7.831 53.6 3.1992 3 193 17.8 392.63  
## 188 0.07875 45.0 3.44 0 0.4370 6.782 41.1 3.7886 5 398 15.2 393.87  
## 189 0.12579 45.0 3.44 0 0.4370 6.556 29.1 4.5667 5 398 15.2 382.84  
## 190 0.08370 45.0 3.44 0 0.4370 7.185 38.9 4.5667 5 398 15.2 396.90  
## 191 0.09068 45.0 3.44 0 0.4370 6.951 21.5 6.4798 5 398 15.2 377.68  
## 192 0.06911 45.0 3.44 0 0.4370 6.739 30.8 6.4798 5 398 15.2 389.71  
## 193 0.08664 45.0 3.44 0 0.4370 7.178 26.3 6.4798 5 398 15.2 390.49  
## 194 0.02187 60.0 2.93 0 0.4010 6.800 9.9 6.2196 1 265 15.6 393.37  
## 195 0.01439 60.0 2.93 0 0.4010 6.604 18.8 6.2196 1 265 15.6 376.70  
## 196 0.01381 80.0 0.46 0 0.4220 7.875 32.0 5.6484 4 255 14.4 394.23  
## 197 0.04011 80.0 1.52 0 0.4040 7.287 34.1 7.3090 2 329 12.6 396.90  
## 198 0.04666 80.0 1.52 0 0.4040 7.107 36.6 7.3090 2 329 12.6 354.31  
## 199 0.03768 80.0 1.52 0 0.4040 7.274 38.3 7.3090 2 329 12.6 392.20  
## 200 0.03150 95.0 1.47 0 0.4030 6.975 15.3 7.6534 3 402 17.0 396.90  
## 201 0.01778 95.0 1.47 0 0.4030 7.135 13.9 7.6534 3 402 17.0 384.30  
## 202 0.03445 82.5 2.03 0 0.4150 6.162 38.4 6.2700 2 348 14.7 393.77  
## 203 0.02177 82.5 2.03 0 0.4150 7.610 15.7 6.2700 2 348 14.7 395.38  
## 204 0.03510 95.0 2.68 0 0.4161 7.853 33.2 5.1180 4 224 14.7 392.78  
## 205 0.02009 95.0 2.68 0 0.4161 8.034 31.9 5.1180 4 224 14.7 390.55  
## 206 0.13642 0.0 10.59 0 0.4890 5.891 22.3 3.9454 4 277 18.6 396.90  
## 207 0.22969 0.0 10.59 0 0.4890 6.326 52.5 4.3549 4 277 18.6 394.87  
## 208 0.25199 0.0 10.59 0 0.4890 5.783 72.7 4.3549 4 277 18.6 389.43  
## 209 0.13587 0.0 10.59 1 0.4890 6.064 59.1 4.2392 4 277 18.6 381.32  
## 210 0.43571 0.0 10.59 1 0.4890 5.344 100.0 3.8750 4 277 18.6 396.90  
## 211 0.17446 0.0 10.59 1 0.4890 5.960 92.1 3.8771 4 277 18.6 393.25  
## 212 0.37578 0.0 10.59 1 0.4890 5.404 88.6 3.6650 4 277 18.6 395.24  
## 213 0.21719 0.0 10.59 1 0.4890 5.807 53.8 3.6526 4 277 18.6 390.94  
## 214 0.14052 0.0 10.59 0 0.4890 6.375 32.3 3.9454 4 277 18.6 385.81  
## 215 0.28955 0.0 10.59 0 0.4890 5.412 9.8 3.5875 4 277 18.6 348.93  
## 216 0.19802 0.0 10.59 0 0.4890 6.182 42.4 3.9454 4 277 18.6 393.63  
## 217 0.04560 0.0 13.89 1 0.5500 5.888 56.0 3.1121 5 276 16.4 392.80  
## 218 0.07013 0.0 13.89 0 0.5500 6.642 85.1 3.4211 5 276 16.4 392.78  
## 219 0.11069 0.0 13.89 1 0.5500 5.951 93.8 2.8893 5 276 16.4 396.90  
## 220 0.11425 0.0 13.89 1 0.5500 6.373 92.4 3.3633 5 276 16.4 393.74  
## 221 0.35809 0.0 6.20 1 0.5070 6.951 88.5 2.8617 8 307 17.4 391.70  
## 222 0.40771 0.0 6.20 1 0.5070 6.164 91.3 3.0480 8 307 17.4 395.24  
## 223 0.62356 0.0 6.20 1 0.5070 6.879 77.7 3.2721 8 307 17.4 390.39  
## 224 0.61470 0.0 6.20 0 0.5070 6.618 80.8 3.2721 8 307 17.4 396.90  
## 225 0.31533 0.0 6.20 0 0.5040 8.266 78.3 2.8944 8 307 17.4 385.05  
## 226 0.52693 0.0 6.20 0 0.5040 8.725 83.0 2.8944 8 307 17.4 382.00  
## 227 0.38214 0.0 6.20 0 0.5040 8.040 86.5 3.2157 8 307 17.4 387.38  
## 228 0.41238 0.0 6.20 0 0.5040 7.163 79.9 3.2157 8 307 17.4 372.08  
## 229 0.29819 0.0 6.20 0 0.5040 7.686 17.0 3.3751 8 307 17.4 377.51  
## 230 0.44178 0.0 6.20 0 0.5040 6.552 21.4 3.3751 8 307 17.4 380.34  
## 231 0.53700 0.0 6.20 0 0.5040 5.981 68.1 3.6715 8 307 17.4 378.35  
## 232 0.46296 0.0 6.20 0 0.5040 7.412 76.9 3.6715 8 307 17.4 376.14  
## 233 0.57529 0.0 6.20 0 0.5070 8.337 73.3 3.8384 8 307 17.4 385.91  
## 234 0.33147 0.0 6.20 0 