log_reg.R

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```r
#### Logistic Regression #####
#install.packages("cowplot",
lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(cowplot)
```

```
##
## **********************************************************

## Note: As of version 1.0.0, cowplot does not change the

##   default ggplot2 theme anymore. To recover the previous

##   behavior, execute:
##   theme_set(theme_cowplot())

## **********************************************************
```

```r
library(dplyr)
```

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

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

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

```r
library(ggplot2)
data <- read.csv("C:/Users/saiprasad/Desktop/Fall 2019/Multi
analysis/MVA/Project/Dataset/HCV-EGY-Data.csv")
attach(data)
Survivorship = data$Survivorship <- if_else( RNA.EOT>= 400000 , 'NC','C')
cbind(data.frame(Survivorship),data)
```

```
##      Survivorship Age Gender BMI Fever Nausea.Vomting Headache Diarrhea
## 1               C  56      1  35     2              1        1        1
## 2               C  46      1  29     1              2        2        1
## 3              NC  57      1  33     2              2        2        2
## 4              NC  49      2  33     1              2        1        2
## 5               C  59      1  32     1              1        2        1
## 6               C  58      2  22     2              2        2        1
```

```
## 7          C  42  2  26  1    1    2    2
## 8          C  48  2  30  1    1    2    2
## 9          C  44  1  23  1    1    2    2
## 10         C  45  1  30  2    1    2    2
## 11        NC  37  2  24  2    1    2    1
## 12         C  36  1  22  2    2    1    1
## 13         C  45  2  25  2    1    1    1
## 14         C  34  1  22  1    2    1    1
## 15        NC  40  2  32  2    2    2    1
## 16        NC  58  1  34  2    1    1    1
## 17         C  61  1  35  1    2    2    2
## 18         C  55  2  24  2    1    2    2
## 19        NC  56  1  27  1    2    2    2
## 20        NC  35  2  23  2    2    1    1
## 21        NC  57  2  23  1    1    2    2
## 22         C  33  1  25  2    1    2    2
## 23         C  41  1  23  1    2    2    2
## 24         C  39  2  29  1    2    1    2
## 25         C  33  2  24  1    2    2    2
## 26         C  43  2  34  2    2    2    1
## 27        NC  51  1  34  2    1    2    2
## 28        NC  39  2  33  2    1    2    1
## 29         C  57  2  26  1    2    2    1
## 30         C  47  2  29  1    1    2    1
## 31         C  55  2  33  1    2    2    1
## 32         C  58  2  35  2    2    2    2
## 33        NC  47  2  25  2    1    2    2
## 34         C  61  1  33  1    2    2    2
## 35        NC  37  1  27  2    2    1    2
## 36        NC  41  1  29  1    2    1    1
## 37         C  60  2  32  2    2    1    2
## 38         C  54  1  29  1    1    1    2
## 39         C  40  2  28  2    1    2    1
## 40         C  32  1  31  1    2    1    1
## 41        NC  58  2  33  1    2    2    2
## 42         C  37  2  23  2    2    1    1
## 43         C  58  1  23  1    1    1    2
## 44        NC  36  1  23  2    2    1    2
## 45         C  47  2  35  1    2    2    1
## 46         C  50  1  33  2    2    1    1
## 47         C  44  1  31  1    1    1    1
## 48        NC  43  1  33  1    1    2    2
## 49        NC  54  1  33  2    1    1    2
## 50        NC  59  2  26  2    1    1    1
## 51         C  33  2  31  1    1    1    2
## 52         C  56  2  23  1    1    1    2
## 53        NC  41  1  33  2    1    1    1
## 54        NC  59  1  32  2    1    1    1
## 55         C  47  1  27  2    2    1    1
## 56         C  50  2  34  1    1    1    2
```

```
##    Fatigue...generalized.bone.ache Jaundice Epigastric.pain   WBC
## 1                                2        2               2  7425
## 2                                2        2               1 12101
## 3                                1        1               1  4178
## 4                                1        2               1  6490
## 5                                2        2               2  3661
## 6                                2        2               1 11785
## 7                                2        2               2 11620
## 8                                1        1               2  7335
## 9                                2        1               2 10480
## 10                               1        1               2  6681
## 11                               2        2               1  4437
## 12                               1        1               1  6052
## 13                               2        1               2  9279
## 14                               2        2               1  5638
## 15                               2        1               1 11507
## 16                               2        1               1  8035
## 17                               1        1               2 10843
## 18                               2        2               2  8476
## 19                               2        2               2  6599
## 20                               1        1               2  4845
## 21                               1        1               1  5925
## 22                               2        2               2  9952
## 23                               2        1               2  7961
## 24                               1        1               2  7136
## 25                               2        1               2  6057
## 26                               1        1               1  6648
## 27                               1        1               2 11032
## 28                               1        1               2  5234
## 29                               1        1               2  6038
## 30                               2        1               2  5846
## 31                               2        1               2  5383
## 32                               1        1               1  7378
## 33                               2        1               2  7486
## 34                               1        1               1 11770
## 35                               2        2               2  6441
## 36                               2        1               2 10304
## 37                               2        2               1  7365
## 38                               2        1               1 10704
## 39                               1        1               1  3009
## 40                               1        1               2  9956
## 41                               1        2               2  6627
## 42                               2        2               1 10393
## 43                               1        1               2 10236
## 44                               2        2               2  4387
## 45                               2        2               2 11924
## 46                               2        1               2 10140
## 47                               2        1               2  3470
## 48                               2        1               2  5420
```

```
## 49                                   1        2               1  6963
## 50                                   1        1               2  6249
## 51                                   1        2               1  5094
## 52                                   2        2               2  4797
## 53                                   2        2               2  5041
## 54                                   1        2               2  6901
## 55                                   1        1               1  7256
## 56                                   2        1               1  8219
## 57                                   1        1               1  4418
## 58                                   1        1               2  6358
## 59                                   2        1               2  8669
## 60                                   1        1               2  9435
## 61                                   2        2               2 11144
## 62                                   1        2               2  5060
## 63                                   1        1               1  7766
## 64                                   2        1               2 10879
## 65                                   1        2               2 11490
## 66                                   1        1               1  4082
## 67                                   2        2               1  5078
## 68                                   1        2               2  4580
## 69                                   2        1               2  7983
## 70                                   2        2               2  5500
```

##	RBC	HGB	Plat	AST.1	ALT.1	ALT4	ALT.12	ALT.24	ALT.36	ALT.48
1	4248807	14	112132	99	84	52	109	81	5	5
2	4429425	10	129367	91	123	95	75	113	57	123
3	4621191	12	151522	113	49	95	107	116	5	5
4	4794631	10	146457	43	64	109	80	88	48	77
5	4606375	11	187684	99	104	67	48	120	94	90
6	3882456	15	131228	66	104	121	96	65	73	114
7	4747333	12	177261	78	57	113	118	107	84	80
8	4405941	11	216176	119	112	80	127	45	96	53
9	4608464	12	148889	93	83	55	102	97	122	39
10	4455329	12	98200	55	68	72	127	81	125	43
11	4265042	12	166027	103	124	111	74	53	123	101
12	4130219	13	144266	75	49	93	52	46	46	59
13	4116937	13	203003	97	101	66	53	95	55	104
14	4321603	14	141110	120	61	64	51	78	90	113
15	4165603	14	222874	127	122	106	105	88	111	111
16	4896464	11	149506	117	53	50	80	120	66	86
17	4165219	10	197640	86	105	70	86	83	87	47
18	4466885	14	163276	53	101	50	95	112	97	68
19	4448466	15	190642	53	124	62	76	57	46	93
20	4436025	10	111819	115	121	63	127	95	124	93
21	4031637	15	116558	86	109	118	119	55	103	84
22	4994729	10	109023	84	77	67	81	117	68	42
23	4595487	14	94733	45	92	103	104	40	115	93
24	4625248	10	211363	70	102	76	58	111	95	58
25	4300774	11	222135	62	91	116	128	41	70	106
26	4529290	15	109871	48	112	99	85	59	87	78
27	4052583	15	94503	41	54	128	64	71	89	87

```
## 28    4906158 12 190314     61    120 113       75     88      114     99
## 29    4763261 13 126721     51    118  98       42     93       53     83
## 30    4753531 15 104729    120     72 117      126     45       95     49
## 31    3999388 15 182262     96     49  59       88     62       58     81
## 32    3998925 10 201114     57    110 128       96     69      105     72
## 33    4599496 11 167354     94     64  54      122     64       64     96
## 34    4581099 13 125642     42     47  82      102     48       76     53

##       ALT.after.24.w RNA.Base    RNA.4   RNA.12 RNA.EOT RNA.EF
## 1                  5   655330   634536   288194       5      5
## 2                 44    40620   538635   637056  336804  31085
## 3                  5   571148   661346        5  735945 558829
## 4                 33  1041941   449939   585688  744463 582301
## 5                 30   660410   738756  3731527  338946 242861
## 6                 29  1157452  1086852        5       5      5
## 7                 28   325694  1034008   275095  214566 635157
## 8                 39   641129    72050   787295  370605 506296
## 9                 45   591441   757361        5  371090 203042
## 10                30  1151206   230488   267320  275295 555516
## 11                33  1023123   103190   731929  448466  59998
## 12                45   137712  1122999   561438   63145 806204
## 13                26   936444   536969        5       5      5
## 14                23   392976   884322   586834  182775 782154
## 15                36  1133727  1111871   421304  437544 124609
## 16                34   614951   314296    83690  671490 135145
## 17                33   900099   721460        5       5      5
## 18                27  1145310   230993   457882  318363 256415
## 19                26   506756   359181   743399  405175 162983
## 20                42  1080499    76404   717159  404314 477719
## 21                32   169624   786017   669076  531187 282524
## 22                32  1135200   572747        5       5      5
## 23                33   293380   440576    53098   18292 187341
## 24                25   993940   992652    96482  334897 762760
## 25                43   243433   981370    12504  360015 753383
## 26                35   955296   540654        5       5      5
## 27                34   766355   531269   737603  734863 372837
## 28                43   486467    45990    45578  733292  19572
## 29                45   285374   186657        5       5      5
## 30                38   426136   247777   767015  377123 315150
## 31                41  1194301   928679    29778  124250 244049
## 32                26   557708   287714   623587   66891  35044
## 33                24   604063   416313   323352  716655 678548
## 34                34  1159877   318505   463260  381345 282914
## 35                45   272600    91626   404523  674101 242552
## 36                40  1165166    51508   367178  588014 746328
## 37                35   112401   489112   461641  336006 287261
## 38                43    47190   581000   789780  262941 118971
## 39                31   961292    71146    28241   31034   1417
## 40                39   855099   102520   407306  220006 405497
## 41                33  1047535   320353   349454  546832 643942
```

```
## 42                       33   271349   206329   151217   307729 174523
## 43                       39   272507  1061189   230947   201997 293804
## 44                       43   594248  1156859   436512   728279 685286
## 45                       26   651671   422729   412086    91529 376394
## 46                       35    57911   867787   758773   319688 159764
## 47                       32   751073   825583   355919   100948 634168
## 48                       28   740502  1197447   180453   524563 291808

