Chapter 4

Chapter 4 The tidyverse

Up to now we have been manipulating vectors by reordering and subsetting them through indexing. However, once we start more advanced analyses, the preferred unit for data storage is not the vector but the data frame. In this chapter we learn to work directly with data frames, which greatly facilitate the organization of information. We will be using data frames for the majority of this book. We will focus on a specific data format referred to as tidy and on specific collection of packages that are particularly helpful for working with tidy data referred to as the tidyverse.

We can load all the tidyverse packages at once by installing and loading the tidyverse package:

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.2     v dplyr   1.0.7
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   2.0.1     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

We will learn how to implement the tidyverse approach throughout the book, but before delving into the details, in this chapter we introduce some of the most widely used tidyverse functionality, starting with the dplyr package for manipulating data frames and the purrr package for working with functions. Note that the tidyverse also includes a graphing package, ggplot2, which we introduce later in Chapter 7 in the Data Visualization part of the book; the readr package discussed in Chapter 5; and many others. In this chapter, we first introduce the concept of tidy data and then demonstrate how we use the tidyverse to work with data frames in this format.

4.1 Tidy data

We say that a data table is in tidy format if each row represents one observation and columns represent the different variables available for each of these observations. The murders dataset is an example of a tidy data frame.

```
#>        state abb region population total
#> 1    Alabama  AL  South    4779736   135
#> 2     Alaska  AK   West     710231    19
#> 3    Arizona  AZ   West    6392017   232
#> 4   Arkansas  AR  South    2915918    93
#> 5 California  CA   West   37253956  1257
#> 6   Colorado  CO   West    5029196    65
```

Each row represent a state with each of the five columns providing a different variable related to these states: name, abbreviation, region, population, and total murders.

To see how the same information can be provided in different formats, consider the following example:

```
#>       country year fertility
#> 1     Germany 1960      2.41
#> 2 South Korea 1960      6.16
#> 3     Germany 1961      2.44
#> 4 South Korea 1961      5.99
#> 5     Germany 1962      2.47
#> 6 South Korea 1962      5.79
```

This tidy dataset provides fertility rates for two countries across the years. This is a tidy dataset because each row presents one observation with the three variables being country, year, and fertility rate. However, this dataset originally came in another format and was reshaped for the dslabs package. Originally, the data was in the following format:

```
#>       country 1960 1961 1962
#> 1     Germany 2.41 2.44 2.47
#> 2 South Korea 6.16 5.99 5.79
```

The same information is provided, but there are two important differences in the format: 1) each row includes several observations and 2) one of the variables, year, is stored in the header. For the tidyverse packages to be optimally used, data need to be reshaped into tidy format, which you will learn to do in the Data Wrangling part of the book. Until then, we will use example datasets that are already in tidy format.

Although not immediately obvious, as you go through the book you will start to appreciate the advantages of working in a framework in which functions use tidy formats for both inputs and outputs. You will see how this permits the data analyst to focus on more important aspects of the analysis rather than the format of the data.

4.2 Exercises

1. Examine the built-in dataset co2. Which of the following is true:

```
co2
```

```
##         Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1959 315.42 316.31 316.50 317.56 318.13 318.00 316.39 314.65 313.68 313.18
## 1960 316.27 316.81 317.42 318.87 319.87 319.43 318.01 315.74 314.00 313.68
## 1961 316.73 317.54 318.38 319.31 320.42 319.61 318.42 316.63 314.83 315.16
## 1962 317.78 318.40 319.53 320.42 320.85 320.45 319.45 317.25 316.11 315.27
## 1963 318.58 318.92 319.70 321.22 322.08 321.31 319.58 317.61 316.05 315.83
## 1964 319.41 320.07 320.74 321.40 322.06 321.73 320.27 318.54 316.54 316.71
## 1965 319.27 320.28 320.73 321.97 322.00 321.71 321.05 318.71 317.66 317.14
## 1966 320.46 321.43 322.23 323.54 323.91 323.59 322.24 320.20 318.48 317.94
## 1967 322.17 322.34 322.88 324.25 324.83 323.93 322.38 320.76 319.10 319.24
## 1968 322.40 322.99 323.73 324.86 325.40 325.20 323.98 321.95 320.18 320.09
## 1969 323.83 324.26 325.47 326.50 327.21 326.54 325.72 323.50 322.22 321.62
## 1970 324.89 325.82 326.77 327.97 327.91 327.50 326.18 324.53 322.93 322.90
## 1971 326.01 326.51 327.01 327.62 328.76 328.40 327.20 325.27 323.20 323.40
## 1972 326.60 327.47 327.58 329.56 329.90 328.92 327.88 326.16 324.68 325.04
```

```
## 1973 328.37 329.40 330.14 331.33 332.31 331.90 330.70 329.15 327.35 327.02
## 1974 329.18 330.55 331.32 332.48 332.92 332.08 331.01 329.23 327.27 327.21
## 1975 330.23 331.25 331.87 333.14 333.80 333.43 331.73 329.90 328.40 328.17
## 1976 331.58 332.39 333.33 334.41 334.71 334.17 332.89 330.77 329.14 328.78
## 1977 332.75 333.24 334.53 335.90 336.57 336.10 334.76 332.59 331.42 330.98
## 1978 334.80 335.22 336.47 337.59 337.84 337.72 336.37 334.51 332.60 332.38
## 1979 336.05 336.59 337.79 338.71 339.30 339.12 337.56 335.92 333.75 333.70
## 1980 337.84 338.19 339.91 340.60 341.29 341.00 339.39 337.43 335.72 335.84
## 1981 339.06 340.30 341.21 342.33 342.74 342.08 340.32 338.26 336.52 336.68
## 1982 340.57 341.44 342.53 343.39 343.96 343.18 341.88 339.65 337.81 337.69
## 1983 341.20 342.35 342.93 344.77 345.58 345.14 343.81 342.21 339.69 339.82
## 1984 343.52 344.33 345.11 346.88 347.25 346.62 345.22 343.11 340.90 341.18
## 1985 344.79 345.82 347.25 348.17 348.74 348.07 346.38 344.51 342.92 342.62
## 1986 346.11 346.78 347.68 349.37 350.03 349.37 347.76 345.73 344.68 343.99
## 1987 347.84 348.29 349.23 350.80 351.66 351.07 349.33 347.92 346.27 346.18
## 1988 350.25 351.54 352.05 353.41 354.04 353.62 352.22 350.27 348.55 348.72
## 1989 352.60 352.92 353.53 355.26 355.52 354.97 353.75 351.52 349.64 349.83
## 1990 353.50 354.55 355.23 356.04 357.00 356.07 354.67 352.76 350.82 351.04
## 1991 354.59 355.63 357.03 358.48 359.22 358.12 356.06 353.92 352.05 352.11
## 1992 355.88 356.63 357.72 359.07 359.58 359.17 356.94 354.92 352.94 353.23
## 1993 356.63 357.10 358.32 359.41 360.23 359.55 357.53 355.48 353.67 353.95
## 1994 358.34 358.89 359.95 361.25 361.67 360.94 359.55 357.49 355.84 356.00
## 1995 359.98 361.03 361.66 363.48 363.82 363.30 361.94 359.50 358.11 357.80
## 1996 362.09 363.29 364.06 364.76 365.45 365.01 363.70 361.54 359.51 359.65
## 1997 363.23 364.06 364.61 366.40 366.84 365.68 364.52 362.57 360.24 360.83
##         Nov    Dec
## 1959 314.66 315.43
## 1960 314.84 316.03
## 1961 315.94 316.85
## 1962 316.53 317.53
## 1963 316.91 318.20
## 1964 317.53 318.55
## 1965 318.70 319.25
## 1966 319.63 320.87
## 1967 320.56 321.80
## 1968 321.16 322.74
## 1969 322.69 323.95
## 1970 323.85 324.96
## 1971 324.63 325.85
## 1972 326.34 327.39
## 1973 327.99 328.48
## 1974 328.29 329.41
## 1975 329.32 330.59
## 1976 330.14 331.52
## 1977 332.24 333.68
## 1978 333.75 334.78
## 1979 335.12 336.56
## 1980 336.93 338.04
## 1981 338.19 339.44
## 1982 339.09 340.32
## 1983 340.98 342.82
## 1984 342.80 344.04
## 1985 344.06 345.38
## 1986 345.48 346.72
```

```
## 1987 347.64 348.78
## 1988 349.91 351.18
## 1989 351.14 352.37
## 1990 352.69 354.07
## 1991 353.64 354.89
## 1992 354.09 355.33
## 1993 355.30 356.78
## 1994 357.59 359.05
## 1995 359.61 360.74
## 1996 360.80 362.38
## 1997 362.49 364.34
```

Answer: d.co2 is not tidy: to be tidy we would have to wrangle it to have three columns (year, month and value), then each co2 observation would have a row.