0.5070 8.247 70.4 3.6519 8 307 17.4 378.95  
## 235 0.44791 0.0 6.20 1 0.5070 6.726 66.5 3.6519 8 307 17.4 360.20  
## 236 0.33045 0.0 6.20 0 0.5070 6.086 61.5 3.6519 8 307 17.4 376.75  
## 237 0.52058 0.0 6.20 1 0.5070 6.631 76.5 4.1480 8 307 17.4 388.45  
## 238 0.51183 0.0 6.20 0 0.5070 7.358 71.6 4.1480 8 307 17.4 390.07  
## 239 0.08244 30.0 4.93 0 0.4280 6.481 18.5 6.1899 6 300 16.6 379.41  
## 240 0.09252 30.0 4.93 0 0.4280 6.606 42.2 6.1899 6 300 16.6 383.78  
## 241 0.11329 30.0 4.93 0 0.4280 6.897 54.3 6.3361 6 300 16.6 391.25  
## 242 0.10612 30.0 4.93 0 0.4280 6.095 65.1 6.3361 6 300 16.6 394.62  
## 243 0.10290 30.0 4.93 0 0.4280 6.358 52.9 7.0355 6 300 16.6 372.75  
## 244 0.12757 30.0 4.93 0 0.4280 6.393 7.8 7.0355 6 300 16.6 374.71  
## 245 0.20608 22.0 5.86 0 0.4310 5.593 76.5 7.9549 7 330 19.1 372.49  
## 246 0.19133 22.0 5.86 0 0.4310 5.605 70.2 7.9549 7 330 19.1 389.13  
## 247 0.33983 22.0 5.86 0 0.4310 6.108 34.9 8.0555 7 330 19.1 390.18  
## 248 0.19657 22.0 5.86 0 0.4310 6.226 79.2 8.0555 7 330 19.1 376.14  
## 249 0.16439 22.0 5.86 0 0.4310 6.433 49.1 7.8265 7 330 19.1 374.71  
## 250 0.19073 22.0 5.86 0 0.4310 6.718 17.5 7.8265 7 330 19.1 393.74  
## 251 0.14030 22.0 5.86 0 0.4310 6.487 13.0 7.3967 7 330 19.1 396.28  
## 252 0.21409 22.0 5.86 0 0.4310 6.438 8.9 7.3967 7 330 19.1 377.07  
## 253 0.08221 22.0 5.86 0 0.4310 6.957 6.8 8.9067 7 330 19.1 386.09  
## 254 0.36894 22.0 5.86 0 0.4310 8.259 8.4 8.9067 7 330 19.1 396.90  
## 255 0.04819 80.0 3.64 0 0.3920 6.108 32.0 9.2203 1 315 16.4 392.89  
## 256 0.03548 80.0 3.64 0 0.3920 5.876 19.1 9.2203 1 315 16.4 395.18  
## 257 0.01538 90.0 3.75 0 0.3940 7.454 34.2 6.3361 3 244 15.9 386.34  
## 258 0.61154 20.0 3.97 0 0.6470 8.704 86.9 1.8010 5 264 13.0 389.70  
## 259 0.66351 20.0 3.97 0 0.6470 7.333 100.0 1.8946 5 264 13.0 383.29  
## 260 0.65665 20.0 3.97 0 0.6470 6.842 100.0 2.0107 5 264 13.0 391.93  
## 261 0.54011 20.0 3.97 0 0.6470 7.203 81.8 2.1121 5 264 13.0 392.80  
## 262 0.53412 20.0 3.97 0 0.6470 7.520 89.4 2.1398 5 264 13.0 388.37  
## 263 0.52014 20.0 3.97 0 0.6470 8.398 91.5 2.2885 5 264 13.0 386.86  
## 264 0.82526 20.0 3.97 0 0.6470 7.327 94.5 2.0788 5 264 13.0 393.42  
## 265 0.55007 20.0 3.97 0 0.6470 7.206 91.6 1.9301 5 264 13.0 387.89  
## 266 0.76162 20.0 3.97 0 0.6470 5.560 62.8 1.9865 5 264 13.0 392.40  
## 267 0.78570 20.0 3.97 0 0.6470 7.014 84.6 2.1329 5 264 13.0 384.07  
## 268 0.57834 20.0 3.97 0 0.5750 8.297 67.0 2.4216 5 264 13.0 384.54  
## 269 0.54050 20.0 3.97 0 0.5750 7.470 52.6 2.8720 5 264 13.0 390.30  
## 270 0.09065 20.0 6.96 1 0.4640 5.920 61.5 3.9175 3 223 18.6 391.34  
## 271 0.29916 20.0 6.96 0 0.4640 5.856 42.1 4.4290 3 223 18.6 388.65  
## 272 0.16211 20.0 6.96 0 0.4640 6.240 16.3 4.4290 3 223 18.6 396.90  
## 273 0.11460 20.0 6.96 0 0.4640 6.538 58.7 3.9175 3 223 18.6 394.96  
## 274 0.22188 20.0 6.96 1 0.4640 7.691 51.8 4.3665 3 223 18.6 390.77  
## 275 0.05644 40.0 6.41 1 0.4470 6.758 32.9 4.0776 4 254 17.6 396.90  
## 276 0.09604 40.0 6.41 0 0.4470 6.854 42.8 4.2673 4 254 17.6 396.90  
## 277 0.10469 40.0 6.41 1 0.4470 7.267 49.0 4.7872 4 254 17.6 389.25  
## 278 0.06127 40.0 6.41 1 0.4470 6.826 27.6 4.8628 4 254 17.6 393.45  
## 279 0.07978 40.0 6.41 0 0.4470 6.482 32.1 4.1403 4 254 17.6 396.90  
## 280 0.21038 20.0 3.33 0 0.4429 6.812 32.2 4.1007 5 216 14.9 396.90  
## 281 