##      Baseline.histological.Grading Baselinehistological.staging
## 1                               13                            2
## 2                                4                            2
## 3                                4                            4
## 4                               10                            3
## 5                               11                            1
## 6                                4                            4
## 7                               12                            4
## 8                               12                            3
## 9                                5                            2
## 10                               4                            2
## 11                              15                            2
## 12                              16                            1
## 13                               8                            1
## 14                               9                            2
## 15                               8                            2
## 16                              15                            1
## 17                               3                            4
## 18                               4                            3
## 19                               6                            4
## 20                              16                            4
## 21                               6                            2
## 22                               4                            1
## 23                              10                            3
## 24                              15                            4
## 25                               6                            3
## 26                               9                            4
## 27                               5                            1
## 28                              15                            2
## 29                               9                            3
## 30                               9                            1
## 31                               7                            1
## 32                               5                            2
## 33                               8                            1
## 34                              10                            1
## 35                              11                            3
## 36                              16                            3
## 37                               5                            2
## 38                              15                            1
## 39                               9                            2
## 40                               7                            4
## 41                              13                            1
```

```
## 42                             6                        1
## 43                            14                        3
## 44                             5                        4
## 45                            12                        3
## 46                            13                        2
## 47                            11                        4
## 48                            15                        2
## 49                             9                        3
## 50                            15                        1
## 51                             8                        4
## 52                            13                        2
## 53                             8                        1
## 54                             5                        2
## 55                            13                        1
## 56                            11                        2
## 57                            14                        3
## 58                            13                        4
## 59                            13                        1
## 60                             3                        1
## 61                             8                        4
## 62                            12                        3

##       Survivorship
## 1                C
## 2                C
## 3               NC
## 4               NC
## 5                C
## 6                C
## 7                C
## 8                C
## 9                C
## 10               C
## 11              NC
## 12               C
## 13               C
## 14               C
## 15              NC
## 16              NC
## 17               C
## 18               C
## 19              NC
## 20              NC
## 21              NC
## 22               C
## 23               C
## 24               C
## 25               C
## 26               C
## 27              NC
```

```
## 28          NC
## 29           C
## 30           C
## 31           C
## 32           C
## 33          NC
## 34           C
## 35          NC
## 36          NC
## 37           C
## 38           C
## 39           C
## 40           C
## 41          NC
## 42           C
## 43           C
## 44          NC
## 45           C
## 46           C
## 47           C
## 48          NC
## 49          NC
## 50          NC
## 51           C
## 52           C
## 53          NC
## 54          NC
## 55           C
## 56           C
## 57           C
## 58           C
## 59           C
## 60          NC
## 61           C
## 62           C
## 63          NC
## 64          NC
## 65          NC
## 66           C
## 67           C
## 68           C
## 69          NC
## 70          NC
## 71           C
## 72           C
## 73           C
## 74          NC
## 75          NC
```

```r
data$Survivorship <- as.factor(data$Survivorship)
#####################################
##
## Reformat the data so that it is
## 1) Easy to use (add nice column names)
## 2) Interpreted correctly by glm()..
##
#####################################
head(data) # you see data, but no column names
```

```
##    Age Gender BMI Fever Nausea.Vomting Headache Diarrhea
## 1  56      1  35     2              1        1        1
## 2  46      1  29     1              2        2        1
## 3  57      1  33     2              2        2        2
## 4  49      2  33     1              2        1        2
## 5  59      1  32     1              1        2        1
## 6  58      2  22     2              2        2        1
##    Fatigue...generalized.bone.ache Jaundice Epigastric.pain   WBC     RBC
## 1                                2        2               2  7425 4248807
## 2                                2        2               1 12101 4429425
## 3                                1        1               1  4178 4621191
## 4                                1        2               1  6490 4794631
## 5                                2        2               2  3661 4606375
## 6                                2        2               1 11785 3882456
##    HGB    Plat AST.1 ALT.1 ALT4 ALT.12 ALT.24 ALT.36 ALT.48 ALT.after.24.w
## 1   14 112132    99    84   52    109     81      5      5              5
## 2   10 129367    91   123   95     75    113     57    123             44
## 3   12 151522   113    49   95    107    116      5      5              5
## 4   10 146457    43    64  109     80     88     48     77             33
## 5   11 187684    99   104   67     48    120     94     90             30
## 6   15 131228    66   104  121     96     65     73    114             29
##    RNA.Base   RNA.4   RNA.12 RNA.EOT RNA.EF Baseline.histological.Grading
## 1    655330  634536   288194       5      5                            13
## 2     40620  538635   637056  336804  31085                             4
## 3    571148  661346        5  735945 558829                             4
## 4   1041941  449939   585688  744463 582301                            10
## 5    660410  738756  3731527  338946 242861                            11
## 6   1157452 1086852        5       5      5                             4
##    Baselinehistological.staging Survivorship
## 1                             2            C
## 2                             2            C
## 3                             4           NC
## 4                             3           NC
## 5                             1            C
## 6                             4            C
```

```r
str(data)
```

```
## 'data.frame':    1385 obs. of  30 variables:
##  $ Age                              : int  56 46 57 49 59 58 42 48 44 45 ...
```

```
##  $ Gender                       : int  1 1 1 2 1 2 2 2 1 1 ...
##  $ BMI                          : int  35 29 33 33 32 22 26 30 23 30 ...
##  $ Fever                        : int  2 1 2 1 1 2 1 1 1 2 ...
##  $ Nausea.Vomting               : int  1 2 2 2 1 2 1 1 1 1 ...
##  $ Headache                     : int  1 2 2 1 2 2 2 2 2 2 ...
##  $ Diarrhea                     : int  1 1 2 2 1 1 2 2 2 2 ...
##  $ Fatigue...generalized.bone.ache: int  2 2 1 1 2 2 2 1 2 1 ...
##  $ Jaundice                     : int  2 2 1 2 2 2 2 1 1 1 ...
##  $ Epigastric.pain              : int  2 1 1 1 2 1 2 2 2 2 ...
##  $ WBC                          : int  7425 12101 4178 6490 3661 11785
11620 7335 10480 6681 ...
##  $ RBC                          : num  4248807 4429425 4621191 4794631
4606375 ...
##  $ HGB                          : int  14 10 12 10 11 15 12 11 12 12 ...
##  $ Plat                         : num  112132 129367 151522 146457
187684 ...
##  $ AST.1                        : int  99 91 113 43 99 66 78 119 93 55
...
##  $ ALT.1                        : int  84 123 49 64 104 104 57 112 83 68
...
##  $ ALT4                         : num  52 95 95 109 67 121 113 80 55 72
...
##  $ ALT.12                       : int  109 75 107 80 48 96 118 127 102
127 ...
##  $ ALT.24                       : int  81 113 116 88 120 65 107 45 97 81
...
##  $ ALT.36                       : int  5 57 5 48 94 73 84 96 122 125 ...
##  $ ALT.48                       : int  5 123 5 77 90 114 80 53 39 43 ...
##  $ ALT.after.24.w               : int  5 44 5 33 30 29 28 39 45 30 ...
##  $ RNA.Base                     : int  655330 40620 571148 1041941
660410 1157452 325694 641129 591441 1151206 ...
##  $ RNA.4                        : int  634536 538635 661346 449939
738756 1086852 1034008 72050 757361 230488 ...
##  $ RNA.12                       : int  288194 637056 5 585688 3731527 5
275095 787295 5 267320 ...
##  $ RNA.EOT                      : int  5 336804 735945 744463 338946 5
214566 370605 371090 275295 ...
##  $ RNA.EF                       : int  5 31085 558829 582301 242861 5
635157 506296 203042 555516 ...
##  $ Baseline.histological.Grading : int  13 4 4 10 11 4 12 12 5 4 ...
##  $ Baselinehistological.staging  : int  2 2 4 3 1 4 4 3 2 2 ...
##  $ Survivorship                  : Factor w/ 2 levels "C","NC": 1 1 2 2 1
1 1 1 1 1 ...
```

```r
# this shows that we need to tell R which columns contain factors it also
shows us that there are some missing values. There are "?"s
## in the dataset. These are in the "ca" and "thal" columns. First, convert
"?"s to NAs...
data[data == "?"] <- NA
## Now add factors for variables that are factors and clean up the factors
```

```r
that had missing data...
data[data$Gender == 1,]$Gender <- "M"
data[data$Gender == 2,]$Gender <- "F"
data$Gender <- as.factor(data$Gender)
data[data$Fever == 1,]$Fever <- "No"
data[data$Fever == 2,]$Fever <- "Yes"
data$Fever <- as.factor(data$Fever)
data[data$Nausea.Vomting == 1,]$Nausea.Vomting <- "No"
data[data$Nausea.Vomting == 2,]$Nausea.Vomting <- "Yes"
data$Nausea.Vomting <- as.factor(data$Nausea.Vomting)
data[data$Headache == 1,]$Headache <- "No"
data[data$Headache == 2,]$Headache <- "Yes"
data$Headache <- as.factor(data$Headache)
data[data$Diarrhea == 1,]$Diarrhea <- "No"
data[data$Diarrhea == 2,]$Diarrhea <- "Yes"
data$Diarrhea <- as.factor(data$Diarrhea)
data[data$Fatigue...generalized.bone.ache ==
1,]$Fatigue...generalized.bone.ache <- "No"
data[data$Fatigue...generalized.bone.ache ==
2,]$Fatigue...generalized.bone.ache <- "Yes"
data$Fatigue...generalized.bone.ache <-
as.factor(data$Fatigue...generalized.bone.ache)
data[data$Jaundice == 1,]$Jaundice <- "No"
data[data$Jaundice == 2,]$Jaundice <- "Yes"
data$Jaundice <- as.factor(data$Jaundice)
data[data$Epigastric.pain == 1,]$Epigastric.pain <- "No"
data[data$Epigastric.pain == 2,]$Epigastric.pain <- "Yes"
data$Epigastric.pain <- as.factor(data$Epigastric.pain)
data[data$Baselinehistological.staging == 1,]$Baselinehistological.staging <-
"Portal Fibrosis"
data[data$Baselinehistological.staging == 2,]$Baselinehistological.staging<-
"Few Septa"
data[data$Baselinehistological.staging == 3,]$Baselinehistological.staging <-
"Many Septa "
data[data$Baselinehistological.staging == 4,]$Baselinehistological.staging <-
"Cirrhosis"
data$Baseline.histological.Grading <-
as.factor(data$Baseline.histological.Grading)
data$Baselinehistological.staging <-
as.factor(data$Baselinehistological.staging)
str(data)

## 'data.frame':    1385 obs. of  30 variables:
##  $ Age                         : int  56 46 57 49 59 58 42 48 44 45 ...
##  $ Gender                      : Factor w/ 2 levels "F","M": 2 2 2 1 2
1 1 1 2 2 ...
##  $ BMI                         : int  35 29 33 33 32 22 26 30 23 30 ...
##  $ Fever                       : Factor w/ 2 levels "No","Yes": 2 1 2 1
1 2 1 1 1 2 ...
##  $ Nausea.Vomting              : Factor w/ 2 levels "No","Yes": 1 2 2 2
```