2. Examine the built-in dataset ChickWeight. Which of the following is true:

```
ChickWeight
```

```
##      weight Time Chick Diet
## 1        42    0     1    1
## 2        51    2     1    1
## 3        59    4     1    1
## 4        64    6     1    1
## 5        76    8     1    1
## 6        93   10     1    1
## 7       106   12     1    1
## 8       125   14     1    1
## 9       149   16     1    1
## 10      171   18     1    1
## 11      199   20     1    1
## 12      205   21     1    1
## 13       40    0     2    1
## 14       49    2     2    1
## 15       58    4     2    1
## 16       72    6     2    1
## 17       84    8     2    1
## 18      103   10     2    1
## 19      122   12     2    1
## 20      138   14     2    1
## 21      162   16     2    1
## 22      187   18     2    1
## 23      209   20     2    1
## 24      215   21     2    1
## 25       43    0     3    1
## 26       39    2     3    1
## 27       55    4     3    1
## 28       67    6     3    1
## 29       84    8     3    1
## 30       99   10     3    1
## 31      115   12     3    1
## 32      138   14     3    1
## 33      163   16     3    1
```

```
## 34        187   18      3     1
## 35        198   20      3     1
## 36        202   21      3     1
## 37         42    0      4     1
## 38         49    2      4     1
## 39         56    4      4     1
## 40         67    6      4     1
## 41         74    8      4     1
## 42         87   10      4     1
## 43        102   12      4     1
## 44        108   14      4     1
## 45        136   16      4     1
## 46        154   18      4     1
## 47        160   20      4     1
## 48        157   21      4     1
## 49         41    0      5     1
## 50         42    2      5     1
## 51         48    4      5     1
## 52         60    6      5     1
## 53         79    8      5     1
## 54        106   10      5     1
## 55        141   12      5     1
## 56        164   14      5     1
## 57        197   16      5     1
## 58        199   18      5     1
## 59        220   20      5     1
## 60        223   21      5     1
## 61         41    0      6     1
## 62         49    2      6     1
## 63         59    4      6     1
## 64         74    6      6     1
## 65         97    8      6     1
## 66        124   10      6     1
## 67        141   12      6     1
## 68        148   14      6     1
## 69        155   16      6     1
## 70        160   18      6     1
## 71        160   20      6     1
## 72        157   21      6     1
## 73         41    0      7     1
## 74         49    2      7     1
## 75         57    4      7     1
## 76         71    6      7     1
## 77         89    8      7     1
## 78        112   10      7     1
## 79        146   12      7     1
## 80        174   14      7     1
## 81        218   16      7     1
## 82        250   18      7     1
## 83        288   20      7     1
## 84        305   21      7     1
## 85         42    0      8     1
## 86         50    2      8     1
## 87         61    4      8     1
```

```
## 88      71   6   8  1
## 89      84   8   8  1
## 90      93  10   8  1
## 91     110  12   8  1
## 92     116  14   8  1
## 93     126  16   8  1
## 94     134  18   8  1
## 95     125  20   8  1
## 96      42   0   9  1
## 97      51   2   9  1
## 98      59   4   9  1
## 99      68   6   9  1
## 100     85   8   9  1
## 101     96  10   9  1
## 102     90  12   9  1
## 103     92  14   9  1
## 104     93  16   9  1
## 105    100  18   9  1
## 106    100  20   9  1
## 107     98  21   9  1
## 108     41   0  10  1
## 109     44   2  10  1
## 110     52   4  10  1
## 111     63   6  10  1
## 112     74   8  10  1
## 113     81  10  10  1
## 114     89  12  10  1
## 115     96  14  10  1
## 116    101  16  10  1
## 117    112  18  10  1
## 118    120  20  10  1
## 119    124  21  10  1
## 120     43   0  11  1
## 121     51   2  11  1
## 122     63   4  11  1
## 123     84   6  11  1
## 124    112   8  11  1
## 125    139  10  11  1
## 126    168  12  11  1
## 127    177  14  11  1
## 128    182  16  11  1
## 129    184  18  11  1
## 130    181  20  11  1
## 131    175  21  11  1
## 132     41   0  12  1
## 133     49   2  12  1
## 134     56   4  12  1
## 135     62   6  12  1
## 136     72   8  12  1
## 137     88  10  12  1
## 138    119  12  12  1
## 139    135  14  12  1
## 140    162  16  12  1
## 141    185  18  12  1
```

```
## 142    195   20    12    1
## 143    205   21    12    1
## 144     41    0    13    1
## 145     48    2    13    1
## 146     53    4    13    1
## 147     60    6    13    1
## 148     65    8    13    1
## 149     67   10    13    1
## 150     71   12    13    1
## 151     70   14    13    1
## 152     71   16    13    1
## 153     81   18    13    1
## 154     91   20    13    1
## 155     96   21    13    1
## 156     41    0    14    1
## 157     49    2    14    1
## 158     62    4    14    1
## 159     79    6    14    1
## 160    101    8    14    1
## 161    128   10    14    1
## 162    164   12    14    1
## 163    192   14    14    1
## 164    227   16    14    1
## 165    248   18    14    1
## 166    259   20    14    1
## 167    266   21    14    1
## 168     41    0    15    1
## 169     49    2    15    1
## 170     56    4    15    1
## 171     64    6    15    1
## 172     68    8    15    1
## 173     68   10    15    1
## 174     67   12    15    1
## 175     68   14    15    1
## 176     41    0    16    1
## 177     45    2    16    1
## 178     49    4    16    1
## 179     51    6    16    1
## 180     57    8    16    1
## 181     51   10    16    1
## 182     54   12    16    1
## 183     42    0    17    1
## 184     51    2    17    1
## 185     61    4    17    1
## 186     72    6    17    1
## 187     83    8    17    1
## 188     89   10    17    1
## 189     98   12    17    1
## 190    103   14    17    1
## 191    113   16    17    1
## 192    123   18    17    1
## 193    133   20    17    1
## 194    142   21    17    1
## 195     39    0    18    1
```

```
## 196     35    2    18    1
## 197     43    0    19    1
## 198     48    2    19    1
## 199     55    4    19    1
## 200     62    6    19    1
## 201     65    8    19    1
## 202     71   10    19    1
## 203     82   12    19    1
## 204     88   14    19    1
## 205    106   16    19    1
## 206    120   18    19    1
## 207    144   20    19    1
## 208    157   21    19    1
## 209     41    0    20    1
## 210     47    2    20    1
## 211     54    4    20    1
## 212     58    6    20    1
## 213     65    8    20    1
## 214     73   10    20    1
## 215     77   12    20    1
## 216     89   14    20    1
## 217     98   16    20    1
## 218    107   18    20    1
## 219    115   20    20    1
## 220    117   21    20    1
## 221     40    0    21    2
## 222     50    2    21    2
## 223     62    4    21    2
## 224     86    6    21    2
## 225    125    8    21    2
## 226    163   10    21    2
## 227    217   12    21    2
## 228    240   14    21    2
## 229    275   16    21    2
## 230    307   18    21    2
## 231    318   20    21    2
## 232    331   21    21    2
## 233     41    0    22    2
## 234     55    2    22    2
## 235     64    4    22    2
## 236     77    6    22    2
## 237     90    8    22    2
## 238     95   10    22    2
## 239    108   12    22    2
## 240    111   14    22    2
## 241    131   16    22    2
## 242    148   18    22    2
## 243    164   20    22    2
## 244    167   21    22    2
## 245     43    0    23    2
## 246     52    2    23    2
## 247     61    4    23    2
## 248     73    6    23    2
## 249     90    8    23    2
```

```
## 250    103  10    23    2
## 251    127  12    23    2
## 252    135  14    23    2
## 253    145  16    23    2
## 254    163  18    23    2
## 255    170  20    23    2
## 256    175  21    23    2
## 257     42   0    24    2
## 258     52   2    24    2
## 259     58   4    24    2
## 260     74   6    24    2
## 261     66   8    24    2
## 262     68  10    24    2
## 263     70  12    24    2
## 264     71  14    24    2
## 265     72  16    24    2
## 266     72  18    24    2
## 267     76  20    24    2
## 268     74  21    24    2
## 269     40   0    25    2
## 270     49   2    25    2
## 271     62   4    25    2
## 272     78   6    25    2
## 273    102   8    25    2
## 274    124  10    25    2
## 275    146  12    25    2
## 276    164  14    25    2
## 277    197  16    25    2
## 278    231  18    25    2
## 279    259  20    25    2
## 280    265  21    25    2
## 281     42   0    26    2
## 282     48   2    26    2
## 283     57   4    26    2
## 284     74   6    26    2
## 285     93   8    26    2
## 286    114  10    26    2
## 287    136  12    26    2
## 288    147  14    26    2
## 289    169  16    26    2
## 290    205  18    26    2
## 291    236  20    26    2
## 292    251  21    26    2
## 293     39   0    27    2
## 294     46   2    27    2
## 295     58   4    27    2
## 296     73   6    27    2
## 297     87   8    27    2
## 298    100  10    27    2
## 299    115  12    27    2
## 300    123  14    27    2
## 301    144  16    27    2
## 302    163  18    27    2
## 303    185  20    27    2
```