0.03578 20.0 3.33 0 0.4429 7.820 64.5 4.6947 5 216 14.9 387.31  
## 282 0.03705 20.0 3.33 0 0.4429 6.968 37.2 5.2447 5 216 14.9 392.23  
## 283 0.06129 20.0 3.33 1 0.4429 7.645 49.7 5.2119 5 216 14.9 377.07  
## 284 0.01501 90.0 1.21 1 0.4010 7.923 24.8 5.8850 1 198 13.6 395.52  
## 285 0.00906 90.0 2.97 0 0.4000 7.088 20.8 7.3073 1 285 15.3 394.72  
## 286 0.01096 55.0 2.25 0 0.3890 6.453 31.9 7.3073 1 300 15.3 394.72  
## 287 0.01965 80.0 1.76 0 0.3850 6.230 31.5 9.0892 1 241 18.2 341.60  
## 288 0.03871 52.5 5.32 0 0.4050 6.209 31.3 7.3172 6 293 16.6 396.90  
## 289 0.04590 52.5 5.32 0 0.4050 6.315 45.6 7.3172 6 293 16.6 396.90  
## 290 0.04297 52.5 5.32 0 0.4050 6.565 22.9 7.3172 6 293 16.6 371.72  
## 291 0.03502 80.0 4.95 0 0.4110 6.861 27.9 5.1167 4 245 19.2 396.90  
## 292 0.07886 80.0 4.95 0 0.4110 7.148 27.7 5.1167 4 245 19.2 396.90  
## 293 0.03615 80.0 4.95 0 0.4110 6.630 23.4 5.1167 4 245 19.2 396.90  
## 294 0.08265 0.0 13.92 0 0.4370 6.127 18.4 5.5027 4 289 16.0 396.90  
## 295 0.08199 0.0 13.92 0 0.4370 6.009 42.3 5.5027 4 289 16.0 396.90  
## 296 0.12932 0.0 13.92 0 0.4370 6.678 31.1 5.9604 4 289 16.0 396.90  
## 297 0.05372 0.0 13.92 0 0.4370 6.549 51.0 5.9604 4 289 16.0 392.85  
## 298 0.14103 0.0 13.92 0 0.4370 5.790 58.0 6.3200 4 289 16.0 396.90  
## 299 0.06466 70.0 2.24 0 0.4000 6.345 20.1 7.8278 5 358 14.8 368.24  
## 300 0.05561 70.0 2.24 0 0.4000 7.041 10.0 7.8278 5 358 14.8 371.58  
## 301 0.04417 70.0 2.24 0 0.4000 6.871 47.4 7.8278 5 358 14.8 390.86  
## 302 0.03537 34.0 6.09 0 0.4330 6.590 40.4 5.4917 7 329 16.1 395.75  
## 303 0.09266 34.0 6.09 0 0.4330 6.495 18.4 5.4917 7 329 16.1 383.61  
## 304 0.10000 34.0 6.09 0 0.4330 6.982 17.7 5.4917 7 329 16.1 390.43  
## 305 0.05515 33.0 2.18 0 0.4720 7.236 41.1 4.0220 7 222 18.4 393.68  
## 306 0.05479 33.0 2.18 0 0.4720 6.616 58.1 3.3700 7 222 18.4 393.36  
## 307 0.07503 33.0 2.18 0 0.4720 7.420 71.9 3.0992 7 222 18.4 396.90  
## 308 0.04932 33.0 2.18 0 0.4720 6.849 70.3 3.1827 7 222 18.4 396.90  
## 309 0.49298 0.0 9.90 0 0.5440 6.635 82.5 3.3175 4 304 18.4 396.90  
## 310 0.34940 0.0 9.90 0 0.5440 5.972 76.7 3.1025 4 304 18.4 396.24  
## 311 2.63548 0.0 9.90 0 0.5440 4.973 37.8 2.5194 4 304 18.4 350.45  
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## 313 0.26169 0.0 9.90 0 0.5440 6.023 90.4 2.8340 4 304 18.4 396.30  
## 314 0.26938 0.0 9.90 0 0.5440 6.266 82.8 3.2628 4 304 18.4 393.39  
## 315 0.36920 0.0 9.90 0 0.5440 6.567 87.3 3.6023 4 304 18.4 395.69  
## 316 0.25356 0.0 9.90 0 0.5440 5.705 77.7 3.9450 4 304 18.4 396.42  
## 317 0.31827 0.0 9.90 0 0.5440 5.914 83.2 3.9986 4 304 18.4 390.70  
## 318 0.24522 0.0 9.90 0 0.5440 5.782 71.7 4.0317 4 304 18.4 396.90  
## 319 0.40202 0.0 9.90 0 0.5440 6.382 67.2 3.5325 4 304 18.4 395.21  
## 320 0.47547 0.0 9.90 0 0.5440 6.113 58.8 4.0019 4 304 18.4 396.23  
## 321 0.16760 0.0 7.38 0 0.4930 6.426 52.3 4.5404 5 287 19.6 396.90  
## 322 0.18159 0.0 7.38 0 0.4930 6.376 54.3 4.5404 5 287 19.6 396.90  
## 323 0.35114 0.0 7.38 0 0.4930 6.041 49.9 4.7211 5 287 19.6 396.90  
## 324 0.28392 0.0 7.38 0 0.4930 5.708 74.3 4.7211 5 287 19.6 391.13  
## 325 0.34109 0.0 7.38 0 0.4930 6.415 40.1 4.7211 5 287 19.6 396.90  
## 326 0.19186 0.0 7.38 0 0.4930 6.431 14.7 5.4159 5 287 19.6 393.68  
## 327 0.30347 0.0 7.38 0 0.4930 6.312 28.9 5.4159 5 287 19.6 396.90  
## 328 0.24103 0.0 7.38 0 