```
1 2 1 1 1 1 ...
##  $ Headache                     : Factor w/ 2 levels "No","Yes": 1 2 2 1
2 2 2 2 2 2 ...
##  $ Diarrhea                     : Factor w/ 2 levels "No","Yes": 1 1 2 2
1 1 2 2 2 2 ...
##  $ Fatigue...generalized.bone.ache: Factor w/ 2 levels "No","Yes": 2 2 1 1
2 2 2 1 2 1 ...
##  $ Jaundice                     : Factor w/ 2 levels "No","Yes": 2 2 1 2
2 2 2 1 1 1 ...
##  $ Epigastric.pain              : Factor w/ 2 levels "No","Yes": 2 1 1 1
2 1 2 2 2 2 ...
##  $ WBC                          : int  7425 12101 4178 6490 3661 11785
11620 7335 10480 6681 ...
##  $ RBC                          : num  4248807 4429425 4621191 4794631
4606375 ...
##  $ HGB                          : int  14 10 12 10 11 15 12 11 12 12 ...
##  $ Plat                         : num  112132 129367 151522 146457
187684 ...
##  $ AST.1                        : int  99 91 113 43 99 66 78 119 93 55
...
##  $ ALT.1                        : int  84 123 49 64 104 104 57 112 83 68
...
##  $ ALT4                         : num  52 95 95 109 67 121 113 80 55 72
...
##  $ ALT.12                       : int  109 75 107 80 48 96 118 127 102
127 ...
##  $ ALT.24                       : int  81 113 116 88 120 65 107 45 97 81
...
##  $ ALT.36                       : int  5 57 5 48 94 73 84 96 122 125 ...
##  $ ALT.48                       : int  5 123 5 77 90 114 80 53 39 43 ...
##  $ ALT.after.24.w               : int  5 44 5 33 30 29 28 39 45 30 ...
##  $ RNA.Base                     : int  655330 40620 571148 1041941
660410 1157452 325694 641129 591441 1151206 ...
##  $ RNA.4                        : int  634536 538635 661346 449939
738756 1086852 1034008 72050 757361 230488 ...
##  $ RNA.12                       : int  288194 637056 5 585688 3731527 5
275095 787295 5 267320 ...
##  $ RNA.EOT                      : int  5 336804 735945 744463 338946 5
214566 370605 371090 275295 ...
##  $ RNA.EF                       : int  5 31085 558829 582301 242861 5
635157 506296 203042 555516 ...
##  $ Baseline.histological.Grading : Factor w/ 14 levels
"3","4","5","6",..: 11 2 2 8 9 2 10 10 3 2 ...
##  $ Baselinehistological.staging : Factor w/ 4 levels "Cirrhosis","Few
Septa",..: 2 2 1 3 4 1 1 3 2 2 ...
##  $ Survivorship                 : Factor w/ 2 levels "C","NC": 1 1 2 2 1
1 1 1 1 1 ...

###################################
xtabs(~ Survivorship + Gender, data=data)
```

```
##            Gender
## Survivorship   F   M
##            C  425 478
##            NC 253 229
```

```
xtabs(~ Survivorship + Fever, data=data)
```

```
##            Fever
## Survivorship  No Yes
##            C  440 463
##            NC 231 251
```

```
xtabs(~ Survivorship + Nausea.Vomting, data=data)
```

```
##            Nausea.Vomting
## Survivorship  No Yes
##            C  451 452
##            NC 238 244
```

```
xtabs(~ Survivorship + Headache, data=data)
```

```
##            Headache
## Survivorship  No Yes
##            C  450 453
##            NC 248 234
```

```
xtabs(~ Survivorship + Diarrhea, data=data)
```

```
##            Diarrhea
## Survivorship  No Yes
##            C  452 451
##            NC 237 245
```

```
xtabs(~ Survivorship + Fatigue...generalized.bone.ache, data=data)
```

```
##            Fatigue...generalized.bone.ache
## Survivorship  No Yes
##            C  463 440
##            NC 231 251
```

```
xtabs(~ Survivorship + Jaundice, data=data)
```

```
##            Jaundice
## Survivorship  No Yes
##            C  462 441
##            NC 229 253
```

```
xtabs(~ Survivorship + Epigastric.pain, data=data)
```

```
##            Epigastric.pain
## Survivorship  No Yes
##            C  458 445
##            NC 229 253
```

```
xtabs(~ Survivorship + Baselinehistological.staging, data=data)

##            Baselinehistological.staging
## Survivorship Cirrhosis Few Septa Many Septa  Portal Fibrosis
##          C       235       221       234              213
##         NC       127       111       121              123

## Now we are ready for some logistic regression. First we'll create a very
## simple model that uses sex to predict heart disease
##
xtabs(~ Survivorship + Gender, data=data)

##            Gender
## Survivorship   F   M
##          C  425 478
##         NC  253 229

## Most of the females are healthy and most of the males are unhealthy.
## Being female is likely to decrease the odds in being unhealthy.
##    In other words, if a sample is female, the odds are against it that it
##    will be unhealthy
## Being male is likely to increase the odds in being unhealthy...
##    In other words, if a sample is male, the odds are for it being
unhealthy
logistic_simple <- glm(Survivorship ~ Gender, data=data, family="binomial")
summary(logistic_simple)

##
## Call:
## glm(formula = Survivorship ~ Gender, family = "binomial", data = data)
##
## Deviance Residuals:
##     Min      1Q  Median      3Q     Max
## -0.9665  -0.9665  -0.8848  1.4041  1.5015
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -0.51870    0.07941  -6.532 6.48e-11 ***
## GenderM     -0.21719    0.11298  -1.922   0.0546 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 1790.0  on 1384  degrees of freedom
## Residual deviance: 1786.3  on 1383  degrees of freedom
## AIC: 1790.3
##
## Number of Fisher Scoring iterations: 4
```

```r
## The intercept is the log(odds) a female will be unhealthy. This is because
## female is the first factor in "sex" (the factors are ordered,
## alphabetically by default,"female", "male")
## Now let's look at the second coefficient...
##    sexM        1.2737     0.2725   4.674 2.95e-06 ***
##
## sexM is the log(odds ratio) that tells us that if a sample has sex=M, the
## odds of being unhealthy are, on a log scale, 1.27 times greater than if
## a sample has sex=F.
female.log.odds <- log(253 /425)
female.log.odds
```

```
## [1] -0.5186997
```

```r
# Now you know how these are calculated
male.log.odds.ratio <- log((229 / 478) / (253/425))
male.log.odds.ratio
```

```
## [1] -0.217189
```

```r
## Now calculate the overall "Pseudo R-squared" and its p-value
## NOTE: Since we are doing logistic regression...
## Null devaiance = 2*(0 - LogLikelihood(null model))
##                = -2*LogLikihood(null model)
## Residual deviance = 2*(0 - LogLikelihood(proposed model))
##                    = -2*LogLikelihood(proposed model)
ll.null <- logistic_simple$null.deviance/-2
ll.proposed <- logistic_simple$deviance/-2
ll.null
```

```
## [1] -894.9992
```

```r
ll.proposed
```

```
## [1] -893.1488
```

```r
## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null
```

```
## [1] 0.002067477
```

```r
## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed - ll.null), df=1)
```

```
## [1] 0.05438701
```

```r
1 - pchisq((logistic_simple$null.deviance - logistic_simple$deviance), df=1)
```

```
## [1] 0.05438701
```

```r
## Lastly, let's  see what this logistic regression predicts, given
## that a patient is either female or male (and no other data about them).
```

```
predicted.data <-
data.frame(probability.of.Survivorship=logistic_simple$fitted.values,Gender=d
ata$Gender)
predicted.data
```

```
##      probability.of.Survivorship Gender
## 1                     0.3239038      M
## 2                     0.3239038      M
## 3                     0.3239038      M
## 4                     0.3731563      F
## 5                     0.3239038      M
## 6                     0.3731563      F
## 7                     0.3731563      F
## 8                     0.3731563      F
## 9                     0.3239038      M
## 10                    0.3239038      M
## 11                    0.3731563      F
## 12                    0.3239038      M
## 13                    0.3731563      F
## 14                    0.3239038      M
## 15                    0.3731563      F
## 16                    0.3239038      M
## 17                    0.3239038      M
## 18                    0.3731563      F
## 19                    0.3239038      M
## 20                    0.3731563      F
## 21                    0.3731563      F
## 22                    0.3239038      M
## 23                    0.3239038      M
## 24                    0.3731563      F
## 25                    0.3731563      F
## 26                    0.3731563      F
## 27                    0.3239038      M
## 28                    0.3731563      F
## 29                    0.3731563      F
## 30                    0.3731563      F
## 31                    0.3731563      F
## 32                    0.3731563      F
## 33                    0.3731563      F
## 34                    0.3239038      M
## 35                    0.3239038      M
## 36                    0.3239038      M
## 37                    0.3731563      F
## 38                    0.3239038      M
## 39                    0.3731563      F
## 40                    0.3239038      M
## 41                    0.3731563      F
## 42                    0.3731563      F
## 43                    0.3239038      M
## 44                    0.3239038      M
```

```
## 45                      0.3731563    F
## 46                      0.3239038    M
## 47                      0.3239038    M
## 48                      0.3239038    M
## 49                      0.3239038    M
## 50                      0.3731563    F
## 51                      0.3731563    F
## 52                      0.3731563    F
## 53                      0.3239038    M
## 54                      0.3239038    M
## 55                      0.3239038    M
## 56                      0.3731563    F
## 57                      0.3731563    F
## 58                      0.3239038    M
## 59                      0.3731563    F
## 60                      0.3731563    F
## 61                      0.3731563    F
## 62                      0.3731563    F
## 63                      0.3731563    F
## 64                      0.3731563    F
## 65                      0.3239038    M
## 66                      0.3239038    M
## 67                      0.3731563    F
## 68                      0.3731563    F
## 69                      0.3731563    F
## 70                      0.3239038    M
## 71                      0.3239038    M
## 72                      0.3731563    F
## 73                      0.3731563    F
## 74                      0.3239038    M
## 75                      0.3731563    F
## 76                      0.3239038    M
## 77                      0.3731563    F
## 78                      0.3239038    M
## 79                      0.3239038    M
## 80                      0.3239038    M
## 81                      0.3239038    M
## 82                      0.3239038    M
## 83                      0.3239038    M
## 84                      0.3239038    M
## 85                      0.3731563    F
## 86                      0.3239038    M
## 87                      0.3731563    F
## 88                      0.3731563    F
## 89                      0.3239038    M
## 90                      0.3239038    M
## 91                      0.3731563    F
## 92                      0.3731563    F
## 93                      0.3731563    F
## 94                      0.3239038    M
```