```
## 304    192  21  27  2
## 305     39   0  28  2
## 306     46   2  28  2
## 307     58   4  28  2
## 308     73   6  28  2
## 309     92   8  28  2
## 310    114  10  28  2
## 311    145  12  28  2
## 312    156  14  28  2
## 313    184  16  28  2
## 314    207  18  28  2
## 315    212  20  28  2
## 316    233  21  28  2
## 317     39   0  29  2
## 318     48   2  29  2
## 319     59   4  29  2
## 320     74   6  29  2
## 321     87   8  29  2
## 322    106  10  29  2
## 323    134  12  29  2
## 324    150  14  29  2
## 325    187  16  29  2
## 326    230  18  29  2
## 327    279  20  29  2
## 328    309  21  29  2
## 329     42   0  30  2
## 330     48   2  30  2
## 331     59   4  30  2
## 332     72   6  30  2
## 333     85   8  30  2
## 334     98  10  30  2
## 335    115  12  30  2
## 336    122  14  30  2
## 337    143  16  30  2
## 338    151  18  30  2
## 339    157  20  30  2
## 340    150  21  30  2
## 341     42   0  31  3
## 342     53   2  31  3
## 343     62   4  31  3
## 344     73   6  31  3
## 345     85   8  31  3
## 346    102  10  31  3
## 347    123  12  31  3
## 348    138  14  31  3
## 349    170  16  31  3
## 350    204  18  31  3
## 351    235  20  31  3
## 352    256  21  31  3
## 353     41   0  32  3
## 354     49   2  32  3
## 355     65   4  32  3
## 356     82   6  32  3
## 357    107   8  32  3
```

```
## 358     129   10     32     3
## 359     159   12     32     3
## 360     179   14     32     3
## 361     221   16     32     3
## 362     263   18     32     3
## 363     291   20     32     3
## 364     305   21     32     3
## 365      39    0     33     3
## 366      50    2     33     3
## 367      63    4     33     3
## 368      77    6     33     3
## 369      96    8     33     3
## 370     111   10     33     3
## 371     137   12     33     3
## 372     144   14     33     3
## 373     151   16     33     3
## 374     146   18     33     3
## 375     156   20     33     3
## 376     147   21     33     3
## 377      41    0     34     3
## 378      49    2     34     3
## 379      63    4     34     3
## 380      85    6     34     3
## 381     107    8     34     3
## 382     134   10     34     3
## 383     164   12     34     3
## 384     186   14     34     3
## 385     235   16     34     3
## 386     294   18     34     3
## 387     327   20     34     3
## 388     341   21     34     3
## 389      41    0     35     3
## 390      53    2     35     3
## 391      64    4     35     3
## 392      87    6     35     3
## 393     123    8     35     3
## 394     158   10     35     3
## 395     201   12     35     3
## 396     238   14     35     3
## 397     287   16     35     3
## 398     332   18     35     3
## 399     361   20     35     3
## 400     373   21     35     3
## 401      39    0     36     3
## 402      48    2     36     3
## 403      61    4     36     3
## 404      76    6     36     3
## 405      98    8     36     3
## 406     116   10     36     3
## 407     145   12     36     3
## 408     166   14     36     3
## 409     198   16     36     3
## 410     227   18     36     3
## 411     225   20     36     3
```

```
## 412     220  21     36     3
## 413      41   0     37     3
## 414      48   2     37     3
## 415      56   4     37     3
## 416      68   6     37     3
## 417      80   8     37     3
## 418      83  10     37     3
## 419     103  12     37     3
## 420     112  14     37     3
## 421     135  16     37     3
## 422     157  18     37     3
## 423     169  20     37     3
## 424     178  21     37     3
## 425      41   0     38     3
## 426      49   2     38     3
## 427      61   4     38     3
## 428      74   6     38     3
## 429      98   8     38     3
## 430     109  10     38     3
## 431     128  12     38     3
## 432     154  14     38     3
## 433     192  16     38     3
## 434     232  18     38     3
## 435     280  20     38     3
## 436     290  21     38     3
## 437      42   0     39     3
## 438      50   2     39     3
## 439      61   4     39     3
## 440      78   6     39     3
## 441      89   8     39     3
## 442     109  10     39     3
## 443     130  12     39     3
## 444     146  14     39     3
## 445     170  16     39     3
## 446     214  18     39     3
## 447     250  20     39     3
## 448     272  21     39     3
## 449      41   0     40     3
## 450      55   2     40     3
## 451      66   4     40     3
## 452      79   6     40     3
## 453     101   8     40     3
## 454     120  10     40     3
## 455     154  12     40     3
## 456     182  14     40     3
## 457     215  16     40     3
## 458     262  18     40     3
## 459     295  20     40     3
## 460     321  21     40     3
## 461      42   0     41     4
## 462      51   2     41     4
## 463      66   4     41     4
## 464      85   6     41     4
## 465     103   8     41     4
```

```
## 466    124  10   41    4
## 467    155  12   41    4
## 468    153  14   41    4
## 469    175  16   41    4
## 470    184  18   41    4
## 471    199  20   41    4
## 472    204  21   41    4
## 473     42   0   42    4
## 474     49   2   42    4
## 475     63   4   42    4
## 476     84   6   42    4
## 477    103   8   42    4
## 478    126  10   42    4
## 479    160  12   42    4
## 480    174  14   42    4
## 481    204  16   42    4
## 482    234  18   42    4
## 483    269  20   42    4
## 484    281  21   42    4
## 485     42   0   43    4
## 486     55   2   43    4
## 487     69   4   43    4
## 488     96   6   43    4
## 489    131   8   43    4
## 490    157  10   43    4
## 491    184  12   43    4
## 492    188  14   43    4
## 493    197  16   43    4
## 494    198  18   43    4
## 495    199  20   43    4
## 496    200  21   43    4
## 497     42   0   44    4
## 498     51   2   44    4
## 499     65   4   44    4
## 500     86   6   44    4
## 501    103   8   44    4
## 502    118  10   44    4
## 503    127  12   44    4
## 504    138  14   44    4
## 505    145  16   44    4
## 506    146  18   44    4
## 507     41   0   45    4
## 508     50   2   45    4
## 509     61   4   45    4
## 510     78   6   45    4
## 511     98   8   45    4
## 512    117  10   45    4
## 513    135  12   45    4
## 514    141  14   45    4
## 515    147  16   45    4
## 516    174  18   45    4
## 517    197  20   45    4
## 518    196  21   45    4
## 519     40   0   46    4
```

```
## 520      52   2   46    4
## 521      62   4   46    4
## 522      82   6   46    4
## 523     101   8   46    4
## 524     120  10   46    4
## 525     144  12   46    4
## 526     156  14   46    4
## 527     173  16   46    4
## 528     210  18   46    4
## 529     231  20   46    4
## 530     238  21   46    4
## 531      41   0   47    4
## 532      53   2   47    4
## 533      66   4   47    4
## 534      79   6   47    4
## 535     100   8   47    4
## 536     123  10   47    4
## 537     148  12   47    4
## 538     157  14   47    4
## 539     168  16   47    4
## 540     185  18   47    4
## 541     210  20   47    4
## 542     205  21   47    4
## 543      39   0   48    4
## 544      50   2   48    4
## 545      62   4   48    4
## 546      80   6   48    4
## 547     104   8   48    4
## 548     125  10   48    4
## 549     154  12   48    4
## 550     170  14   48    4
## 551     222  16   48    4
## 552     261  18   48    4
## 553     303  20   48    4
## 554     322  21   48    4
## 555      40   0   49    4
## 556      53   2   49    4
## 557      64   4   49    4
## 558      85   6   49    4
## 559     108   8   49    4
## 560     128  10   49    4
## 561     152  12   49    4
## 562     166  14   49    4
## 563     184  16   49    4
## 564     203  18   49    4
## 565     233  20   49    4
## 566     237  21   49    4
## 567      41   0   50    4
## 568      54   2   50    4
## 569      67   4   50    4
## 570      84   6   50    4
## 571     105   8   50    4
## 572     122  10   50    4
## 573     155  12   50    4
```

```
## 574    175   14    50    4
## 575    205   16    50    4
## 576    234   18    50    4
## 577    264   20    50    4
## 578    264   21    50    4
```