0.4930 6.083 43.7 5.4159 5 287 19.6 396.90  
## 329 0.06617 0.0 3.24 0 0.4600 5.868 25.8 5.2146 4 430 16.9 382.44  
## 330 0.06724 0.0 3.24 0 0.4600 6.333 17.2 5.2146 4 430 16.9 375.21  
## 331 0.04544 0.0 3.24 0 0.4600 6.144 32.2 5.8736 4 430 16.9 368.57  
## 332 0.05023 35.0 6.06 0 0.4379 5.706 28.4 6.6407 1 304 16.9 394.02  
## 333 0.03466 35.0 6.06 0 0.4379 6.031 23.3 6.6407 1 304 16.9 362.25  
## 334 0.05083 0.0 5.19 0 0.5150 6.316 38.1 6.4584 5 224 20.2 389.71  
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## 336 0.03961 0.0 5.19 0 0.5150 6.037 34.5 5.9853 5 224 20.2 396.90  
## 337 0.03427 0.0 5.19 0 0.5150 5.869 46.3 5.2311 5 224 20.2 396.90  
## 338 0.03041 0.0 5.19 0 0.5150 5.895 59.6 5.6150 5 224 20.2 394.81  
## 339 0.03306 0.0 5.19 0 0.5150 6.059 37.3 4.8122 5 224 20.2 396.14  
## 340 0.05497 0.0 5.19 0 0.5150 5.985 45.4 4.8122 5 224 20.2 396.90  
## 341 0.06151 0.0 5.19 0 0.5150 5.968 58.5 4.8122 5 224 20.2 396.90  
## 342 0.01301 35.0 1.52 0 0.4420 7.241 49.3 7.0379 1 284 15.5 394.74  
## 343 0.02498 0.0 1.89 0 0.5180 6.540 59.7 6.2669 1 422 15.9 389.96  
## 344 0.02543 55.0 3.78 0 0.4840 6.696 56.4 5.7321 5 370 17.6 396.90  
## 345 0.03049 55.0 3.78 0 0.4840 6.874 28.1 6.4654 5 370 17.6 387.97  
## 346 0.03113 0.0 4.39 0 0.4420 6.014 48.5 8.0136 3 352 18.8 385.64  
## 347 0.06162 0.0 4.39 0 0.4420 5.898 52.3 8.0136 3 352 18.8 364.61  
## 348 0.01870 85.0 4.15 0 0.4290 6.516 27.7 8.5353 4 351 17.9 392.43  
## 349 0.01501 80.0 2.01 0 0.4350 6.635 29.7 8.3440 4 280 17.0 390.94  
## 350 0.02899 40.0 1.25 0 0.4290 6.939 34.5 8.7921 1 335 19.7 389.85  
## 351 0.06211 40.0 1.25 0 0.4290 6.490 44.4 8.7921 1 335 19.7 396.90  
## 352 0.07950 60.0 1.69 0 0.4110 6.579 35.9 10.7103 4 411 18.3 370.78  
## 353 0.07244 60.0 1.69 0 0.4110 5.884 18.5 10.7103 4 411 18.3 392.33  
## 354 0.01709 90.0 2.02 0 0.4100 6.728 36.1 12.1265 5 187 17.0 384.46  
## 355 0.04301 80.0 1.91 0 0.4130 5.663 21.9 10.5857 4 334 22.0 382.80  
## 356 0.10659 80.0 1.91 0 0.4130 5.936 19.5 10.5857 4 334 22.0 376.04  
## 357 8.98296 0.0 18.10 1 0.7700 6.212 97.4 2.1222 24 666 20.2 377.73  
## 358 3.84970 0.0 18.10 1 0.7700 6.395 91.0 2.5052 24 666 20.2 391.34  
## 359 5.20177 0.0 18.10 1 0.7700 6.127 83.4 2.7227 24 666 20.2 395.43  
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## 361 4.54192 0.0 18.10 0 0.7700 6.398 88.0 2.5182 24 666 20.2 374.56  
## 362 3.83684 0.0 18.10 0 0.7700 6.251 91.1 2.2955 24 666 20.2 350.65  
## 363 3.67822 0.0 18.10 0 0.7700 5.362 96.2 2.1036 24 666 20.2 380.79  
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## 369 4.89822 0.0 18.10 0 0.6310 4.970 100.0 1.3325 24 666 20.2 375.52  
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## 378 9.82349 0.0 18.10 0 0.6710 6.794 98.8 1.3580 24 666 20.2 396.90  
## 379 23.64820 0.0 18.10 0 0.6710 6.380 96.2 1.3861 24 666 20.2 396.90  
## 380 17.86670 0.0 18.10 0 0.6710 6.223 100.0 1.3861 24 666 20.2 393.74  
## 381 88.97620 0.0 18.10 0 0.6710 6.968 91.9 1.4165 24 666 20.2 396.90  
## 382 15.87440 0.0 18.10 0 0.6710 6.545 99.1 1.5192 24 666 20.2 396.90  
## 383 9.18702 0.0 18.10 0 0.7000 5.536 100.0 1.5804 24 666 20.2 396.90  
## 384 7.99248 0.0 18.10 0 0.7000 5.520 100.0 1.5331 24 666 20.2 396.90  
## 385 20.08490 0.0 18.10 0 0.7000 4.368 91.2 1.4395 24 666 20.2 285.83  
## 386 16.81180 0.0 18.10 0 0.7000 5.277 98.1 1.4261 24 666 20.2 396.90  
## 387 24.39380 0.0 18.10 0 0.7000 4.652 100.0 1.4672 24 666 20.2 396.90  
## 388 22.59710 0.0 18.10 0 0.7000 5.000 89.5 1.5184 24 666 20.2 396.90  
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## 390 8.15174 0.0 18.10 0 0.7000 5.390 98.9 1.7281 24 666 20.2 396.90  