```
## We can plot the data...
ggplot(data=predicted.data, aes(x=Gender, y=probability.of.Survivorship)) +
  geom_point(aes(color=Gender), size=5) +
  xlab("Gender") +
  ylab("Predicted probability of getting HCV Disease")
```
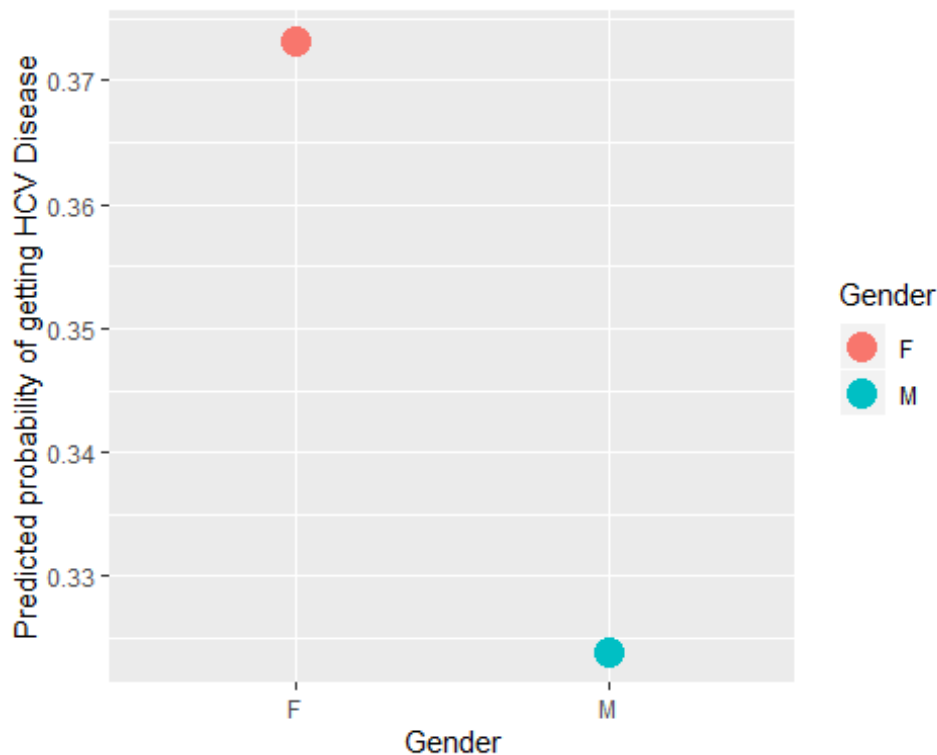


```
## Since there are only two probabilities (one for females and one for
males),
## we can use a table to summarize the predicted probabilities.
xtabs(~ probability.of.Survivorship + Gender, data=predicted.data)

##                               Gender
## probability.of.Survivorship    F    M
##           0.323903818953405    0  707
##           0.373156342182894  678    0


################################
##
## Now we will use all of the data available to predict heart disease. This
is not the best way to do this
##
################################
logistic <- glm(Survivorship ~ ., data=data, family="binomial")

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
summary(logistic)
```

```
##
## Call:
## glm(formula = Survivorship ~ ., family = "binomial", data = data)
##
## Deviance Residuals:
##        Min          1Q      Median          3Q         Max
## -2.001e-04  -2.100e-08  -2.100e-08   2.100e-08   2.034e-04
##
## Coefficients:
##                                        Estimate Std. Error z value
## (Intercept)                           -6.147e+02  6.931e+04  -0.009
## Age                                   -4.518e-01  4.139e+02  -0.001
## GenderM                               -3.424e+00  1.281e+04   0.000
## BMI                                   -2.747e-01  6.578e+02   0.000
## FeverYes                               8.441e+00  7.660e+03   0.001
## Nausea.VomtingYes                     -1.017e+01  7.678e+03  -0.001
## HeadacheYes                           -2.229e+00  6.399e+03   0.000
## DiarrheaYes                            2.269e+00  6.636e+03   0.000
## Fatigue...generalized.bone.acheYes     4.740e+00  9.352e+03   0.001
## JaundiceYes                            1.829e+01  5.086e+03   0.004
## Epigastric.painYes                    -4.547e+00  1.172e+04   0.000
## WBC                                    7.295e-04  1.239e+00   0.001
## RBC                                    8.384e-06  1.097e-02   0.001
## HGB                                    5.689e+00  1.694e+03   0.003
## Plat                                   3.605e-05  7.103e-02   0.001
## AST.1                                  1.728e-02  9.804e+01   0.000
## ALT.1                                 -1.263e-01  2.944e+02   0.000
## ALT4                                   2.783e-01  1.365e+02   0.002
## ALT.12                                 5.809e-02  9.432e+01   0.001
## ALT.24                                 1.513e-01  1.629e+02   0.001
## ALT.36                                 1.265e-01  1.200e+02   0.001
## ALT.48                                 1.336e-01  1.011e+02   0.001
## ALT.after.24.w                        -1.292e+00  8.390e+02  -0.002
## RNA.Base                               2.232e-05  1.296e-02   0.002
## RNA.4                                 -7.059e-06  6.352e-03  -0.001
## RNA.12                                 1.689e-06  1.613e-02   0.000
## RNA.EOT                                1.236e-03  7.123e-02   0.017
## RNA.EF                                -2.340e-05  1.077e-02  -0.002
## Baseline.histological.Grading4         1.320e+01  1.614e+04   0.001
## Baseline.histological.Grading5        -3.246e+00  1.755e+04   0.000
## Baseline.histological.Grading6         3.274e+01  3.118e+04   0.001
## Baseline.histological.Grading7         4.915e+00  1.318e+05   0.000
## Baseline.histological.Grading8        -5.185e-01  1.415e+04   0.000
## Baseline.histological.Grading9         1.295e+01  6.432e+04   0.000
## Baseline.histological.Grading10        1.530e+01  1.485e+04   0.001
## Baseline.histological.Grading11        1.852e+01  2.826e+04   0.001
## Baseline.histological.Grading12        2.538e+01  1.779e+04   0.001
## Baseline.histological.Grading13       -1.473e+01  2.040e+04  -0.001
```

```
## Baseline.histological.Grading14                     1.434e+01  1.784e+04   0.001
## Baseline.histological.Grading15                     1.279e+01  1.579e+04   0.001
## Baseline.histological.Grading16                     4.808e+01  2.328e+04   0.002
## Baselinehistological.stagingFew Septa              -1.186e+01  9.410e+03  -0.001
## Baselinehistological.stagingMany Septa             -5.362e+00  7.264e+03  -0.001
## Baselinehistological.stagingPortal Fibrosis -9.128e+00  1.078e+04  -0.001
##                                              Pr(>|z|)
## (Intercept)                                     0.993
## Age                                             0.999
## GenderM                                         1.000
## BMI                                             1.000
## FeverYes                                        0.999
## Nausea.VomtingYes                               0.999
## HeadacheYes                                     1.000
## DiarrheaYes                                     1.000
## Fatigue...generalized.bone.acheYes              1.000
## JaundiceYes                                     0.997
## Epigastric.painYes                              1.000
## WBC                                             1.000
## RBC                                             0.999
## HGB                                             0.997
## Plat                                            1.000
## AST.1                                           1.000
## ALT.1                                           1.000
## ALT4                                            0.998
## ALT.12                                          1.000
## ALT.24                                          0.999
## ALT.36                                          0.999
## ALT.48                                          0.999
## ALT.after.24.w                                  0.999
## RNA.Base                                        0.999
## RNA.4                                           0.999
## RNA.12                                          1.000
## RNA.EOT                                         0.986
## RNA.EF                                          0.998
## Baseline.histological.Grading4                  0.999
## Baseline.histological.Grading5                  1.000
## Baseline.histological.Grading6                  0.999
## Baseline.histological.Grading7                  1.000
## Baseline.histological.Grading8                  1.000
## Baseline.histological.Grading9                  1.000
## Baseline.histological.Grading10                 0.999
## Baseline.histological.Grading11                 0.999
## Baseline.histological.Grading12                 0.999
## Baseline.histological.Grading13                 0.999
## Baseline.histological.Grading14                 0.999
## Baseline.histological.Grading15                 0.999
## Baseline.histological.Grading16                 0.998
## Baselinehistological.stagingFew Septa           0.999
## Baselinehistological.stagingMany Septa          0.999
```

```
## Baselinehistological.stagingPortal Fibrosis    0.999
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 1.790e+03  on 1384  degrees of freedom
## Residual deviance: 6.632e-07  on 1341  degrees of freedom
## AIC: 88
##
## Number of Fisher Scoring iterations: 25

## Now calculate the overall "Pseudo R-squared" and its p-value
ll.null <- logistic$null.deviance/-2
ll.proposed <- logistic$deviance/-2
## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null

## [1] 1

## The p-value for the R^2
1 - pchisq(2*(ll.proposed - ll.null), df=(length(logistic$coefficients)-1))

## [1] 0

## now we can plot the data
predicted.data <-
data.frame(probability.of.Survivorship=logistic$fitted.values,Survivorship=da
ta$Survivorship)
predicted.data <-
predicted.data[order(predicted.data$probability.of.Survivorship,
decreasing=FALSE),]
predicted.data$rank <- 1:nrow(predicted.data)
## Lastly, we can plot the predicted probabilities for each sample having
## heart disease and color by whether or not they actually had heart disease
ggplot(data=predicted.data, aes(x=rank, y=probability.of.Survivorship)) +
  geom_point(aes(color=Survivorship), alpha=1, shape=4, stroke=2) +
  xlab("Index") +
  ylab("Predicted probability of getting HCV disease")
```
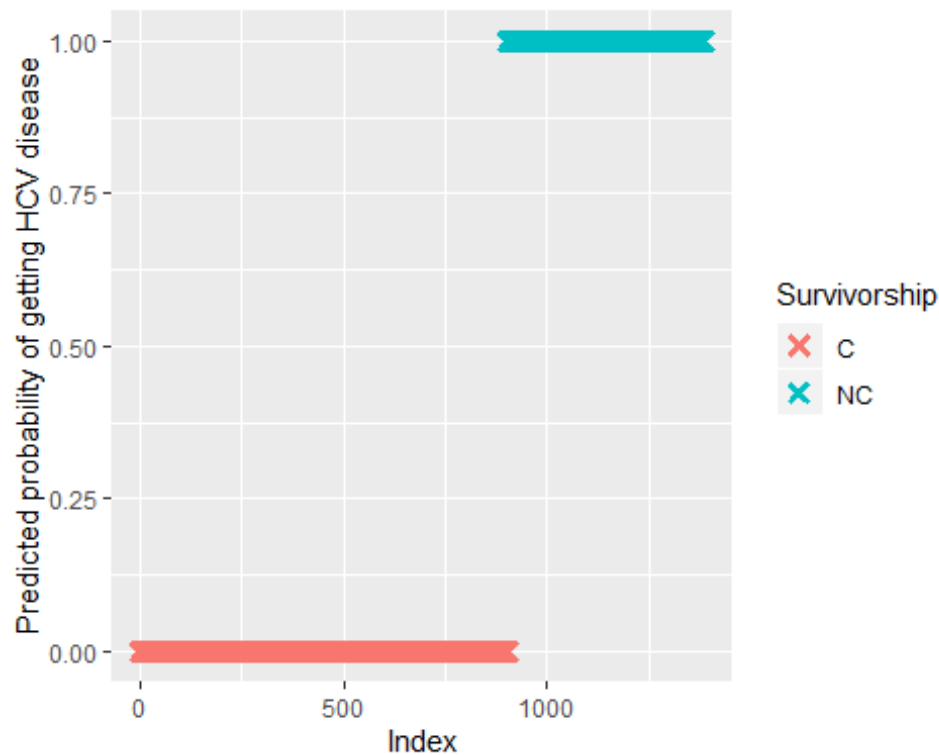
```
# Few packages for confusion matrix. Lets look at them one by one
#install.packages("regclass",
lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(regclass)