Answer: b. ChickWeight is tidy: each observation (a weight) is represented by one row. The chick from which this measurement came is one of the variables.

3. Examine the built-in dataset BOD. Which of the following is true:

```
BOD
```

```
##   Time demand
## 1    1    8.3
## 2    2   10.3
## 3    3   19.0
## 4    4   16.0
## 5    5   15.6
## 6    7   19.8
```

Answer: c. BOD is tidy: each row is an observation with two values (time and demand)

4. Which of the following built-in datasets is tidy (you can pick more than one):

```
BJsales
```

```
## Time Series:
## Start = 1
## End = 150
## Frequency = 1
##   [1] 200.1 199.5 199.4 198.9 199.0 200.2 198.6 200.0 200.3 201.2 201.6 201.5
##  [13] 201.5 203.5 204.9 207.1 210.5 210.5 209.8 208.8 209.5 213.2 213.7 215.1
##  [25] 218.7 219.8 220.5 223.8 222.8 223.8 221.7 222.3 220.8 219.4 220.1 220.6
##  [37] 218.9 217.8 217.7 215.0 215.3 215.9 216.7 216.7 217.7 218.7 222.9 224.9
##  [49] 222.2 220.7 220.0 218.7 217.0 215.9 215.8 214.1 212.3 213.9 214.6 213.6
##  [61] 212.1 211.4 213.1 212.9 213.3 211.5 212.3 213.0 211.0 210.7 210.1 211.4
##  [73] 210.0 209.7 208.8 208.8 208.8 210.6 211.9 212.8 212.5 214.8 215.3 217.5
##  [85] 218.8 220.7 222.2 226.7 228.4 233.2 235.7 237.1 240.6 243.8 245.3 246.0
##  [97] 246.3 247.7 247.6 247.8 249.4 249.0 249.9 250.5 251.5 249.0 247.6 248.8
## [109] 250.4 250.7 253.0 253.7 255.0 256.2 256.0 257.4 260.4 260.0 261.3 260.4
## [121] 261.6 260.8 259.8 259.0 258.9 257.4 257.7 257.9 257.4 257.3 257.6 258.9
## [133] 257.8 257.7 257.2 257.5 256.8 257.5 257.0 257.6 257.3 257.5 259.6 261.1
## [145] 262.9 263.3 262.8 261.8 262.2 262.7
```

```
EuStockMarkets
```

```
## Time Series:
## Start = c(1991, 130)
## End = c(1998, 169)
## Frequency = 260
```

```
##               DAX    SMI    CAC   FTSE
## 1991.496 1628.75 1678.1 1772.8 2443.6
## 1991.500 1613.63 1688.5 1750.5 2460.2
## 1991.504 1606.51 1678.6 1718.0 2448.2
## 1991.508 1621.04 1684.1 1708.1 2470.4
## 1991.512 1618.16 1686.6 1723.1 2484.7
## 1991.515 1610.61 1671.6 1714.3 2466.8
## 1991.519 1630.75 1682.9 1734.5 2487.9
## 1991.523 1640.17 1703.6 1757.4 2508.4
## 1991.527 1635.47 1697.5 1754.0 2510.5
## 1991.531 1645.89 1716.3 1754.3 2497.4
## 1991.535 1647.84 1723.8 1759.8 2532.5
## 1991.538 1638.35 1730.5 1755.5 2556.8
## 1991.542 1629.93 1727.4 1758.1 2561.0
## 1991.546 1621.49 1733.3 1757.5 2547.3
## 1991.550 1624.74 1734.0 1763.5 2541.5
## 1991.554 1627.63 1728.3 1762.8 2558.5
## 1991.558 1631.99 1737.1 1768.9 2587.9
## 1991.562 1621.18 1723.1 1778.1 2580.5
## 1991.565 1613.42 1723.6 1780.1 2579.6
## 1991.569 1604.95 1719.0 1767.7 2589.3
## 1991.573 1605.75 1721.2 1757.9 2595.0
## 1991.577 1616.67 1725.3 1756.6 2595.6
## 1991.581 1619.29 1727.2 1754.7 2588.8
## 1991.585 1620.49 1727.2 1766.8 2591.7
## 1991.588 1619.67 1731.6 1766.5 2601.7
## 1991.592 1623.07 1724.1 1762.2 2585.4
## 1991.596 1613.98 1716.9 1759.5 2573.3
## 1991.600 1631.87 1723.4 1782.4 2597.4
## 1991.604 1630.37 1723.0 1789.5 2600.6
## 1991.608 1633.47 1728.4 1783.5 2570.6
## 1991.612 1626.55 1722.1 1780.4 2569.4
## 1991.615 1650.43 1724.5 1808.8 2584.9
## 1991.619 1650.06 1733.6 1820.3 2608.8
## 1991.623 1654.11 1739.0 1820.3 2617.2
## 1991.627 1653.60 1726.2 1820.3 2621.0
## 1991.631 1501.82 1587.4 1687.5 2540.5
## 1991.635 1524.28 1630.6 1725.6 2554.5
## 1991.638 1603.65 1685.5 1792.9 2601.9
## 1991.642 1622.49 1701.3 1819.1 2623.0
## 1991.646 1636.68 1718.0 1833.5 2640.7
## 1991.650 1652.10 1726.2 1853.4 2640.7
## 1991.654 1645.81 1716.6 1849.7 2619.8
## 1991.658 1650.36 1725.8 1851.8 2624.2
## 1991.662 1651.55 1737.4 1857.7 2638.2
## 1991.665 1649.88 1736.6 1864.3 2645.7
## 1991.669 1653.52 1732.4 1863.5 2679.6
## 1991.673 1657.51 1731.2 1873.2 2669.0
## 1991.677 1649.55 1726.9 1860.8 2664.6
## 1991.681 1649.09 1727.8 1868.7 2663.3
## 1991.685 1646.41 1720.2 1860.4 2667.4
## 1991.688 1638.65 1715.4 1855.9 2653.2
## 1991.692 1625.80 1708.7 1840.5 2630.8
## 1991.696 1628.64 1713.0 1842.6 2626.6
```

```
## 1991.700 1632.22 1713.5 1861.2 2641.9
## 1991.704 1633.65 1718.0 1876.2 2625.8
## 1991.708 1631.17 1701.7 1878.3 2606.0
## 1991.712 1635.80 1701.7 1878.4 2594.4
## 1991.715 1621.27 1684.9 1869.4 2583.6
## 1991.719 1624.70 1687.2 1880.4 2588.7
## 1991.723 1616.13 1690.6 1885.5 2600.3
## 1991.727 1618.12 1684.3 1888.4 2579.5
## 1991.731 1627.80 1679.9 1885.2 2576.6
## 1991.735 1625.79 1672.9 1877.9 2597.8
## 1991.738 1614.80 1663.1 1876.5 2595.6
## 1991.742 1612.80 1669.3 1883.8 2599.0
## 1991.746 1605.47 1664.7 1880.6 2621.7
## 1991.750 1609.32 1672.3 1887.4 2645.6
## 1991.754 1607.48 1687.7 1878.3 2644.2
## 1991.758 1607.48 1686.8 1867.1 2625.6
## 1991.762 1604.89 1686.6 1851.9 2624.6
## 1991.765 1589.12 1675.8 1843.6 2596.2
## 1991.769 1582.27 1677.4 1848.1 2599.5
## 1991.773 1567.99 1673.2 1843.4 2584.1
## 1991.777 1568.16 1665.0 1843.6 2570.8
## 1991.781 1569.71 1671.3 1833.8 2555.0
## 1991.785 1571.74 1672.4 1833.4 2574.5
## 1991.788 1585.41 1676.2 1856.9 2576.7
## 1991.792 1570.01 1692.6 1863.4 2579.0
## 1991.796 1561.89 1696.5 1855.5 2588.7
## 1991.800 1565.18 1716.1 1864.2 2601.1
## 1991.804 1570.34 1713.3 1846.0 2575.7
## 1991.808 1577.00 1705.1 1836.8 2559.5
## 1991.812 1590.29 1711.3 1830.4 2561.1
## 1991.815 1572.72 1709.8 1831.6 2528.3
## 1991.819 1572.07 1688.6 1834.8 2514.7
## 1991.823 1579.19 1698.9 1852.1 2558.5
## 1991.827 1588.73 1700.0 1849.8 2553.3
## 1991.831 1586.01 1693.0 1861.8 2577.1
## 1991.835 1579.77 1683.9 1856.7 2566.0
## 1991.838 1572.58 1679.2 1856.7 2549.5
## 1991.842 1568.09 1673.9 1841.5 2527.8
## 1991.846 1578.21 1683.9 1846.9 2540.9
## 1991.850 1573.94 1688.4 1836.1 2534.2
## 1991.854 1582.06 1693.9 1838.6 2538.0
## 1991.858 1610.18 1720.9 1857.6 2559.0
## 1991.862 1605.16 1717.9 1857.6 2554.9
## 1991.865 1623.84 1733.6 1858.4 2575.5
## 1991.869 1615.26 1729.7 1846.8 2546.5
## 1991.873 1627.08 1735.6 1868.5 2561.6
## 1991.877 1626.97 1734.1 1863.2 2546.6
## 1991.881 1605.70 1699.3 1808.3 2502.9
## 1991.885 1589.70 1678.6 1765.1 2463.1
## 1991.888 1589.70 1675.5 1763.5 2472.6
## 1991.892 1603.26 1670.1 1766.0 2463.5
## 1991.896 1599.75 1652.2 1741.3 2446.3
## 1991.900 1590.86 1635.0 1743.3 2456.2
## 1991.904 1603.50 1654.9 1769.0 2471.5
```

```