## 391 6.96215 0.0 18.10 0 0.7000 5.713 97.0 1.9265 24 666 20.2 394.43  
## 392 5.29305 0.0 18.10 0 0.7000 6.051 82.5 2.1678 24 666 20.2 378.38  
## 393 11.57790 0.0 18.10 0 0.7000 5.036 97.0 1.7700 24 666 20.2 396.90  
## 394 8.64476 0.0 18.10 0 0.6930 6.193 92.6 1.7912 24 666 20.2 396.90  
## 395 13.35980 0.0 18.10 0 0.6930 5.887 94.7 1.7821 24 666 20.2 396.90  
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## 398 7.67202 0.0 18.10 0 0.6930 5.747 98.9 1.6334 24 666 20.2 393.10  
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## 400 9.91655 0.0 18.10 0 0.6930 5.852 77.8 1.5004 24 666 20.2 338.16  
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## 402 14.23620 0.0 18.10 0 0.6930 6.343 100.0 1.5741 24 666 20.2 396.90  
## 403 9.59571 0.0 18.10 0 0.6930 6.404 100.0 1.6390 24 666 20.2 376.11  
## 404 24.80170 0.0 18.10 0 0.6930 5.349 96.0 1.7028 24 666 20.2 396.90  
## 405 41.52920 0.0 18.10 0 0.6930 5.531 85.4 1.6074 24 666 20.2 329.46  
## 406 67.92080 0.0 18.10 0 0.6930 5.683 100.0 1.4254 24 666 20.2 384.97  
## 407 20.71620 0.0 18.10 0 0.6590 4.138 100.0 1.1781 24 666 20.2 370.22  
## 408 11.95110 0.0 18.10 0 0.6590 5.608 100.0 1.2852 24 666 20.2 332.09  
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## 411 51.13580 0.0 18.10 0 0.5970 5.757 100.0 1.4130 24 666 20.2 2.60  
## 412 14.05070 0.0 18.10 0 0.5970 6.657 100.0 1.5275 24 666 20.2 35.05  
## 413 18.81100 0.0 18.10 0 0.5970 4.628 100.0 1.5539 24 666 20.2 28.79  
## 414 28.65580 0.0 18.10 0 0.5970 5.155 100.0 1.5894 24 666 20.2 210.97  
## 415 45.74610 0.0 18.10 0 0.6930 4.519 100.0 1.6582 24 666 20.2 88.27  
## 416 18.08460 0.0 18.10 0 0.6790 6.434 100.0 1.8347 24 666 20.2 27.25  
## 417 10.83420 0.0 18.10 0 0.6790 6.782 90.8 1.8195 24 666 20.2 21.57  
## 418 25.94060 0.0 18.10 0 0.6790 5.304 89.1 1.6475 24 666 20.2 127.36  
## 419 73.53410 0.0 18.10 0 0.6790 5.957 100.0 1.8026 24 666 20.2 16.45  
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## 421 11.08740 0.0 18.10 0 0.7180 6.411 100.0 1.8589 24 666 20.2 318.75  
## 422 7.02259 0.0 18.10 0 0.7180 6.006 95.3 1.8746 24 666 20.2 319.98  
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## 425 8.79212 0.0 18.10 0 0.5840 5.565 70.6 2.0635 24 666 20.2 3.65  
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## 484 2.81838 0.0 18.10 0 0.5320 5.762 40.3 4.0983 24 666 20.2 392.92  
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## 489 0.15086 0.0 27.74 0 0.6090 5.454 92.7 1.8209 4 711 20.1 395.09  
## 490 0.18337 0.0 27.74 0 0.6090 5.414 98.3 1.7554 4 711 20.1 344.05  
## 491 0.20746 0.0 27.74 0 0.6090 5.093 98.0 1.8226 4 711 20.1 318.43  
## 492 0.10574 0.0 27.74 0 0.6090 5.983 98.8 1.8681 4 711 20.1 390.11  
## 493 0.11132 0.0 27.74 0 0.6090 5.983 83.5 2.1099 4 711 20.1 396.90  
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## 498 0.26838 0.0 9.69 0 0.5850 5.794 70.6 2.8927 6 391 19.2 396.90  
## 499 0.23912 0.0 9.69 0 0.5850 6.019 65.3 2.4091 6 391 19.2 396.90  
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## 502 0.06263 0.0 11.93 0 0.5730 6.593 69.1 2.4786 1 273 21.0 391.99  