## Loading required package: bestglm

## Loading required package: leaps

## Loading required package: VGAM

## Loading required package: stats4

## Loading required package: splines

## Loading required package: rpart

## Loading required package: randomForest

## randomForest 4.6-14

## Type rfNews() to see new features/changes/bug fixes.

##
## Attaching package: 'randomForest'

## The following object is masked from 'package:ggplot2':
##
##     margin
```

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

## Important regclass change from 1.3:
## All functions that had a . in the name now have an _
## all.correlations -> all_correlations, cor.demo -> cor_demo, etc.
```

```r
confusion_matrix(logistic)
```

```
##           Predicted C Predicted NC Total
## Actual C          903            0   903
## Actual NC           0          482   482
## Total             903          482  1385
```

```r
#install.packages("caret",
lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(caret)
```

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

```
##
## Attaching package: 'lattice'
```

```
## The following object is masked from 'package:regclass':
##
##     qq
```

```
##
## Attaching package: 'caret'
```

```
## The following object is masked from 'package:VGAM':
##
##     predictors
```

```r
pdata <- predict(logistic,newdata=data,type="response" )
pdata
```

```
##             1            2            3            4            5
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##             6            7            8            9           10
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##            11           12           13           14           15
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##            16           17           18           19           20
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##            21           22           23           24           25
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##            26           27           28           29           30
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##            31           32           33           34           35
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
```

```
##           36           37           38           39           40 
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 
##           41           42           43           44           45 
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 
##           46           47           48           49           50 
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 
##           51           52           53           54           55 
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 
##           56           57           58           59           60 
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 
##           61           62           63           64           65 
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 
##           66           67           68           69           70 
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 
##           71           72           73           74           75 
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 
##           76           77           78           79           80 
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 
##           81           82           83           84           85 
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 
##           86           87           88           89           90 
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 
##           91           92           93           94           95 
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 
##           96           97           98           99          100 
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 
##          101          102          103          104          105 
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 
##          106          107          108          109          110 
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 
##          111          112          113          114          115 
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 
##          116          117          118          119          120 
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 
##          121          122          123          124          125 
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 
##          126          127          128          129          130 
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 
##          131          132          133          134          135 
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 
##          136          137          138          139          140 
## 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 
##          141          142          143          144          145 
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 
##          146          147          148          149          150 
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 
##          151          152          153          154          155 
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 
##          156          157          158          159          160 
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 
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##           161          162          163          164          165
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           166          167          168          169          170
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           171          172          173          174          175
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           176          177          178          179          180
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           181          182          183          184          185
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##           186          187          188          189          190
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           191          192          193          194          195
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           196          197          198          199          200
## 1.000000e+00 4.624073e-09 2.220446e-16 2.220446e-16 1.000000e+00
##           201          202          203          204          205
## 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##           206          207          208          209          210
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##           211          212          213          214          215
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##           216          217          218          219          220
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           221          222          223          224          225
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##           226          227          228          229          230
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           231          232          233          234          235
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           236          237          238          239          240
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           241          242          243          244          245
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           246          247          248          249          250
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           251          252          253          254          255
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           256          257          258          259          260
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           261          262          263          264          265
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##           266          267          268          269          270
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           271          272          273          274          275
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##           276          277          278          279          280
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##           281          282          283          284          285
## 1.226682e-12 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
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##           286          287          288          289          290
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##           291          292          293          294          295
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##           296          297          298          299          300
## 1.400537e-08 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##           301          302          303          304          305
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           306          307          308          309          310
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##           311          312          313          314          315
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##           316          317          318          319          320
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##           321          322          323          324          325
## 1.000000e+00 2.220446e-16 2.220446e-16 1.062546e-13 2.220446e-16
##           326          327          328          329          330
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##           331          332          333          334          335
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           336          337          338          339          340
## 1.000000e+00 1.000000e+00 2.144440e-11 1.000000e+00 2.220446e-16
##           341          342          343          344          345
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##           346          347          348          349          350
## 1.096984e-10 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           351          352          353          354          355
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           356          357          358          359          360
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##           361          362          363          364          365
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##           366          367          368          369          370
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           371          372          373          374          375
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           376          377          378          379          380
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           381          382          383          384          385
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##           386          387          388          389          390
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           391          392          393          394          395
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##           396          397          398          399          400
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##           401          402          403          404          405
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           406          407          408          409          410
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
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##           411          412          413          414          415
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           416          417          418          419          420
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##           421          422          423          424          425
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##           426          427          428          429          430
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           431          432          433          434          435
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           436          437          438          439          440
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           441          442          443          444          445
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           446          447          448          449          450
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##           451          452          453          454          455
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           456          457          458          459          460
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           461          462          463          464          465
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##           466          467          468          469          470
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##           471          472          473          474          475
## 2.220446e-16 2.553865e-10 1.000000e+00 1.000000e+00 2.220446e-16
##           476          477          478          479          480
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           481          482          483          484          485
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##           486          487          488          489          490
## 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16
##           491          492          493          494          495
## 2.220446e-16 1.000000e+00 2.220446e-16 6.696274e-09 2.220446e-16
##           496          497          498          499          500
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##           501          502          503          504          505
## 1.000000e+00 1.000000e+00 1.422738e-08 2.220446e-16 1.000000e+00
##           506          507          508          509          510
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##           511          512          513          514          515
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           516          517          518          519          520
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           521          522          523          524          525
## 2.858549e-09 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16
##           526          527          528          529          530
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           531          532          533          534          535
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
```

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##          536          537          538          539          540
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##          541          542          543          544          545
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##          546          547          548          549          550
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##          551          552          553          554          555
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          556          557          558          559          560
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          561          562          563          564          565
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          566          567          568          569          570
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          571          572          573          574          575
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          576          577          578          579          580
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          581          582          583          584          585
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          586          587          588          589          590
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          591          592          593          594          595
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          596          597          598          599          600
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##          601          602          603          604          605
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##          606          607          608          609          610
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          611          612          613          614          615
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##          616          617          618          619          620
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          621          622          623          624          625
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 5.933679e-09
##          626          627          628          629          630
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##          631          632          633          634          635
## 3.887578e-09 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##          636          637          638          639          640
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          641          642          643          644          645
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          646          647          648          649          650
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##          651          652          653          654          655
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##          656          657          658          659          660
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
```

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##           661          662          663          664          665
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##           666          667          668          669          670
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           671          672          673          674          675
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##           676          677          678          679          680
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##           681          682          683          684          685
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           686          687          688          689          690
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##           691          692          693          694          695
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##           696          697          698          699          700
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           701          702          703          704          705
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           706          707          708          709          710
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           711          712          713          714          715
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##           716          717          718          719          720
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           721          722          723          724          725
## 2.220446e-16 2.220446e-16 1.000000e+00 1.350791e-08 1.000000e+00
##           726          727          728          729          730
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##           731          732          733          734          735
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           736          737          738          739          740
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##           741          742          743          744          745
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##           746          747          748          749          750
## 2.220446e-16 1.124887e-08 2.220446e-16 2.220446e-16 2.220446e-16
##           751          752          753          754          755
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##           756          757          758          759          760
## 1.000000e+00 3.704052e-09 1.000000e+00 2.220446e-16 1.000000e+00
##           761          762          763          764          765
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           766          767          768          769          770
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           771          772          773          774          775
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##           776          777          778          779          780
## 5.595202e-10 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##           781          782          783          784          785
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
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##          786          787          788          789          790
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          791          792          793          794          795
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##          796          797          798          799          800
## 2.220446e-16 1.000000e+00 1.034868e-10 1.000000e+00 1.000000e+00
##          801          802          803          804          805
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          806          807          808          809          810
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          811          812          813          814          815
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          816          817          818          819          820
## 1.000000e+00 7.154129e-09 1.000000e+00 2.220446e-16 2.220446e-16
##          821          822          823          824          825
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          826          827          828          829          830
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##          831          832          833          834          835
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          836          837          838          839          840
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.001750e-08
##          841          842          843          844          845
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##          846          847          848          849          850
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##          851          852          853          854          855
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          856          857          858          859          860
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          861          862          863          864          865
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##          866          867          868          869          870
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          871          872          873          874          875
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16
##          876          877          878          879          880
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          881          882          883          884          885
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##          886          887          888          889          890
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          891          892          893          894          895
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##          896          897          898          899          900
## 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##          901          902          903          904          905
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##          906          907          908          909          910
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
```

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##          911          912          913          914          915
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          916          917          918          919          920
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          921          922          923          924          925
## 1.000000e+00 1.239056e-08 1.000000e+00 1.466301e-09 2.220446e-16
##          926          927          928          929          930
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##          931          932          933          934          935
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          936          937          938          939          940
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          941          942          943          944          945
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          946          947          948          949          950
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          951          952          953          954          955
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          956          957          958          959          960
## 2.220446e-16 2.220446e-16 2.220446e-16 8.654866e-09 1.000000e+00
##          961          962          963          964          965
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##          966          967          968          969          970
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##          971          972          973          974          975
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          976          977          978          979          980
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          981          982          983          984          985
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##          986          987          988          989          990
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##          991          992          993          994          995
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          996          997          998          999         1000
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##         1001         1002         1003         1004         1005
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##         1006         1007         1008         1009         1010
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##         1011         1012         1013         1014         1015
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##         1016         1017         1018         1019         1020
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##         1021         1022         1023         1024         1025
## 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##         1026         1027         1028         1029         1030
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##         1031         1032         1033         1034         1035
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
```

```
##          1036         1037         1038         1039         1040
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          1041         1042         1043         1044         1045
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          1046         1047         1048         1049         1050
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          1051         1052         1053         1054         1055
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##          1056         1057         1058         1059         1060
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          1061         1062         1063         1064         1065
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16
##          1066         1067         1068         1069         1070
## 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##          1071         1072         1073         1074         1075
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 3.639874e-09
##          1076         1077         1078         1079         1080
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##          1081         1082         1083         1084         1085
## 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##          1086         1087         1088         1089         1090
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          1091         1092         1093         1094         1095
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##          1096         1097         1098         1099         1100
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##          1101         1102         1103         1104         1105
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##          1106         1107         1108         1109         1110
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##          1111         1112         1113         1114         1115
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          1116         1117         1118         1119         1120
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##          1121         1122         1123         1124         1125
## 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##          1126         1127         1128         1129         1130
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##          1131         1132         1133         1134         1135
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##          1136         1137         1138         1139         1140
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00
##          1141         1142         1143         1144         1145
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          1146         1147         1148         1149         1150
## 2.220446e-16 2.220446e-16 1.000000e+00 1.237843e-08 1.000000e+00
##          1151         1152         1153         1154         1155
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          1156         1157         1158         1159         1160
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
```