## 1991.908 1589.86 1642.0 1757.9 2447.5
## 1991.912 1587.92 1638.7 1754.9 2428.6
## 1991.915 1571.06 1622.6 1739.7 2420.2
## 1991.919 1549.81 1596.1 1708.8 2414.9
## 1991.923 1549.36 1612.4 1722.2 2420.2
## 1991.927 1554.65 1625.0 1713.9 2423.8
## 1991.931 1557.52 1610.5 1703.2 2407.0
## 1991.935 1555.31 1606.6 1685.7 2388.7
## 1991.938 1559.76 1610.7 1663.4 2409.6
## 1991.942 1548.44 1603.1 1636.9 2392.0
## 1991.946 1543.99 1591.5 1645.6 2380.2
## 1991.950 1550.21 1605.2 1671.6 2423.3
## 1991.954 1557.03 1621.4 1688.3 2451.6
## 1991.958 1551.78 1622.5 1696.8 2440.8
## 1991.962 1562.89 1626.6 1711.7 2432.9
## 1991.965 1570.28 1627.4 1706.2 2413.6
## 1991.969 1559.26 1614.9 1684.2 2391.6
## 1991.973 1545.87 1602.3 1648.5 2358.1
## 1991.977 1542.77 1598.3 1633.6 2345.4
## 1991.981 1542.77 1627.0 1699.1 2384.4
## 1991.985 1542.77 1627.0 1699.1 2384.4
## 1991.988 1542.77 1627.0 1722.5 2384.4
## 1991.992 1564.27 1655.7 1720.7 2418.7
## 1991.996 1577.26 1670.1 1741.9 2420.0
## 1992.000 1577.26 1670.1 1765.7 2493.1
## 1992.004 1577.26 1670.1 1765.7 2493.1
## 1992.008 1598.19 1670.1 1749.9 2492.8
## 1992.012 1604.05 1704.0 1770.3 2504.1
## 1992.015 1604.69 1711.8 1787.6 2493.2
## 1992.019 1593.65 1700.5 1778.7 2482.9
## 1992.023 1581.68 1690.3 1785.6 2467.1
## 1992.027 1599.14 1715.4 1833.9 2497.9
## 1992.031 1613.82 1723.5 1837.4 2477.9
## 1992.035 1620.45 1719.4 1824.3 2490.1
## 1992.038 1629.51 1734.4 1843.8 2516.3
## 1992.042 1663.70 1772.8 1873.6 2537.1
## 1992.046 1664.09 1760.3 1860.2 2541.6
## 1992.050 1669.29 1747.2 1860.2 2536.7
## 1992.054 1685.14 1750.2 1865.9 2544.9
## 1992.058 1687.07 1755.3 1867.9 2543.4
## 1992.062 1680.13 1754.6 1841.3 2522.0
## 1992.065 1671.84 1751.2 1838.7 2525.3
## 1992.069 1669.52 1752.5 1849.9 2510.4
## 1992.073 1686.71 1769.4 1869.3 2539.9
## 1992.077 1685.51 1767.6 1890.6 2552.0
## 1992.081 1671.01 1750.0 1879.6 2546.5
## 1992.085 1683.06 1747.1 1873.9 2550.8
## 1992.088 1685.70 1753.5 1875.3 2571.2
## 1992.092 1685.66 1752.8 1857.0 2560.2
## 1992.096 1678.77 1752.9 1856.5 2556.8
## 1992.100 1685.85 1764.7 1865.8 2547.1
## 1992.104 1683.71 1776.8 1860.6 2534.3
## 1992.108 1686.59 1779.3 1861.6 2517.2
## 1992.112 1683.73 1785.1 1865.6 2538.4
```

```
## 1992.115 1679.14 1798.2 1864.1 2537.1
## 1992.119 1685.03 1794.1 1861.6 2523.7
## 1992.123 1680.81 1795.2 1876.5 2522.6
## 1992.127 1676.17 1780.4 1865.1 2513.9
## 1992.131 1688.46 1789.5 1882.1 2541.0
## 1992.135 1696.55 1794.2 1912.2 2555.9
## 1992.138 1690.24 1784.4 1915.4 2536.7
## 1992.142 1711.35 1800.1 1951.2 2543.4
## 1992.146 1711.29 1804.0 1962.4 2542.3
## 1992.150 1729.86 1816.2 1976.5 2559.7
## 1992.154 1716.63 1810.5 1953.5 2546.8
## 1992.158 1743.36 1821.9 1981.3 2565.0
## 1992.162 1745.17 1828.2 1985.1 2562.0
## 1992.165 1746.76 1840.6 1983.4 2562.1
## 1992.169 1749.29 1841.1 1979.7 2554.3
## 1992.173 1763.86 1846.3 1983.8 2565.4
## 1992.177 1762.27 1850.0 1988.1 2558.4
## 1992.181 1762.29 1839.0 1973.0 2538.3
## 1992.185 1746.77 1820.2 1966.9 2533.1
## 1992.188 1753.50 1815.2 1976.3 2550.7
## 1992.192 1753.21 1820.6 1993.9 2574.8
## 1992.196 1739.88 1807.1 1968.0 2522.4
## 1992.200 1723.92 1791.4 1941.8 2493.3
## 1992.204 1734.42 1806.2 1947.1 2476.0
## 1992.208 1723.13 1798.7 1929.2 2470.7
## 1992.212 1732.92 1818.2 1943.6 2491.2
## 1992.215 1729.89 1820.5 1928.2 2464.7
## 1992.219 1725.74 1833.3 1922.0 2467.6
## 1992.223 1730.90 1837.1 1919.1 2456.6
## 1992.227 1714.17 1818.2 1884.6 2441.0
## 1992.231 1716.20 1824.1 1896.3 2458.7
## 1992.235 1719.06 1830.1 1928.3 2464.9
## 1992.238 1718.21 1835.6 1934.8 2472.2
## 1992.242 1698.84 1828.7 1923.5 2447.9
## 1992.246 1714.76 1839.2 1943.8 2452.9
## 1992.250 1718.35 1837.2 1942.4 2440.1
## 1992.254 1706.69 1826.7 1928.1 2408.6
## 1992.258 1723.37 1838.0 1942.0 2405.4
## 1992.262 1716.18 1829.1 1942.7 2382.7
## 1992.265 1738.78 1843.1 1974.8 2400.9
## 1992.269 1737.41 1850.5 1975.4 2404.2
## 1992.273 1714.77 1827.1 1907.5 2393.2
## 1992.277 1724.24 1829.1 1943.6 2436.4
## 1992.281 1733.77 1848.0 1974.1 2572.6
## 1992.285 1729.96 1840.5 1963.3 2591.0
## 1992.288 1734.46 1853.8 1972.3 2600.5
## 1992.292 1744.35 1874.1 1990.7 2640.2
## 1992.296 1746.88 1871.3 1978.2 2638.6
## 1992.300 1746.88 1871.3 1978.2 2638.6
## 1992.304 1746.88 1871.3 1978.2 2638.6
## 1992.308 1747.47 1860.5 1980.4 2625.8
## 1992.312 1753.10 1874.7 1983.7 2607.8
## 1992.315 1745.17 1880.1 1978.1 2609.8
## 1992.319 1745.72 1874.7 1984.9 2643.0
```

```
## 1992.323 1742.92 1875.6 1995.7 2658.2
## 1992.327 1731.68 1859.5 2006.6 2651.0
## 1992.331 1731.18 1874.2 2036.7 2664.9
## 1992.335 1728.09 1880.1 2031.1 2654.1
## 1992.338 1728.09 1880.1 2031.1 2659.8
## 1992.342 1731.29 1907.7 2041.6 2659.8
## 1992.346 1733.82 1920.5 2046.9 2662.2
## 1992.350 1745.78 1937.3 2047.2 2698.7
## 1992.354 1752.57 1936.8 2063.4 2701.9
## 1992.358 1748.13 1949.1 2063.4 2725.7
## 1992.362 1750.70 1963.7 2077.5 2737.8
## 1992.365 1747.91 1950.8 2063.6 2722.4
## 1992.369 1745.79 1953.5 2053.2 2720.5
## 1992.373 1735.34 1945.0 2017.0 2694.7
## 1992.377 1719.92 1921.1 2024.0 2682.6
## 1992.381 1763.59 1939.1 2051.6 2703.6
## 1992.385 1766.76 1928.0 2023.1 2700.6
## 1992.388 1785.40 1933.4 2030.8 2711.9
## 1992.392 1783.56 1925.7 2016.8 2702.0
## 1992.396 1804.42 1931.7 2045.1 2715.0
## 1992.400 1812.33 1928.7 2046.3 2715.0
## 1992.404 1799.51 1924.5 2029.6 2704.6
## 1992.408 1792.80 1914.2 2014.1 2698.6
## 1992.412 1792.80 1914.2 2014.1 2694.2
## 1992.415 1806.36 1920.6 2033.3 2707.6
## 1992.419 1798.23 1923.3 2017.4 2697.6
## 1992.423 1800.62 1930.4 2024.9 2705.9
## 1992.427 1786.19 1915.2 1992.6 2680.9
## 1992.431 1791.35 1916.9 1994.9 2681.9
## 1992.435 1789.05 1913.8 1981.6 2668.5
## 1992.438 1789.05 1913.8 1981.6 2645.8
## 1992.442 1784.71 1899.7 1962.2 2635.4
## 1992.446 1789.45 1888.0 1953.7 2636.1
## 1992.450 1779.74 1868.8 1928.8 2614.1
## 1992.454 1786.97 1879.9 1928.3 2603.7
## 1992.458 1773.25 1865.7 1918.1 2593.6
## 1992.462 1781.62 1881.3 1931.4 2616.3
## 1992.465 1773.75 1873.1 1908.8 2598.4
## 1992.469 1773.75 1862.5 1891.8 2562.7
## 1992.473 1776.34 1869.3 1913.9 2584.8
## 1992.477 1770.72 1846.9 1885.8 2550.3
## 1992.481 1772.39 1847.1 1895.8 2560.6
## 1992.485 1762.55 1838.3 1899.6 2532.6
## 1992.488 1764.35 1845.8 1920.3 2557.3
## 1992.492 1752.83 1835.5 1915.3 2534.1
## 1992.496 1755.98 1846.6 1907.3 2515.8
## 1992.500 1754.95 1854.8 1900.6 2521.2
## 1992.504 1759.90 1845.3 1880.9 2493.9
## 1992.508 1759.84 1854.5 1873.5 2476.1
## 1992.512 1776.50 1870.5 1883.6 2497.1
## 1992.515 1769.98 1862.6 1868.5 2469.0
## 1992.519 1766.98 1856.6 1879.1 2493.7
## 1992.523 1752.29 1837.6 1847.8 2472.6
## 1992.527 1760.17 1846.7 1861.8 2497.9
```

```
## 1992.531 1750.32 1856.5 1859.4 2490.8
## 1992.535 1731.44 1841.8 1859.4 2478.3
## 1992.538 1735.51 1835.0 1859.4 2484.0
## 1992.542 1733.84 1844.4 1853.3 2486.4
## 1992.546 1730.78 1838.9 1851.2 2483.4
## 1992.550 1699.46 1805.6 1801.8 2431.9
## 1992.554 1652.71 1756.6 1767.9 2403.7
## 1992.558 1654.09 1786.1 1762.7 2415.6
## 1992.562 1636.81 1757.1 1727.5 2387.9
## 1992.565 1622.81 1762.8 1734.6 2399.5
## 1992.569 1613.36 1756.8 1734.6 2377.2
## 1992.573 1617.78 1761.9 1755.4 2348.0
## 1992.577 1617.18 1778.5 1769.0 2373.4
## 1992.581 1637.62 1812.7 1801.6 2423.2
## 1992.585 1622.20 1806.1 1782.6 2411.6
## 1992.588 1608.49 1798.1 1754.7 2399.6
## 1992.592 1605.11 1794.9 1784.4 2420.2
## 1992.596 1609.61 1805.4 1787.6 2407.5
## 1992.600 1624.94 1820.3 1798.0 2392.8
## 1992.604 1618.07 1819.6 1793.8 2377.6
## 1992.608 1611.96 1809.6 1777.3 2350.1
## 1992.612 1578.95 1799.9 1755.2 2325.7
## 1992.615 1561.39 1800.3 1737.8 2309.6
## 1992.619 1547.87 1793.3 1730.1 2303.1
## 1992.623 1548.63 1784.8 1722.4 2318.0
## 1992.627 1560.16 1791.7 1753.5 2356.8
## 1992.631 1554.76 1800.2 1757.3 