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## 22 13.83 19.6 0  
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## 359 11.48 22.7 1  
## 360 12.67 22.6 1  
## 361 7.79 25.0 1  
## 362 14.19 19.9 1  
## 363 10.19 20.8 1  
## 364 14.64 16.8 1  
## 365 5.29 21.9 1  
## 366 7.12 27.5 1  
## 367 14.00 21.9 1  
## 368 13.33 23.1 1  
## 369 3.26 50.0 1  
## 370 3.73 50.0 1  
## 371 2.96 50.0 1  
## 372 9.53 50.0 1  
## 373 8.88 50.0 1  
## 374 34.77 13.8 1  
## 375 37.97 13.8 1  
## 376 13.44 15.0 1  
## 377 23.24 13.9 1  
## 378 21.24 13.3 1  
## 379 23.69 13.1 1  
## 380 21.78 10.2 1  
## 381 17.21 10.4 1  
## 382 21.08 10.9 1  
## 383 23.60 11.3 1  
## 384 24.56 12.3 1  
## 385 30.63 8.8 1  
## 386 30.81 7.2 1  
## 387 28.28 10.5 1  
## 388 31.99 7.4 1  
## 389 30.62 10.2 1  
## 390 20.85 11.5 1  
## 391 17.11 15.1 1  
## 392 18.76 23.2 1  
## 393 25.68 9.7 1  
## 394 15.17 13.8 1  
## 395 16.35 12.7 1  
## 396 17.12 13.1 1  
## 397 19.37 12.5 1  
## 398 19.92 8.5 1  
## 399 30.59 5.0 1  
## 400 29.97 6.3 1  
## 401 26.77 5.6 1  
## 402 20.32 7.2 1  
## 403 20.31 12.1 1  
## 404 19.77 8.3 1  
## 405 27.38 8.5 1  
## 406 22.98 5.0 1  
## 407 23.34 11.9 1  
## 408 12.13 27.9 1  
## 409 26.40 17.2 1  
## 410 19.78 27.5 1  
## 411 10.11 15.0 1  
## 412 21.22 17.2 1  
## 413 34.37 17.9 1  
## 414 20.08 16.3 1  
## 415 36.98 7.0 1  
## 416 29.05 7.2 1  
## 417 25.79 7.5 1  
## 418 26.64 10.4 1  
## 419 20.62 8.8 1  
## 420 22.74 8.4 1  
## 421 15.02 16.7 1  
## 422 15.70 14.2 1  
## 423 14.10 20.8 1  
## 424 23.29 13.4 1  
## 425 17.16 11.7 1  
## 426 24.39 8.3 1  
## 427 15.69 10.2 1  
## 428 14.52 10.9 1  
## 429 21.52 11.0 1  
## 430 24.08 9.5 1  
## 431 17.64 14.5 1  
## 432 19.69 14.1 1  
## 433 12.03 16.1 1  
## 434 16.22 14.3 1  
## 435 15.17 11.7 1  
## 436 23.27 13.4 1  
## 437 18.05 9.6 1  
## 438 26.45 8.7 1  
## 439 34.02 8.4 1  
## 440 22.88 12.8 1  
## 441 22.11 10.5 1  
## 442 19.52 17.1 1  
## 443 16.59 18.4 1  
## 444 18.85 15.4 1  
## 445 23.79 10.8 1  
## 446 23.98 11.8 1  
## 447 17.79 14.9 1  
## 448 16.44 12.6 1  
## 449 18.13 14.1 1  
## 450 19.31 13.0 1  
## 451 17.44 13.4 1  
## 452 17.73 15.2 1  
## 453 17.27 16.1 1  
## 454 16.74 17.8 1  
## 455 18.71 14.9 1  
## 456 18.13 14.1 1  
## 457 19.01 12.7 1  
## 458 16.94 13.5 1  
## 459 16.23 14.9 1  
## 460 14.70 20.0 1  
## 461 16.42 16.4 1  
## 462 14.65 17.7 1  
## 463 13.99 19.5 1  
## 464 10.29 20.2 1  
## 465 13.22 21.4 1  
## 466 14.13 19.9 1  
## 467 17.15 19.0 1  
## 468 21.32 19.1 1  
## 469 18.13 19.1 1  
## 470 14.76 20.1 1  
## 471 16.29 19.9 1  
## 472 12.87 19.6 1  
## 473 14.36 23.2 1  
## 474 11.66 29.8 1  
## 475 18.14 13.8 1  
## 476 24.10 13.3 1  
## 477 18.68 16.7 1  
## 478 24.91 12.0 1  
## 479 18.03 14.6 1  
## 480 13.11 21.4 1  
## 481 10.74 23.0 1  
## 482 7.74 23.7 1  
## 483 7.01 25.0 1  
## 484 10.42 21.8 1  
## 485 13.34 20.6 1  
## 486 10.58 21.2 1  
## 487 14.98 19.1 1  
## 488 11.45 20.6 1  
## 489 18.06 15.2 0  
## 490 23.97 7.0 0  
## 491 29.68 8.1 0  
## 492 18.07 13.6 0  
## 493 13.35 20.1 0  
## 494 12.01 21.8 0  
## 495 13.59 24.5 0  
## 496 17.60 23.1 0  
## 497 21.14 19.7 0  
## 498 14.10 18.3 0  
## 499 12.92 21.2 0  
## 500 15.10 17.5 0  
## 501 14.33 16.8 0  
## 502 9.67 22.4 0  
## 503 9.08 20.6 0  
## 504 5.64 23.9 0  
## 505 6.48 22.0 0  
## 506 7.88 11.9 0