```
##          1161         1162         1163         1164         1165
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##          1166         1167         1168         1169         1170
## 1.000000e+00 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##          1171         1172         1173         1174         1175
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##          1176         1177         1178         1179         1180
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##          1181         1182         1183         1184         1185
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##          1186         1187         1188         1189         1190
## 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##          1191         1192         1193         1194         1195
## 1.000000e+00 2.220446e-16 2.220446e-16 2.356545e-13 2.220446e-16
##          1196         1197         1198         1199         1200
## 2.220446e-16 1.000000e+00 2.220446e-16 4.090227e-10 2.220446e-16
##          1201         1202         1203         1204         1205
## 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##          1206         1207         1208         1209         1210
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##          1211         1212         1213         1214         1215
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 3.378042e-13
##          1216         1217         1218         1219         1220
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##          1221         1222         1223         1224         1225
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          1226         1227         1228         1229         1230
## 1.000000e+00 1.000000e+00 1.000000e+00 9.498026e-09 2.220446e-16
##          1231         1232         1233         1234         1235
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          1236         1237         1238         1239         1240
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          1241         1242         1243         1244         1245
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##          1246         1247         1248         1249         1250
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##          1251         1252         1253         1254         1255
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16
##          1256         1257         1258         1259         1260
## 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16
##          1261         1262         1263         1264         1265
## 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##          1266         1267         1268         1269         1270
## 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00
##          1271         1272         1273         1274         1275
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##          1276         1277         1278         1279         1280
## 1.000000e+00 1.000000e+00 1.000000e+00 2.220446e-16 2.220446e-16
##          1281         1282         1283         1284         1285
## 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
```

```
##         1286         1287         1288         1289         1290
## 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00
##         1291         1292         1293         1294         1295
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##         1296         1297         1298         1299         1300
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00
##         1301         1302         1303         1304         1305
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##         1306         1307         1308         1309         1310
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##         1311         1312         1313         1314         1315
## 1.000000e+00 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##         1316         1317         1318         1319         1320
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##         1321         1322         1323         1324         1325
## 1.000000e+00 2.220446e-16 1.000000e+00 2.220446e-16 2.220446e-16
##         1326         1327         1328         1329         1330
## 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##         1331         1332         1333         1334         1335
## 2.220446e-16 2.220446e-16 2.220446e-16 5.198558e-12 2.220446e-16
##         1336         1337         1338         1339         1340
## 2.220446e-16 1.135848e-08 2.220446e-16 1.000000e+00 2.220446e-16
##         1341         1342         1343         1344         1345
## 1.000000e+00 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00
##         1346         1347         1348         1349         1350
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##         1351         1352         1353         1354         1355
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 2.220446e-16
##         1356         1357         1358         1359         1360
## 2.220446e-16 2.220446e-16 2.220446e-16 1.000000e+00 2.220446e-16
##         1361         1362         1363         1364         1365
## 2.220446e-16 1.000000e+00 2.220446e-16 1.000000e+00 1.000000e+00
##         1366         1367         1368         1369         1370
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##         1371         1372         1373         1374         1375
## 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16 2.220446e-16
##         1376         1377         1378         1379         1380
## 2.220446e-16 2.220446e-16 1.000000e+00 1.000000e+00 1.000000e+00
##         1381         1382         1383         1384         1385
## 2.220446e-16 2.220446e-16 1.932294e-10 2.220446e-16 2.220446e-16
```

data$Survivorship

```
##   [1] C  C  NC NC C  C  C  C  C  C  NC C  C  C  NC NC C  C  NC NC NC C  C
##  [24] C  C  C  NC NC C  C  C  C  NC C  NC NC C  C  C  C  NC C  C  NC C  C
##  [47] C  NC NC NC C  C  NC NC C  C  C  C  C  NC C  C  NC NC NC C  C  C
## NC
##  [70] NC C  C  C  NC NC C  C  NC NC C  C  C  NC C  NC C  NC NC NC C  C
## NC
##  [93] C  NC NC C  NC C  C  C  NC C  C  C  C  C  C  C  NC C  C  NC NC NC
```

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NC
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##  [139] NC  C   C   C   NC  C   C   C   C   C   C   C   C   NC  C   C   C   NC  NC  C   NC  C   C
##  [162] C   C   NC  C   NC  NC  C   C   C   C   NC  C   C   C   C   C   C   C   C   C   C   NC
NC
##  [185] C   C   NC  C   C   C   C   NC  C   NC  C   NC  C   C   C   NC  NC  C   NC  C   C   C   C
##  [208] C   NC  NC  C   NC  NC  C   C   C   C   C   NC  C   C   C   NC  NC  C   C   C   C   C
NC
##  [231] C   C   C   NC  C   C   C   C   C   C   C   C   C   C   C   C   NC  C   NC  C   NC  C   C
##  [254] C   C   C   NC  C   C   C   NC  NC  NC  C   C   C   NC  C   C   C   NC  NC  NC  C   NC
NC
##  [277] NC  C   C   NC  C   C   C   NC  C   C   C   NC  NC  NC  C   C   C   NC  NC  C   NC  C   C
##  [300] NC  C   C   C   C   C   NC  NC  C   NC  NC  NC  NC  NC  C   NC  C   NC  C   C   NC  NC  C
##  [323] C   C   C   NC  NC  NC  C   NC  C   C   C   C   C   NC  NC  C   NC  C   C   C   NC  C   C
##  [346] C   C   C   C   NC  NC  NC  C   NC  C   C   NC  NC  C   C   C   NC  C   NC  NC  C   C   C
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NC
##  [392] NC  NC  C   C   C   NC  NC  C   C   C   C   C   C   C   C   C   NC  NC  C   C   C   C
##  [415] C   NC  NC  NC  C   NC  NC  NC  C   NC  NC  C   C   C   C   C   NC  C   C   C   C   C   C
##  [438] C   C   NC  C   NC  C   NC  C   C   NC  NC  NC  NC  NC  NC  C   C   C   C   C   C   C   C
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NC
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##  [507] C   NC  NC  NC  C   C   C   C   NC  NC  NC  C   C   C   C   NC  NC  NC  C   C   C   C   C
##  [530] C   C   C   C   NC  C   C   NC  C   NC  NC  NC  NC  C   NC  C   C   NC  NC  C   C   C   C
##  [553] C   NC  C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   NC  C
##  [576] C   C   C   C   NC  NC  C   C   C   NC  C   C   C   NC  C   C   C   C   NC  C   C   C
NC
##  [599] C   C   C   NC  C   NC  C   C   C   C   C   C   C   NC  C   C   NC  NC  C   C   C   NC  C
##  [622] NC  NC  C   C   NC  C   C   NC  NC  C   C   C   NC  NC  NC  C   C   C   C   C   C   C   C
##  [645] C   C   NC  NC  C   NC  NC  NC  NC  C   C   C   C   C   C   NC  NC  NC  NC  C   C   C   C
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##  [691] C   NC  C   C   C   C   C   C   C   C   C   C   C   C   NC  NC  NC  C   NC  C   C   NC  C
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##  [760] NC  NC  C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   NC  C   C
NC
##  [783] NC  NC  NC  NC  C   C   C   NC  NC  NC  C   C   NC  C   NC  C   NC  NC  NC  C   C   C   C
##  [806] C   C   C   C   C   C   C   C   C   C   NC  C   NC  C   C   NC  C   C   C   NC  C   C
NC
##  [829] C   C   C   NC  C   C   C   C   C   C   NC  C   C   C   NC  C   NC  C   NC  C   NC  C   C
##  [852] NC  C   C   C   NC  C   C   C   C   C   C   NC  C   C   C   C   C   C   NC  C   NC  NC
NC
##  [875] C   C   C   C   C   C   C   C   NC  NC  C   C   C   C   C   NC  C   C   C   NC  NC  NC  C
##  [898] NC  C   C   NC  NC  C   C   NC  NC  C   C   NC  C   C   C   C   C   C   C   C   C   C   C
##  [921] NC  C   NC  C   C   NC  C   NC  NC  NC  C   NC  C   C   C   C   C   C   NC  NC  C   C
##  [944] C   C   C   C   C   C   C   C   C   C   C   C   C   C   C   NC  NC  NC  C   C   NC
```

```
NC
## [967] C  NC NC NC C  C  C  C  NC C  C  C  C  NC C  NC C  NC NC NC C  NC
NC
## [990] C  C  C  C  NC C  C  C  C  NC NC NC NC C  C  C  C  NC C  C  NC C  C
## [1013] NC C  NC C  C  C  NC NC NC C  NC C  C  NC C  C  C  NC C  NC C  NC C
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NC
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NC
## [1174] NC C  C  C  C  NC NC C  C  C  NC NC NC NC NC NC NC NC C  C  C  C  C
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NC
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NC
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## [1289] C  NC C  C  C  C  C  C  C  C  C  NC NC C  C  NC C  NC C  C  NC C
NC
## [1312] C  C  C  C  C  C  C  NC C  NC C  NC C  C  NC C  NC NC C  C  C  C  C
## [1335] C  C  C  C  NC C  NC C  C  NC NC C  C  C  C  C  C  NC NC C  C  C
## [1358] C  NC C  C  NC C  NC NC C  C  C  C  C  C  C  C  C  C  C  NC NC
NC
## [1381] C  C  C  C  C
## Levels: C NC
```

```r
#pdataF <- as.factor(ifelse(test=as.numeric(pdata>0.5) == 0, yes="Healthy",
no="Unhealthy"))
#install.packages("e1071",
lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(e1071)
#confusionMatrix(pdataF, data$Survivorship)
#install.packages("pROC",
lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(pROC)
```

```
## Type 'citation("pROC")' for a citation.
```

```
##
## Attaching package: 'pROC'
```

```
## The following objects are masked from 'package:stats':
##
##     cov, smooth, var
```

```r
roc(data$Survivorship,logistic$fitted.values,plot=TRUE)
```

```
## Setting levels: control = C, case = NC

## Setting direction: controls < cases

##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,     plot = TRUE)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 1

par(pty = "s")
roc(data$Survivorship,logistic$fitted.values,plot=TRUE)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```
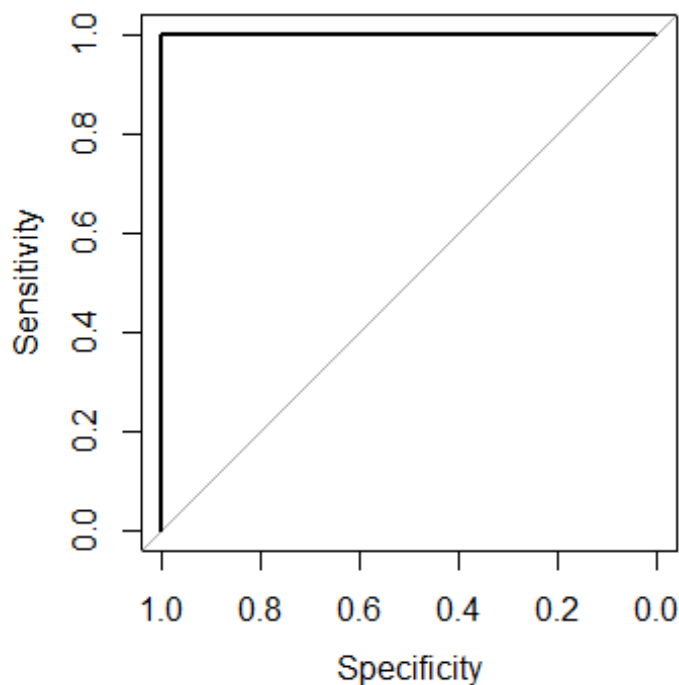