2376.1
## 1992.635 1531.87 1788.6 1736.7 2354.7
## 1992.638 1526.14 1775.7 1734.2 2363.5
## 1992.642 1509.03 1753.5 1724.2 2359.4
## 1992.646 1530.03 1768.2 1744.2 2365.7
## 1992.650 1484.97 1727.9 1689.7 2311.1
## 1992.654 1464.03 1709.6 1667.7 2281.0
## 1992.658 1475.11 1704.6 1667.8 2285.0
## 1992.662 1516.12 1740.6 1687.6 2311.6
## 1992.665 1519.69 1745.7 1687.5 2312.6
## 1992.669 1529.97 1751.7 1684.9 2312.6
## 1992.673 1516.44 1747.3 1674.2 2298.4
## 1992.677 1515.53 1757.8 1711.4 2313.0
## 1992.681 1543.89 1774.2 1780.5 2381.9
## 1992.685 1534.72 1774.4 1779.0 2362.2
## 1992.688 1538.66 1788.3 1779.3 2372.2
## 1992.692 1536.71 1788.0 1763.7 2337.7
## 1992.696 1523.83 1779.1 1756.8 2327.5
## 1992.700 1527.10 1792.8 1774.2 2340.6
## 1992.704 1530.20 1812.0 1802.0 2370.9
## 1992.708 1601.50 1872.1 1873.6 2422.1
## 1992.712 1580.29 1851.4 1836.2 2370.0
## 1992.715 1595.09 1873.4 1859.8 2378.3
## 1992.719 1579.47 1889.6 1852.7 2483.9
## 1992.723 1600.59 1897.5 1882.9 2567.0
## 1992.727 1566.00 1888.8 1826.1 2560.1
## 1992.731 1557.01 1900.4 1832.8 2586.0
## 1992.735 1542.74 1913.4 1828.9 2580.5
```

```
## 1992.738 1536.30 1909.9 1829.5 2621.2
## 1992.742 1510.66 1910.8 1843.5 2601.0
## 1992.746 1481.03 1879.2 1770.3 2560.0
## 1992.750 1483.83 1880.2 1731.9 2565.5
## 1992.754 1470.09 1878.3 1736.7 2553.0
## 1992.758 1484.78 1885.2 1724.0 2572.3
## 1992.762 1475.41 1867.6 1683.3 2549.7
## 1992.765 1402.34 1788.0 1611.0 2446.3
## 1992.769 1421.49 1820.5 1612.5 2488.4
## 1992.773 1434.61 1858.2 1654.2 2517.1
## 1992.777 1446.32 1870.3 1673.9 2538.8
## 1992.781 1437.65 1878.4 1657.3 2541.2
## 1992.785 1441.57 1881.5 1655.1 2557.2
## 1992.788 1471.64 1893.2 1685.1 2584.7
## 1992.792 1453.95 1889.3 1667.9 2574.7
## 1992.796 1453.79 1877.3 1650.0 2546.6
## 1992.800 1458.02 1884.0 1664.2 2563.9
## 1992.804 1479.59 1904.7 1679.1 2562.2
## 1992.808 1504.89 1922.7 1731.3 2617.0
## 1992.812 1496.54 1908.5 1722.2 2645.7
## 1992.815 1511.00 1911.4 1730.7 2658.1
## 1992.819 1528.86 1921.1 1766.4 2669.7
## 1992.823 1534.02 1930.8 1770.7 2661.6
## 1992.827 1536.60 1927.8 1774.5 2669.8
## 1992.831 1508.19 1908.3 1749.9 2650.4
## 1992.835 1493.54 1905.9 1730.9 2642.3
## 1992.838 1489.68 1911.1 1742.4 2658.3
## 1992.842 1482.44 1921.6 1742.4 2687.8
## 1992.846 1483.34 1933.6 1786.9 2705.6
## 1992.850 1470.57 1942.0 1804.1 2691.7
## 1992.854 1484.84 1951.5 1804.7 2711.1
## 1992.858 1487.71 1955.7 1793.6 2702.7
## 1992.862 1508.63 1957.4 1786.7 2695.4
## 1992.865 1515.27 1962.3 1798.5 2714.6
## 1992.869 1509.84 1946.1 1798.5 2696.8
## 1992.873 1542.28 1950.2 1821.5 2726.4
## 1992.877 1541.79 1929.7 1796.8 2697.5
## 1992.881 1542.48 1913.4 1772.7 2679.6
## 1992.885 1550.27 1889.5 1764.4 2679.2
## 1992.888 1550.27 1882.8 1759.2 2704.0
## 1992.892 1543.37 1895.4 1722.3 2706.2
## 1992.896 1547.84 1897.9 1724.2 2732.4
## 1992.900 1523.62 1891.5 1674.8 2722.9
## 1992.904 1526.68 1880.1 1720.6 2727.1
## 1992.908 1513.42 1887.0 1721.0 2709.6
## 1992.912 1523.02 1891.4 1739.7 2741.8
## 1992.915 1529.69 1914.6 1749.7 2760.1
## 1992.919 1545.12 1931.2 1771.4 2778.8
## 1992.923 1546.82 1929.2 1792.3 2792.0
## 1992.927 1528.12 1924.3 1783.3 2764.1
## 1992.931 1530.65 1927.0 1799.4 2771.0
## 1992.935 1526.25 1935.0 1781.7 2759.4
## 1992.938 1519.48 1955.4 1788.6 2754.5
## 1992.942 1506.65 1962.2 1765.9 2769.8
```

```
## 1992.946 1504.30 1980.7 1791.2 2750.7
## 1992.950 1480.65 1987.7 1769.5 2726.5
## 1992.954 1476.70 1993.7 1758.7 2716.2
## 1992.958 1478.07 2015.7 1738.3 2721.8
## 1992.962 1479.62 2005.0 1744.8 2717.9
## 1992.965 1477.55 2023.9 1736.7 2732.8
## 1992.969 1472.59 2028.5 1735.2 2740.3
## 1992.973 1495.60 2044.9 1760.1 2789.7
## 1992.977 1517.45 2045.8 1786.3 2807.7
## 1992.981 1520.93 2057.3 1824.4 2842.0
## 1992.985 1527.06 2061.7 1821.1 2827.4
## 1992.988 1527.06 2061.7 1854.6 2827.5
## 1992.992 1527.06 2061.7 1854.6 2827.5
## 1992.996 1547.51 2092.3 1857.5 2827.5
## 1993.000 1545.82 2090.1 1870.3 2847.8
## 1993.004 1538.43 2105.4 1858.8 2832.5
## 1993.008 1538.43 2105.4 1857.8 2846.5
## 1993.012 1538.43 2105.4 1857.8 2846.5
## 1993.015 1538.04 2117.7 1843.1 2861.5
## 1993.019 1554.03 2128.2 1850.8 2833.6
## 1993.023 1551.17 2124.7 1859.6 2826.0
## 1993.027 1538.37 2079.9 1844.5 2816.5
## 1993.031 1529.10 2074.9 1852.6 2799.2
## 1993.035 1522.26 2046.4 1814.6 2773.4
## 1993.038 1533.79 2079.8 1796.8 2757.9
## 1993.042 1510.18 2076.7 1782.5 2745.3
## 1993.046 1526.91 2104.5 1803.5 2759.2
## 1993.050 1555.52 2101.3 1827.1 2765.1
## 1993.054 1581.49 2084.0 1837.5 2763.1
## 1993.058 1572.61 2063.9 1837.7 2737.6
## 1993.062 1572.69 2062.7 1818.8 2748.7
## 1993.065 1580.64 2089.9 1812.2 2773.3
## 1993.069 1593.35 2102.9 1820.4 2781.2
## 1993.073 1571.28 2086.0 1779.9 2771.9
## 1993.077 1575.59 2085.9 1792.6 2835.7
## 1993.081 1561.78 2064.1 1777.4 2832.5
## 1993.085 1572.68 2072.7 1780.6 2816.9
## 1993.088 1574.04 2091.0 1772.2 2807.2
## 1993.092 1590.33 2120.2 1785.9 2851.6
## 1993.096 1584.14 2120.4 1787.3 2834.4
## 1993.100 1605.91 2117.6 1824.1 2873.8
## 1993.104 1615.98 2123.7 1854.4 2865.9
## 1993.108 1643.83 2132.2 1908.2 2862.9
## 1993.112 1646.85 2137.0 1904.7 2870.0
## 1993.115 1639.12 2134.8 1894.1 2831.3
## 1993.119 1642.80 2121.4 1893.3 2816.4
## 1993.123 1659.07 2127.5 1905.6 2834.3
## 1993.127 1649.64 2135.5 1912.0 2843.0
## 1993.131 1674.93 2144.8 1899.5 2845.9
## 1993.135 1651.60 2131.0 1878.2 2812.2
## 1993.138 1656.35 2112.9 1905.0 2814.0
## 1993.142 1670.90 2131.3 1926.5 2837.7
## 1993.146 1683.30 2117.8 1937.2 2840.0
## 1993.150 1679.41 2096.1 1959.2 2838.3
```

```
## 1993.154 1658.09 2051.5 1944.1 2818.0
## 1993.158 1652.92 2065.7 1953.4 2817.0
## 1993.162 1661.96 2061.0 1944.6 2828.7
## 1993.165 1680.02 2100.6 1983.7 2868.0
## 1993.169 1691.37 2120.5 1998.8 2882.6
## 1993.173 1701.46 2130.9 2001.5 2882.3
## 1993.177 1690.48 2142.4 1995.2 2918.6
## 1993.181 1685.46 2139.5 1986.8 2904.8
## 1993.185 1686.15 2134.6 1995.1 2916.6
## 1993.188 1702.27 2132.2 2004.3 2957.3
## 1993.192 1711.91 2150.1 2009.7 2949.9
## 1993.196 1714.48 2157.0 1992.4 2956.7
## 1993.200 1708.65 2165.0 1988.9 2953.4
## 1993.204 1688.74 2127.2 1965.2 2915.9
## 1993.208 1705.05 2157.2 1986.0 2922.4
## 1993.212 1700.28 2150.8 1975.3 2919.3
## 1993.215 1689.71 2139.1 1967.3 2889.9
## 1993.219 1696.38 2154.7 1963.5 2883.3
## 1993.223 1686.57 2182.4 1962.7 2900.1
## 1993.227 1656.59 2161.3 1939.3 2863.9
## 1993.231 1653.20 2166.3 1952.2 2861.1
## 1993.235 1666.72 2146.8 1954.6 2860.6
## 1993.238 1663.27 2135.7 2001.4 2852.8
## 1993.242 1667.26 2160.9 2025.8 2852.9
## 1993.246 1675.18 2175.7 2033.9 2846.5
## 1993.250 1686.64 2188.9 2035.9 2861.0
## 1993.254 1676.84 2190.3 2031.4 2878.7
## 1993.258 1670.04 2188.4 2005.9 2878.4
## 1993.262 1657.06 2190.3 1990.8 2869.9
## 1993.265 1658.36 2184.0 1974.7 2838.8
## 1993.269 1667.64 2196.0 1995.3 2832.2
## 1993.273 1654.60 2184.9 1984.0 2822.1
## 1993.277 1658.13 2188.3 1986.9 2821.8
## 1993.281 1658.13 2188.3 1986.9 2821.8
## 1993.285 1658.13 2188.3 1986.9 2821.8
## 1993.288 1671.54 2181.7 2018.1 2846.8
## 1993.292 1674.95 2165.7 2015.4 2842.1
## 1993.296 1674.67 2160.5 1988.6 2839.7
## 1993.300 1678.65 2162.9 1986.7 2824.4
## 1993.304 1687.14 2166.3 1968.9 2830.0
## 1993.308 1680.06 2170.8 1949.3 2856.1
## 1993.312 1666.49 2178.1 1931.9 2869.6
## 1993.315 1680.01 2177.3 1944.5 2881.1
## 1993.319 1656.03 2162.3 1916.6 2843.8
## 1993.323 1643.53 2140.4 1911.6 2822.3
## 1993.327 1636.59 2124.7 1927.4 2832.7
## 1993.331 1630.88 2138.2 1942.5 2797.3
## 1993.335 1618.60 2123.2 1920.6 2786.8
## 1993.338 1626.83 2129.7 1939.0 2813.1
## 1993.342 1632.00 2152.8 1937.0 2813.1
## 1993.346 1619.92 2160.0 1923.6 2812.6
## 1993.350 1628.88 2165.8 1926.3 2796.5
## 1993.354 1617.74 2165.4 1920.5 2786.3
## 1993.358 1607.70 2162.6 1878.6 2793.7
```