attach(Boston)

is.factor(crimHigh)

## [1] FALSE

##tell R to treat this variable as categorical  
crimHigh<-factor(crimHigh)  
  
is.factor(crimHigh)

## [1] TRUE

levels(crimHigh)<-c("low","high")  
levels(crimHigh)

## [1] "low" "high"

contrasts(crimHigh)

## high  
## low 0  
## high 1

**Answer Q1a**:

The reference class is low == 0

### Question 1 (b) Randomly split the data into a testing and training set of equal sizes.

For consistency of results among all groups, use set.seed(199). Next, using the training set, fit a logistic regression model, with your newly created variable as the binary response variable, and with the following predictors: indus, nox, rad, tax, lstat, and medv. Then validate your model on the test data by creating an ROC curve.

What does your ROC curve tell you?

**Work on Q1b**

First, split the dataset into training and test:

detach(Boston) #detach Boston so variable names aren't a mess  
  
set.seed(199) #set seed  
  
sample<-sample.int(nrow(Boston), floor(.50\*nrow(Boston)), replace = F) # get random sample to rows  
train<-Boston[sample, ]  
test<-Boston[-sample, ]

Second, fit the model on training data with specified predictors:

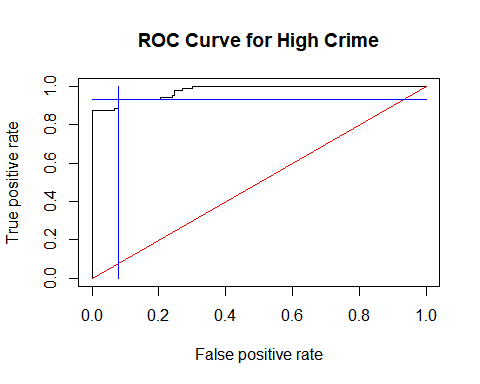
result<-glm(crimHigh ~ indus + nox + rad + tax + lstat + medv, family = "binomial", data=train)

Third, create ROC curve using validation, i.e. test, data.

##predicted prob of high crime vs. low crime rate for testing data based on training data  
preds<-predict(result,newdata=test, type="response") # need to use type=response for probabilities.  
  
##produce the numbers associated with classification table  
rates<-prediction(preds, test$crimHigh) #did it correctly identify CHD diagnosis?  
  
##store the true positive and false postive rates  
roc\_result<-performance(rates,measure="tpr", x.measure="fpr")

Now, plot the resulting ROC:

##plot ROC curve and overlay the diagonal line for random guessing  
plot(roc\_result, main="ROC Curve for High Crime")  
lines(x = c(0,1), y = c(0,1), col="red")  
lines(x = c(0.08,0.08), y = c(0,1), col="blue")  
lines(x = c(0,1), y = c(0.93,0.93), col="blue")

 **Answer Q1b**:

I really am impressed with the predictive power of the model to predict high crime based on indus, nox, rad, tax, lstat, and medv.

This ROC curve shows there is some unknown threshold that predicts with a true positive rate around 93% with a corresponding false positive rate of only ~8%.

### Question 1(c) Find the AUC associated with your ROC curve.

What does your AUC tell you?

**Work on Q1c**

Calculate the AUC…

##compute the AUC  
aucvalues <- performance(rates, measure = "auc")  
auc <- aucvalues@y.values[[1]]  
auc

## [1] 0.9781367

**Answer Q1c**: The AUC = 0.978 means our model can perform with that accuracy when making a classification.

### Quest 1(d) Create a confusion matrix using a cutoff of 0.5.

What is the false positive rate?

What is the false negative rate?

Note: Be very careful with the coding associated with your response variable.

You may want to use the levels() function to check how R was coding your response variable.

**Work on Q1d**

Create the confusion matrix:

table(test$crimHigh, preds>0.5)

##   
## FALSE TRUE  
## 0 164 3  
## 1 11 75

0 == low crime

1 == high crime

trueNeg <- 164  
falseNeg <- 11  
truePos <- 75  
falsePos <- 3  
  
# here are all my calculations  
overallErrorRate <- (falseNeg + falsePos) / (falseNeg + falsePos + trueNeg + truePos)  
print(paste("Overall Error Rate: ",overallErrorRate))

## [1] "Overall Error Rate: 0.0553359683794466"

falsePosRate <- falsePos / (trueNeg + falsePos)  
print(paste("False Positive Rate: ",falsePosRate))

## [1] "False Positive Rate: 0.0179640718562874"

falseNegRate <- falseNeg / (falseNeg + truePos)  
print(paste("False Negative Rate: ",falseNegRate))

## [1] "False Negative Rate: 0.127906976744186"

#sensitivity <- 1 - falseNegRate  
#sensitivity  
  
#specifiity <- 1 - falsePosRate  
#specifiity

**Answer Q1d**

False Positive Rate: 0.018

False Negative Rate: 0.128

### Question 1(e) Bearing in mind …

the governor is most interested in identifying towns with high crime rates, how would you adjust the cutoff value from 0.5? Briefly explain why.

**Answer Q1e**

I am interpreting “most interested” as wanting to make sure as many high crime areas are identified as feasible with the model.

We could set the threshold lower than 0.5 to identify more high crime towns, i.e. fewer false negatives. We would however also be increasing the false positive rate.

## 2. (No R required) …

A study was undertaken to determine the association between several predictors and the duration of pregnancies.

The response variable, pregnancy duration, was recorded as a three-class variable: \* pre-term for pregnancies lasting less than 36 weeks, \* intermediate term for pregnancies lasting between 36 and 37 weeks, \* and full term for pregnancies lasting more than 37 weeks.

The predictors are: \* nutrition: index of nutritional status, higher scores denote better nutritional status \* less20 : 1 =less than 20 years old, 0 otherwise \* greater30 : 1 =greater than 30 years old, 0 otherwise \* alcohol: 1 =drank alcohol during pregnancy, 0 otherwise \* smoking: 1 =smoked during pregnancy, 0 otherwise

A first-order multinomial logistic regression is carried out for this study, and the R output is shown below.

Call:

multinom(formula = preg ~ nutrition + less20 + greater30 + alcohol + smoking)

…

### Quest 2(a) Write down the estimated multinomial logistic regression models associated with this analysis.

**Answer Q2a**

Reference class is **full term pregnancies**. There are 2 logits that are each compared against probability of full term pregnancy.

probability of preterm vs full term = exp(5.48 - (0.065 \* nutrition) + (2.96 \* less20) + (2.06 \* greater30) + (2.04 \* alcohol) + (2.45 \* smoking))

probability of intermediate vs full term = exp(3.96 - (0.046 \* nutrition) + (2.91 \* less20) + (1.89 \* greater30) + (1.07 \* alcohol) +(2.23 \* smoking))

### Question 2 (b) Calculate the Wald test statistics associated with the predictor alcohol, …

and find the corresponding p-value.

What are the conclusions in context at significance level α = 0.05? You do not need to apply the Bonferroni method here.