```
##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,     plot = TRUE)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 1
```

```
## NOTE: By default, roc() uses specificity on the x-axis and the values
range
## from 1 to 0. This makes the graph look like what we would expect, but the
## x-axis itself might induce a headache. To use 1-specificity (i.e. the
## False Positive Rate) on the x-axis, set "legacy.axes" to TRUE.
roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```
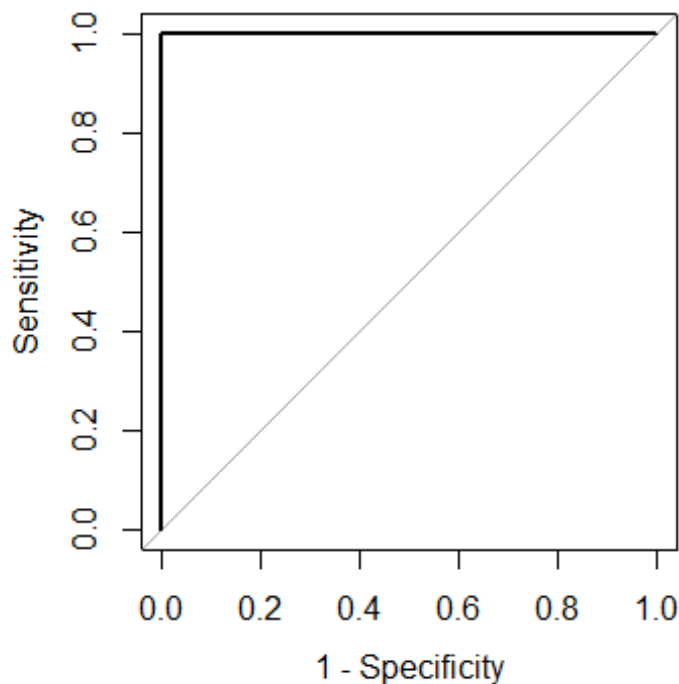


```
##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,      plot = TRUE, legacy.axes = TRUE)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 1

roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage")

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```
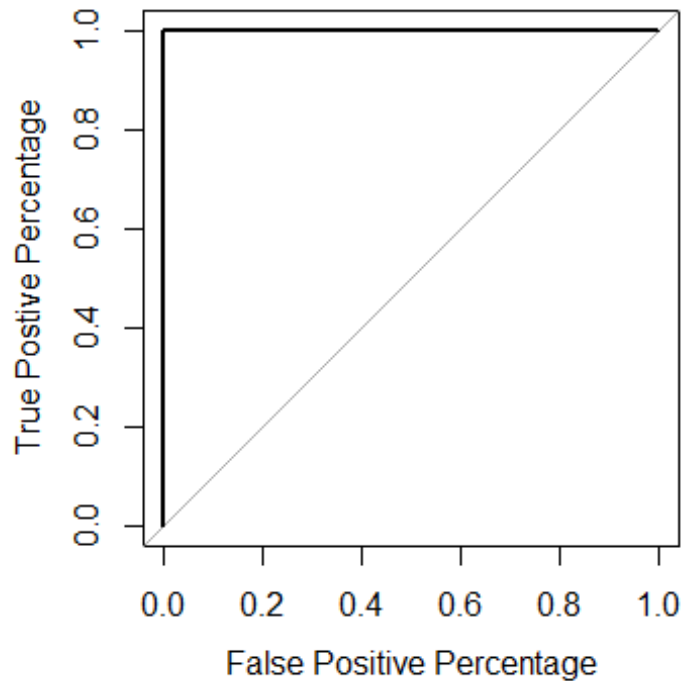
```
## 
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,    plot = TRUE, legacy.axes = TRUE, xlab = "False
Positive Percentage",    ylab = "True Postive Percentage")
## 
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 1

roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```

```
##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,    plot = TRUE, legacy.axes = TRUE, xlab = "False
Positive Percentage",    ylab = "True Postive Percentage", col = "#377eb8",
lwd = 4)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 1
```

```r
roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4)
```

```
## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```

```
##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,    plot = TRUE, legacy.axes = TRUE, xlab = "False
Positive Percentage",    ylab = "True Postive Percentage", col = "#377eb8",
lwd = 4)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
```

```
cases (data$Survivorship NC).
## Area under the curve: 1
```

```
## If we want to find out the optimal threshold we can store the
## data used to make the ROC graph in a variable...
roc.info <- roc(data$Survivorship, logistic$fitted.values, legacy.axes=TRUE)
```