```
## 1993.362 1616.45 2179.1 1877.2 2829.7
## 1993.365 1613.46 2191.1 1854.5 2836.1
## 1993.369 1632.99 2191.5 1872.7 2860.8
## 1993.373 1636.02 2183.3 1879.9 2849.3
## 1993.377 1632.35 2186.3 1851.7 2847.0
## 1993.381 1630.37 2205.2 1835.7 2858.1
## 1993.385 1619.26 2227.2 1846.4 2847.3
## 1993.388 1606.64 2227.0 1836.8 2819.7
## 1993.392 1606.64 2227.0 1836.8 2816.8
## 1993.396 1613.98 2232.9 1836.8 2812.2
## 1993.400 1608.58 2237.4 1861.4 2825.6
## 1993.404 1623.05 2243.5 1891.1 2837.7
## 1993.408 1617.18 2247.5 1890.4 2846.9
## 1993.412 1633.18 2267.1 1904.6 2855.3
## 1993.415 1627.21 2271.6 1888.7 2840.7
## 1993.419 1627.21 2271.6 1888.7 2840.7
## 1993.423 1625.59 2253.8 1872.8 2849.2
## 1993.427 1628.53 2259.8 1875.8 2863.0
## 1993.431 1630.56 2269.0 1867.9 2852.8
## 1993.435 1638.47 2284.2 1859.7 2829.9
## 1993.438 1660.88 2309.7 1887.9 2844.8
## 1993.442 1662.28 2294.5 1893.7 2844.4
## 1993.446 1679.69 2312.5 1915.2 2866.9
## 1993.450 1679.69 2309.2 1911.2 2860.0
## 1993.454 1685.85 2308.6 1920.4 2861.8
## 1993.458 1686.44 2293.8 1916.8 2885.5
## 1993.462 1684.57 2274.0 1897.9 2870.0
## 1993.465 1689.93 2294.6 1918.8 2883.0
## 1993.469 1681.47 2323.4 1900.3 2875.7
## 1993.473 1687.14 2318.0 1910.3 2879.4
## 1993.477 1697.26 2329.5 1929.2 2903.4
## 1993.481 1698.33 2335.0 1935.3 2907.6
## 1993.485 1690.96 2323.9 1942.4 2900.7
## 1993.488 1692.16 2335.8 1963.3 2894.7
## 1993.492 1699.52 2347.3 1960.8 2887.5
## 1993.496 1712.33 2369.8 1991.0 2897.0
## 1993.500 1703.05 2371.9 1977.5 2886.0
## 1993.504 1700.93 2376.2 1971.9 2900.0
## 1993.508 1698.36 2375.5 1960.2 2888.8
## 1993.512 1697.39 2368.8 1941.2 2857.7
## 1993.515 1694.83 2364.4 1925.4 2838.5
## 1993.519 1705.66 2390.9 1935.1 2848.1
## 1993.523 1739.48 2372.0 1943.7 2848.3
## 1993.527 1798.63 2397.1 1980.4 2845.9
## 1993.531 1798.36 2403.0 1985.7 2843.2
## 1993.535 1808.74 2408.7 1992.2 2830.9
## 1993.538 1806.52 2418.1 1991.2 2837.1
## 1993.542 1815.63 2410.5 1991.2 2832.3
## 1993.546 1807.12 2399.9 1963.1 2831.7
## 1993.550 1829.36 2396.4 1974.9 2833.0
## 1993.554 1835.09 2381.8 1981.7 2842.9
## 1993.558 1826.45 2324.5 1968.4 2823.9
## 1993.562 1821.28 2313.7 1947.5 2814.1
## 1993.565 1828.53 2340.2 1965.7 2820.1
```

```
## 1993.569 1830.61 2350.5 1995.0 2827.7
## 1993.573 1859.49 2388.7 2006.2 2844.2
## 1993.577 1846.02 2398.0 1998.1 2879.4
## 1993.581 1832.20 2408.7 1989.5 2884.2
## 1993.585 1823.40 2401.5 2036.0 2917.6
## 1993.588 1823.07 2400.9 2085.9 2926.5
## 1993.592 1818.10 2400.7 2129.0 2941.7
## 1993.596 1857.36 2429.8 2110.6 2945.0
## 1993.600 1861.22 2431.5 2101.4 2941.3
## 1993.604 1870.80 2424.9 2115.3 2943.4
## 1993.608 1878.94 2423.3 2149.8 2969.8
## 1993.612 1870.24 2420.5 2138.5 2986.4
## 1993.615 1864.51 2384.5 2139.8 2971.6
## 1993.619 1894.56 2411.1 2167.4 3006.1
## 1993.623 1908.69 2449.5 2161.9 3009.1
## 1993.627 1917.69 2461.0 2148.0 3010.1
## 1993.631 1903.44 2478.7 2148.0 3008.3
## 1993.635 1918.75 2464.9 2136.3 3025.0
## 1993.638 1930.29 2488.0 2160.8 3073.6
## 1993.642 1937.77 2480.6 2139.2 3065.5
## 1993.646 1909.53 2474.5 2128.2 3057.6
## 1993.650 1893.48 2467.3 2111.4 3042.0
## 1993.654 1907.65 2472.4 2123.4 3049.3
## 1993.658 1915.59 2499.7 2159.3 3079.2
## 1993.662 1890.58 2475.2 2173.6 3079.2
## 1993.665 1909.54 2478.6 2183.9 3100.6
## 1993.669 1929.56 2481.0 2205.7 3100.6
## 1993.673 1931.88 2488.5 2216.5 3100.0
## 1993.677 1923.67 2470.4 2191.9 3085.1
## 1993.681 1928.63 2463.8 2185.1 3072.6
## 1993.685 1920.43 2438.8 2156.1 3057.3
## 1993.688 1911.15 2392.5 2158.0 3055.4
## 1993.692 1878.77 2403.4 2137.3 3038.6
## 1993.696 1870.32 2397.9 2129.4 3035.4
## 1993.700 1870.46 2382.1 2108.8 3031.2
## 1993.704 1868.28 2363.6 2108.4 3037.0
## 1993.708 1874.38 2365.6 2119.1 3024.8
## 1993.712 1869.25 2388.3 2134.1 3028.0
## 1993.715 1852.81 2361.8 2078.5 2989.4
## 1993.719 1862.62 2374.4 2075.6 3003.9
## 1993.723 1884.67 2385.2 2099.5 3005.5
## 1993.727 1922.69 2418.4 2107.4 3004.5
## 1993.731 1922.05 2431.8 2094.4 3001.6
## 1993.735 1899.54 2414.6 2080.0 3007.5
## 1993.738 1902.14 2425.8 2057.5 3001.3
## 1993.742 1890.18 2445.9 2092.6 3005.2
## 1993.746 1914.40 2482.4 2108.6 3026.3
## 1993.750 1915.61 2478.3 2120.0 3036.9
## 1993.754 1908.97 2485.4 2126.8 3030.1
## 1993.758 1910.23 2473.1 2114.6 3037.5
## 1993.762 1920.46 2481.6 2116.7 3039.3
## 1993.765 1934.99 2490.3 2128.7 3067.7
## 1993.769 1973.45 2521.3 2158.8 3085.2
## 1993.773 1994.09 2534.8 2164.5 3100.8
```

```
## 1993.777 1991.95 2528.0 2147.4 3092.4
## 1993.781 2015.71 2533.6 2156.4 3108.6
## 1993.785 2009.28 2548.5 2138.7 3102.2
## 1993.788 2004.11 2552.5 2126.9 3094.7
## 1993.792 1999.60 2571.0 2127.3 3080.9
## 1993.796 1995.35 2586.4 2113.9 3086.3
## 1993.800 2023.26 2612.6 2139.3 3120.8
## 1993.804 2032.25 2663.6 2145.0 3137.6
## 1993.808 2036.93 2660.7 2147.3 3129.6
## 1993.812 2029.87 2668.4 2149.7 3156.3
## 1993.815 2048.05 2690.1 2199.7 3188.3
## 1993.819 2083.62 2701.4 2231.9 3199.0
## 1993.823 2061.18 2685.0 2227.7 3184.8
## 1993.827 2048.75 2700.2 2210.4 3165.3
## 1993.831 2040.97 2715.9 2192.0 3154.3
## 1993.835 2053.66 2720.9 2196.0 3163.0
## 1993.838 2064.98 2723.2 2182.0 3171.0
## 1993.842 2068.51 2727.1 2182.0 3164.4
## 1993.846 2086.40 2742.9 2169.7 3164.1
## 1993.850 2086.22 2749.9 2171.2 3162.3
## 1993.854 2057.10 2706.6 2136.0 3149.0
## 1993.858 2013.65 2654.2 2081.0 3085.6
## 1993.862 2007.50 2675.3 2084.8 3077.6
## 1993.865 2040.74 2727.1 2112.9 3096.0
## 1993.869 2020.11 2742.1 2087.3 3098.5
## 1993.873 2021.81 2720.1 2087.3 3099.7
## 1993.877 2023.06 2721.1 2096.9 3099.1
## 1993.881 2047.20 2717.4 2117.9 3093.3
## 1993.885 2070.17 2712.3 2115.9 3097.5
## 1993.888 2070.17 2711.1 2148.0 3120.0
## 1993.892 2075.99 2727.1 2149.7 3125.5
## 1993.896 2072.13 2733.9 2145.2 3108.0
## 1993.900 2020.36 2696.5 2082.6 3070.6
## 1993.904 2027.99 2702.1 2071.5 3069.3
## 1993.908 2036.45 2717.8 2070.6 3067.2
## 1993.912 2057.80 2726.8 2118.4 3093.1
## 1993.915 2045.25 2741.9 2120.6 3111.4
## 1993.919 2052.09 2738.2 2119.3 3135.8
## 1993.923 2052.92 2738.5 2110.1 3166.9
## 1993.927 2089.77 2774.3 2154.0 3233.2
## 1993.931 2099.76 2787.2 2160.5 3223.9
## 1993.935 2128.30 2819.0 2188.4 3234.2
## 1993.938 2118.01 2836.4 2186.7 3237.3
## 1993.942 2127.39 2834.8 2176.1 3237.3
## 1993.946 2165.95 2843.8 2205.3 3277.4
## 1993.950 2166.58 2858.4 2211.4 3271.6
## 1993.954 2165.50 2861.2 2198.1 3261.3
## 1993.958 2163.83 2876.9 2196.3 3254.6
## 1993.962 2128.07 2867.8 2156.5 3248.4
## 1993.965 2129.52 2850.6 2162.6 3278.8
## 1993.969 2144.03 2867.7 2160.3 3311.2
## 1993.973 2154.76 2889.5 2196.4 3337.1
## 1993.977 2188.18 2909.0 2223.5 3364.9
## 1993.981 2183.78 2918.0 2215.9 3342.4
```