**Work on Q2b**

Calculate z and p values for the coefficients:

#preTermNutritionZ <- -0.065 / 0.018  
#preTermNutritionP <- (1 - pnorm(abs(preTermNutritionZ)))\*2  
#print(paste("Preterm Nutrition Z Score: ", preTermNutritionZ))  
#print(paste("Preterm Nutrition P Value: ", preTermNutritionP))  
  
#preTermLess20Z <- 2.96 / .096  
#preTermLess20P <- (1 - pnorm(abs(preTermLess20Z)))\*2  
#print(paste("Preterm Less 20 Z Score: ", preTermLess20Z))  
#print(paste("Preterm Less 20 P Value: ", preTermLess20P))  
  
#preTermGreater30Z <- 2.06 / 0.89  
#preTermGreater30P <- (1 - pnorm(abs(preTermGreater30Z)))\*2  
#print(paste("Preterm Greater 30 Z Score: ", preTermGreater30Z))  
#print(paste("Preterm Greater 30 P Value: ", preTermGreater30P))  
  
preTermAlcoholZ <- 2.04 / 0.71  
preTermAlcoholP <- (1 - pnorm(abs(preTermAlcoholZ)))\*2  
print(paste("Preterm Alcohol Z Score: ", preTermAlcoholZ))

## [1] "Preterm Alcohol Z Score: 2.87323943661972"

print(paste("Preterm Alcohol P Value: ", preTermAlcoholP))

## [1] "Preterm Alcohol P Value: 0.00406286067275619"

#preTermSmokingZ <- 2.45 / 0.73  
#preTermSmokingP <- (1 - pnorm(abs(preTermSmokingZ)))\*2  
#print(paste("Preterm Smoking Z Score: ", preTermSmokingZ))  
#print(paste("Preterm Smoking P Value: ", preTermSmokingP))  
  
#intNutritionZ <- -0.046 / 0.015  
#intNutritionP <- (1 - pnorm(abs(intNutritionZ)))\*2  
#print(paste("Intermediate Nutrition Z Score: ", intNutritionZ))  
#print(paste("Intermediate Nutrition P Value: ", intNutritionP))  
  
#intLess20Z <- 2.91 / 0.86  
#intLess20P <- (1 - pnorm(abs(intLess20Z)))\*2  
#print(paste("Intermediate Less 20 Z Score: ", intLess20Z))  
#print(paste("Intermediate Less 20 P Value: ", intLess20P))  
  
#intGreater30Z <- 1.89 / 0.81  
#intGreater30P <- (1 - pnorm(abs(intGreater30Z)))\*2  
#print(paste("Intermediate Greater 30 Z Score: ", intGreater30Z))  
#print(paste("Intermediate Greater 30 P Value: ", intGreater30P))  
  
intAlcoholZ <- 1.07 / 0.65  
intAlcoholP <- (1 - pnorm(abs(intAlcoholZ)))\*2  
print(paste("Intermediate Alcohol Z Score: ", intAlcoholZ))

## [1] "Intermediate Alcohol Z Score: 1.64615384615385"

print(paste("Intermediate Alcohol P Value: ", intAlcoholP))

## [1] "Intermediate Alcohol P Value: 0.09973208878439"

#intSmokingZ <- 2.23 / 0.67  
#intSmokingP <- (1 - pnorm(abs(intSmokingZ)))\*2  
#print(paste("Intermediate Smoking Z Score: ", intSmokingZ))  
#print(paste("Intermediate Smoking P Value: ", intSmokingP))

**Answer Q2b**: Alcohol is significant when predicting preterm vs full term, but not when predicting intermediate term vs full term in this model.

For preterm vs fullterm, because the p-value is < 0.05, we reject H0, and say alcohol is significant in this model.

For intermediate vs. fullterm, because the p-value is < 0.05, we fail to reject H0, and say alcohol is not significant in this model.

### Question 2(c) Calculate the 95% confidence intervals associated with the predictor alcohol, …

and interpret these intervals in context, in terms of relative risk of having a pregnancy that is pre-term, intermediate, or full term. You do not need to apply the Bonferroni method here.

**Work on 2c**

**Answer 2C**

preBhat <- 2.0429  
preBse <- 0.7097461  
  
preciLow <- preBhat - (1.96 \* preBse)  
preciHigh <- preBhat + (1.96 \* preBse)  
  
print(paste("preterm vs full term alcohol CI: ",preciLow, " - ",preciHigh))

## [1] "preterm vs full term alcohol CI: 0.651797644 - 3.434002356"

print(paste("EXP preterm vs full term alcohol CI: ",exp(preciLow), " - ",exp(preciHigh)))

## [1] "EXP preterm vs full term alcohol CI: 1.9189873864054 - 31.0004697005188"

intBhat <- 1.067001  
intBse <- 0.6495262  
   
intciLow <- intBhat - (1.96 \* intBse)  
intciHigh <- intBhat + (1.96 \* intBse)  
  
print(paste("intermediate vs full term alcohol CI: ",intciLow, " - ",intciHigh))

## [1] "intermediate vs full term alcohol CI: -0.206070352 - 2.340072352"

print(paste("EXP intermediate vs full term alcohol CI: ",exp(intciLow), " - ",exp(intciHigh)))

## [1] "EXP intermediate vs full term alcohol CI: 0.813775823512285 - 10.3819876931322"

**Answer Q2c** 95% CI for preterm vs full term coefficient within our model is: preterm 0.652 - 3.43. We are 95% confident the relative risk of preterm vs full term pregnancies when alcohol is consumed, and all other variables are held constant ,is between 1.92 and 31.

The 95% CI for the alcohol coefficient is between -0.21 and 2.34; since 0 is within the 95% CI, this CI agrees with our Wald’s test that when predicting intermediate pregnancy length vs full length pregnancies alcohol is not a significant predictor within our model.