```
## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```

```
str(roc.info)
```

```
## List of 15
##  $ percent         : logi FALSE
##  $ sensitivities   : num [1:71] 1 1 1 1 1 1 1 1 1 1 ...
##  $ specificities   : num [1:71] 0 0.966 0.967 0.968 0.969 ...
##  $ thresholds      : num [1:71] -Inf 5.32e-14 1.71e-13 2.87e-13 7.82e-13
...
##  $ direction       : chr "<"
##  $ cases           : Named num [1:482] 1 1 1 1 1 ...
##   ..- attr(*, "names")= chr [1:482] "3" "4" "11" "15" ...
##  $ controls        : Named num [1:903] 2.22e-16 2.22e-16 2.22e-16 2.22e-
16 2.22e-16 ...
##   ..- attr(*, "names")= chr [1:903] "1" "2" "5" "6" ...
##  $ fun.sesp        :function (thresholds, controls, cases, direction)
##  $ auc             : 'auc' num 1
##   ..- attr(*, "partial.auc")= logi FALSE
##   ..- attr(*, "percent")= logi FALSE
##   ..- attr(*, "roc")=List of 15
##   .. ..$ percent         : logi FALSE
##   .. ..$ sensitivities   : num [1:71] 1 1 1 1 1 1 1 1 1 1 ...
##   .. ..$ specificities   : num [1:71] 0 0.966 0.967 0.968 0.969 ...
##   .. ..$ thresholds      : num [1:71] -Inf 5.32e-14 1.71e-13 2.87e-13
7.82e-13 ...
##   .. ..$ direction       : chr "<"
##   .. ..$ cases           : Named num [1:482] 1 1 1 1 1 ...
##   .. .. ..- attr(*, "names")= chr [1:482] "3" "4" "11" "15" ...
##   .. ..$ controls        : Named num [1:903] 2.22e-16 2.22e-16 2.22e-16
2.22e-16 2.22e-16 ...
##   .. .. ..- attr(*, "names")= chr [1:903] "1" "2" "5" "6" ...
##   .. ..$ fun.sesp        :function (thresholds, controls, cases,
direction)
##   .. ..$ auc             : 'auc' num 1
##   .. .. ..- attr(*, "partial.auc")= logi FALSE
##   .. .. ..- attr(*, "percent")= logi FALSE
##   .. .. ..- attr(*, "roc")=List of 8
##   .. .. .. ..$ percent      : logi FALSE
##   .. .. .. ..$ sensitivities: num [1:71] 1 1 1 1 1 1 1 1 1 1 ...
##   .. .. .. ..$ specificities: num [1:71] 0 0.966 0.967 0.968 0.969 ...
##   .. .. .. ..$ thresholds   : num [1:71] -Inf 5.32e-14 1.71e-13 2.87e-13
7.82e-13 ...
```

```
##   .. .. .. ..$ direction     : chr "<"
##   .. .. .. ..$ cases         : Named num [1:482] 1 1 1 1 1 ...
##   .. .. .. .. ..- attr(*, "names")= chr [1:482] "3" "4" "11" "15" ...
##   .. .. .. ..$ controls      : Named num [1:903] 2.22e-16 2.22e-16 2.22e-16
2.22e-16 2.22e-16 ...
##   .. .. .. .. ..- attr(*, "names")= chr [1:903] "1" "2" "5" "6" ...
##   .. .. .. ..$ fun.sesp      :function (thresholds, controls, cases,
direction)
##   .. .. .. ..- attr(*, "class")= chr "roc"
##   .. ..$ call             : language roc.default(response =
data$Survivorship, predictor = logistic$fitted.values,     legacy.axes =
TRUE)
##   .. ..$ original.predictor: Named num [1:1385] 2.22e-16 2.22e-16 1.00
1.00 2.22e-16 ...
##   .. .. ..- attr(*, "names")= chr [1:1385] "1" "2" "3" "4" ...
##   .. ..$ original.response : Factor w/ 2 levels "C","NC": 1 1 2 2 1 1 1 1
1 1 ...
##   .. ..$ predictor         : Named num [1:1385] 2.22e-16 2.22e-16 1.00
1.00 2.22e-16 ...
##   .. .. ..- attr(*, "names")= chr [1:1385] "1" "2" "3" "4" ...
##   .. ..$ response          : Factor w/ 2 levels "C","NC": 1 1 2 2 1 1 1 1
1 1 ...
##   .. ..$ levels            : chr [1:2] "C" "NC"
##   .. ..- attr(*, "class")= chr "roc"
##  $ call             : language roc.default(response = data$Survivorship,
predictor = logistic$fitted.values,     legacy.axes = TRUE)
##  $ original.predictor: Named num [1:1385] 2.22e-16 2.22e-16 1.00 1.00
2.22e-16 ...
##   ..- attr(*, "names")= chr [1:1385] "1" "2" "3" "4" ...
##  $ original.response : Factor w/ 2 levels "C","NC": 1 1 2 2 1 1 1 1 1 1
...
##  $ predictor         : Named num [1:1385] 2.22e-16 2.22e-16 1.00 1.00
2.22e-16 ...
##   ..- attr(*, "names")= chr [1:1385] "1" "2" "3" "4" ...
##  $ response          : Factor w/ 2 levels "C","NC": 1 1 2 2 1 1 1 1 1 1
...
##  $ levels            : chr [1:2] "C" "NC"
##  - attr(*, "class")= chr "roc"
```

```r
roc.df <- data.frame(tpp=roc.info$sensitivities*100, ## tpp = true positive
percentage
                     fpp=(1 - roc.info$specificities)*100, ## fpp = false
positive precentage
                     thresholds=roc.info$thresholds)
roc.df
```

```
##        tpp         fpp   thresholds
## 1 100.00000 100.0000000        -Inf
## 2 100.00000   3.4330011 5.323833e-14
## 3 100.00000   3.3222591 1.709546e-13
```

```
## 4  100.00000    3.2115172 2.867293e-13
## 5  100.00000    3.1007752 7.822429e-13
## 6  100.00000    2.9900332 3.212620e-12
## 7  100.00000    2.8792913 1.332148e-11
## 8  100.00000    2.7685493 6.246558e-11
## 9  100.00000    2.6578073 1.065926e-10
## 10 100.00000    2.5470653 1.514639e-10
## 11 100.00000    2.4363234 2.243080e-10
## 12 100.00000    2.3255814 3.322046e-10
## 13 100.00000    2.2148394 4.842714e-10
## 14 100.00000    2.1040975 1.012910e-09
## 15 100.00000    1.9933555 2.162425e-09
## 16 100.00000    1.8826135 3.249212e-09
## 17 100.00000    1.7718715 3.671963e-09
## 18 100.00000    1.6611296 3.795815e-09
## 19 100.00000    1.5503876 4.255825e-09
## 20 100.00000    1.4396456 5.278876e-09
## 21 100.00000    1.3289037 6.314976e-09
## 22 100.00000    1.2181617 6.925201e-09
## 23 100.00000    1.1074197 7.904498e-09
## 24 100.00000    0.9966777 9.076446e-09
## 25 100.00000    0.8859358 1.037345e-08
## 26 100.00000    0.7751938 1.130368e-08
## 27 100.00000    0.6644518 1.186846e-08
## 28 100.00000    0.5537099 1.238450e-08
## 29 100.00000    0.4429679 1.294924e-08
## 30 100.00000    0.3322259 1.375664e-08
## 31 100.00000    0.2214839 1.411637e-08
## 32 100.00000    0.1107420 1.712244e-08
## 33 100.00000    0.0000000 5.000000e-01
## 34  99.79253    0.0000000 1.000000e+00
## 35  99.58506    0.0000000 1.000000e+00
## 36  99.37759    0.0000000 1.000000e+00
## 37  99.17012    0.0000000 1.000000e+00
## 38  98.96266    0.0000000 1.000000e+00
## 39  98.75519    0.0000000 1.000000e+00
## 40  98.54772    0.0000000 1.000000e+00
## 41  98.34025    0.0000000 1.000000e+00
## 42  98.13278    0.0000000 1.000000e+00
## 43  97.92531    0.0000000 1.000000e+00
## 44  97.71784    0.0000000 1.000000e+00
## 45  97.51037    0.0000000 1.000000e+00
## 46  97.30290    0.0000000 1.000000e+00
## 47  97.09544    0.0000000 1.000000e+00
## 48  96.88797    0.0000000 1.000000e+00
## 49  96.68050    0.0000000 1.000000e+00
## 50  96.47303    0.0000000 1.000000e+00
## 51  96.26556    0.0000000 1.000000e+00
## 52  96.05809    0.0000000 1.000000e+00
## 53  95.85062    0.0000000 1.000000e+00
```

```
## 54  95.64315   0.0000000 1.000000e+00
## 55  95.43568   0.0000000 1.000000e+00
## 56  95.22822   0.0000000 1.000000e+00
## 57  95.02075   0.0000000 1.000000e+00
## 58  94.81328   0.0000000 1.000000e+00
## 59  94.60581   0.0000000 1.000000e+00
## 60  94.39834   0.0000000 1.000000e+00
## 61  94.19087   0.0000000 1.000000e+00
## 62  93.98340   0.0000000 1.000000e+00
## 63  93.77593   0.0000000 1.000000e+00
## 64  93.56846   0.0000000 1.000000e+00
## 65  93.36100   0.0000000 1.000000e+00
## 66  93.15353   0.0000000 1.000000e+00
## 67  92.94606   0.0000000 1.000000e+00
## 68  92.73859   0.0000000 1.000000e+00
## 69  92.53112   0.0000000 1.000000e+00
## 70  92.32365   0.0000000 1.000000e+00
## 71   0.00000   0.0000000           Inf
```

```r
head(roc.df) ## head() will show us the values for the upper right-hand
corner of the ROC graph, when the threshold is so low
```

```
##   tpp        fpp  thresholds
## 1 100 100.000000        -Inf
## 2 100   3.433001 5.323833e-14
## 3 100   3.322259 1.709546e-13
## 4 100   3.211517 2.867293e-13
## 5 100   3.100775 7.822429e-13
## 6 100   2.990033 3.212620e-12
```

```r
## (negative infinity) that every single sample is called "obese".
## Thus TPP = 100% and FPP = 100%
tail(roc.df) ## tail() will show us the values for the lower left-hand corner
```

```
##          tpp fpp thresholds
## 66 93.15353   0          1
## 67 92.94606   0          1
## 68 92.73859   0          1
## 69 92.53112   0          1
## 70 92.32365   0          1
## 71  0.00000   0        Inf
```

```r
## of the ROC graph, when the threshold is so high (infinity)
## that every single sample is called "not obese".
## Thus, TPP = 0% and FPP = 0%
## now let's look at the thresholds between TPP 60% and 80%
roc.df[roc.df$tpp > 60 & roc.df$tpp < 80,]
```

```
## [1] tpp        fpp        thresholds
## <0 rows> (or 0-length row.names)
```

```
roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4, percent=TRUE)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```
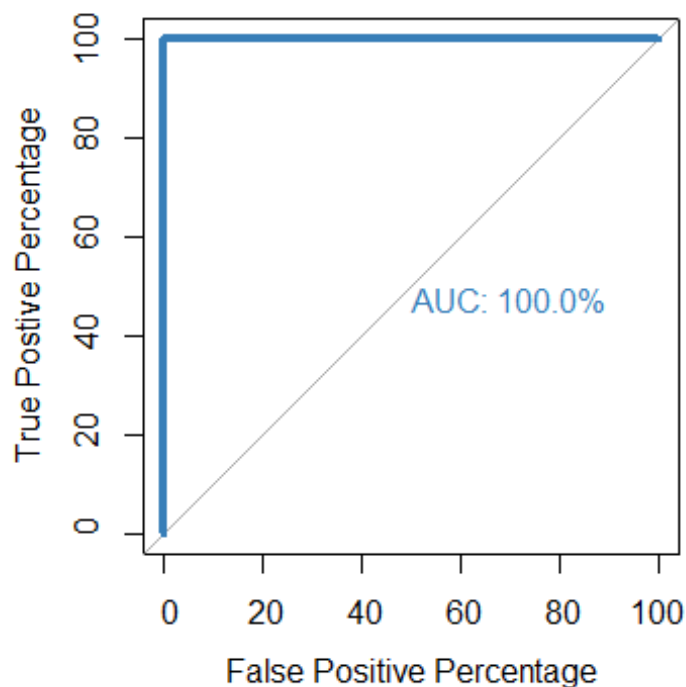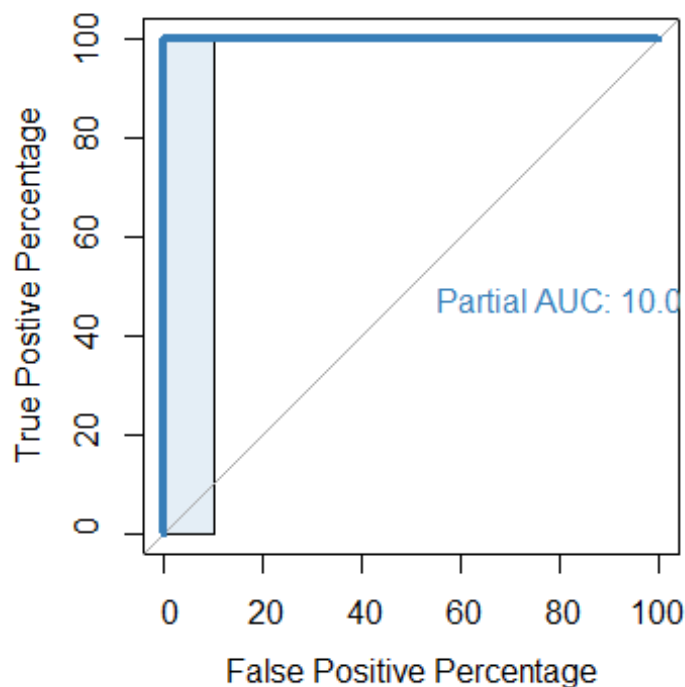


```
##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,      percent = TRUE, plot = TRUE, legacy.axes = TRUE,
xlab = "False Positive Percentage",      ylab = "True Postive Percentage", col
= "#377eb8", lwd = 4)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 100%
```

```
roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4, percent=TRUE, print.auc=TRUE)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```

```
## 
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,    percent = TRUE, plot = TRUE, legacy.axes = TRUE,
xlab = "False Positive Percentage",    ylab = "True Postive Percentage", col
= "#377eb8", lwd = 4,    print.auc = TRUE)
## 
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Area under the curve: 100%

roc(data$Survivorship,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4, percent=TRUE, print.auc=TRUE, partial.auc=c(100, 90),
auc.polygon = TRUE, auc.polygon.col = "#377eb822", print.auc.x=45)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases
```

```
##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic$fitted.values,     percent = TRUE, plot = TRUE, legacy.axes = TRUE,
xlab = "False Positive Percentage",     ylab = "True Postive Percentage", col
= "#377eb8", lwd = 4,     print.auc = TRUE, partial.auc = c(100, 90),
auc.polygon = TRUE,     auc.polygon.col = "#377eb822", print.auc.x = 45)
##
## Data: logistic$fitted.values in 903 controls (data$Survivorship C) < 482
cases (data$Survivorship NC).
## Partial area under the curve (specificity 100%-90%): 10%

# Lets do two roc plots to understand which model is better
roc(data$Survivorship, logistic_simple$fitted.values, plot=TRUE,
legacy.axes=TRUE, percent=TRUE, xlab="False Positive Percentage", ylab="True
Postive Percentage", col="#377eb8", lwd=4, print.auc=TRUE)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases

##
## Call:
## roc.default(response = data$Survivorship, predictor =
logistic_simple$fitted.values,     percent = TRUE, plot = TRUE, legacy.axes =
TRUE, xlab = "False Positive Percentage",     ylab = "True Postive
Percentage", col = "#377eb8", lwd = 4,     print.auc = TRUE)
##
```

```
## Data: logistic_simple$fitted.values in 903 controls (data$Survivorship C)
< 482 cases (data$Survivorship NC).
## Area under the curve: 52.71%

# Lets add the other graph
plot.roc(data$Survivorship, logistic$fitted.values, percent=TRUE,
col="#4daf4a", lwd=4, print.auc=TRUE, add=TRUE, print.auc.y=40)

## Setting levels: control = C, case = NC
## Setting direction: controls < cases

legend("bottomright", legend=c("Simple", "Non Simple"), col=c("#377eb8",
"#4daf4a"), lwd=4) # Make it user friendly
```