```
## 1993.985 2209.17 2942.4 2225.8 3355.7
## 1993.988 2227.63 2967.4 2243.0 3396.5
## 1993.992 2227.63 2967.4 2251.5 3412.3
## 1993.996 2266.70 2972.6 2276.6 3412.3
## 1994.000 2236.91 2930.9 2264.6 3412.3
## 1994.004 2229.62 2934.2 2281.9 3462.0
## 1994.008 2255.29 2957.6 2281.2 3428.8
## 1994.012 2255.29 2957.6 2268.2 3418.4
## 1994.015 2274.62 2996.2 2290.6 3418.4
## 1994.019 2249.85 2999.2 2274.3 3408.5
## 1994.023 2233.61 3009.4 2249.6 3379.2
## 1994.027 2220.63 3021.9 2275.1 3403.0
## 1994.031 2224.95 3042.9 2307.6 3446.0
## 1994.035 2225.00 3015.9 2317.3 3440.6
## 1994.038 2228.10 3026.6 2331.3 3413.8
## 1994.042 2182.06 2999.0 2281.9 3372.0
## 1994.046 2142.37 2949.9 2252.2 3360.0
## 1994.050 2151.05 2990.6 2262.3 3400.6
## 1994.054 2115.56 3011.1 2234.8 3407.8
## 1994.058 2130.35 3037.5 2247.4 3437.0
## 1994.062 2132.52 3049.4 2274.7 3475.1
## 1994.065 2098.36 3045.9 2257.8 3470.0
## 1994.069 2073.94 3039.3 2244.0 3484.2
## 1994.073 2107.29 3041.3 2274.5 3481.4
## 1994.077 2090.78 3066.5 2278.3 3444.0
## 1994.081 2128.66 3091.3 2282.4 3436.1
## 1994.085 2123.31 3095.2 2281.0 3427.3
## 1994.088 2156.61 3140.7 2313.2 3447.4
## 1994.092 2192.60 3178.4 2334.4 3491.8
## 1994.096 2181.88 3148.7 2331.3 3481.5
## 1994.100 2184.05 3169.1 2355.9 3520.3
## 1994.104 2137.08 3151.9 2322.0 3491.5
## 1994.108 2143.90 3166.6 2329.2 3475.4
## 1994.112 2095.11 3089.8 2287.1 3419.1
## 1994.115 2099.57 3097.2 2299.9 3440.2
## 1994.119 2116.43 3054.2 2302.1 3429.1
## 1994.123 2119.69 3012.2 2296.8 3407.0
## 1994.127 2108.77 3012.2 2275.1 3378.9
## 1994.131 2101.93 2947.1 2281.6 3363.5
## 1994.135 2130.71 2947.1 2258.0 3393.2
## 1994.138 2135.25 2947.1 2258.0 3417.7
## 1994.142 2162.29 3033.4 2281.2 3425.3
## 1994.146 2133.85 3025.9 2251.8 3382.6
## 1994.150 2108.06 2997.6 2215.2 3350.3
## 1994.154 2113.64 2982.8 2226.7 3333.7
## 1994.158 2140.25 3027.5 2252.0 3341.9
## 1994.162 2082.90 2958.4 2208.3 3267.5
## 1994.165 2075.33 2929.3 2199.0 3281.2
## 1994.169 2103.24 2888.2 2238.1 3328.1
## 1994.173 2057.20 2847.4 2183.1 3270.6
## 1994.177 2018.69 2768.5 2144.7 3248.1
## 1994.181 2044.45 2803.4 2144.7 3246.5
## 1994.185 2076.76 2865.2 2178.7 3278.0
## 1994.188 2132.12 2918.7 2219.9 3305.9
```

```
## 1994.192 2125.47 2902.4 2216.4 3264.4
## 1994.196 2118.01 2858.5 2199.7 3246.7
## 1994.200 2124.51 2861.2 2184.6 3233.9
## 1994.204 2101.89 2831.6 2175.0 3191.9
## 1994.208 2169.40 2870.5 2215.0 3233.4
## 1994.212 2178.91 2906.9 2258.5 3267.4
## 1994.215 2168.11 2887.1 2242.7 3242.9
## 1994.219 2160.45 2887.7 2247.8 3255.7
## 1994.223 2140.39 2843.5 2221.3 3218.1
## 1994.227 2130.55 2804.3 2202.7 3198.0
## 1994.231 2141.70 2824.7 2200.7 3201.5
## 1994.235 2162.96 2857.0 2200.2 3155.3
## 1994.238 2144.36 2850.8 2152.6 3121.7
## 1994.242 2144.00 2831.8 2136.6 3129.0
## 1994.246 2167.72 2862.4 2144.5 3129.5
## 1994.250 2162.82 2827.4 2123.4 3123.4
## 1994.254 2151.84 2814.5 2083.9 3092.4
## 1994.258 2142.88 2794.8 2081.9 3086.4
## 1994.262 2142.88 2794.8 2081.9 3086.4
## 1994.265 2142.88 2794.8 2081.9 3086.4
## 1994.269 2177.09 2807.3 2100.3 3116.2
## 1994.273 2184.89 2830.2 2128.2 3131.5
## 1994.277 2202.57 2860.9 2119.6 3129.0
## 1994.281 2203.18 2873.4 2114.8 3120.8
## 1994.285 2224.85 2884.0 2145.3 3149.4
## 1994.288 2211.19 2887.8 2148.6 3159.1
## 1994.292 2215.19 2877.7 2152.4 3145.8
## 1994.296 2198.24 2843.7 2139.1 3131.7
## 1994.300 2211.92 2872.9 2159.6 3168.3
## 1994.304 2218.37 2869.1 2160.1 3138.2
## 1994.308 2193.89 2837.1 2136.0 3128.0
## 1994.312 2194.09 2818.7 2102.7 3098.3
## 1994.315 2194.41 2781.6 2092.0 3101.2
## 1994.319 2218.13 2787.9 2135.2 3133.7
## 1994.323 2208.68 2763.5 2116.3 3106.1
## 1994.327 2241.36 2776.2 2130.9 3125.3
## 1994.331 2256.98 2791.3 2147.3 3150.0
## 1994.335 2237.82 2768.9 2150.3 3129.9
## 1994.338 2252.51 2736.3 2166.0 3125.3
## 1994.342 2266.72 2765.2 2186.2 3125.3
## 1994.346 2261.71 2755.9 2179.0 3100.0
## 1994.350 2241.85 2705.6 2141.6 3070.5
## 1994.354 2249.78 2682.2 2162.6 3106.0
## 1994.358 2233.55 2641.4 2158.2 3106.0
## 1994.362 2218.77 2569.5 2139.4 3097.8
## 1994.365 2241.34 2629.0 2165.0 3136.3
## 1994.369 2248.02 2633.0 2176.7 3130.5
## 1994.373 2248.02 2633.0 2176.7 3137.8
## 1994.377 2257.33 2678.7 2187.0 3119.2
## 1994.381 2272.96 2709.0 2187.8 3115.6
## 1994.385 2268.11 2727.1 2195.2 3123.5
## 1994.388 2254.21 2740.6 2184.0 3116.5
## 1994.392 2245.79 2725.8 2165.4 3122.8
## 1994.396 2238.97 2732.7 2155.4 3127.3
```

```
## 1994.400 2238.97 2732.7 2155.4 3108.4
## 1994.404 2188.01 2692.0 2133.3 3089.1
## 1994.408 2137.56 2673.1 2084.4 3020.7
## 1994.412 2146.00 2689.2 2091.9 3019.7
## 1994.415 2112.80 2711.9 2050.7 2966.4
## 1994.419 2129.76 2742.9 2052.5 2966.4
## 1994.423 2137.34 2722.9 2029.9 2970.5
## 1994.427 2113.62 2731.5 1979.7 2931.9
## 1994.431 2120.23 2725.9 2007.4 2980.8
## 1994.435 2158.88 2728.4 2041.7 2997.8
## 1994.438 2163.59 2781.4 2037.2 3009.4
## 1994.442 2131.80 2778.1 2023.7 3004.8
## 1994.446 2143.93 2801.1 2046.8 3038.2
## 1994.450 2131.14 2777.2 2028.4 3028.9
## 1994.454 2143.58 2763.8 2020.7 3055.9
## 1994.458 2084.42 2744.2 1977.7 3016.3
## 1994.462 2088.44 2740.0 1992.0 3039.6
## 1994.465 2073.21 2701.8 1966.4 3045.8
## 1994.469 2047.29 2666.6 1942.8 3030.1
## 1994.473 2031.80 2627.6 1936.0 3022.9
## 1994.477 1986.42 2545.0 1903.0 2971.1
## 1994.481 1957.08 2544.2 1890.8 2940.2
## 1994.485 2004.93 2595.7 1917.0 2960.4
## 1994.488 2032.52 2626.7 1939.0 2942.4
## 1994.492 2005.07 2577.2 1907.0 2876.6
## 1994.496 2000.48 2561.4 1911.6 2899.9
## 1994.500 2022.25 2604.4 1925.8 2909.0
## 1994.504 2042.45 2631.2 1936.3 2946.3
## 1994.508 2020.85 2608.8 1892.0 2919.2
## 1994.512 2040.69 2588.9 1872.9 2936.4
## 1994.515 2061.70 2636.4 1866.2 2970.4
## 1994.519 2034.64 2609.7 1878.7 2965.0
## 1994.523 2031.33 2598.9 1889.0 2946.7
## 1994.527 2049.10 2590.5 1920.8 2964.4
## 1994.531 2047.83 2560.3 1920.8 2962.4
## 1994.535 2069.46 2562.5 1949.8 2983.8
## 1994.538 2048.57 2508.0 1942.1 2963.9
## 1994.542 2051.25 2474.5 1974.6 3005.3
## 1994.546 2070.71 2528.3 1974.6 3050.4
## 1994.550 2103.54 2514.9 1974.6 3074.8
## 1994.554 2116.96 2494.7 2025.1 3082.0
## 1994.558 2129.86 2521.6 2052.3 3091.3
## 1994.562 2120.97 2562.3 2043.7 3077.2
## 1994.565 2126.75 2579.4 2053.8 3095.1
## 1994.569 2148.23 2599.2 2041.4 3114.7
## 1994.573 2144.21 2601.2 2059.8 3106.1
## 1994.577 2163.32 2604.4 2076.8 3117.2
## 1994.581 2135.93 2544.9 2055.7 3082.3
## 1994.585 2134.12 2559.3 2053.4 3095.9
## 1994.588 2152.19 2579.5 2075.0 3082.6
## 1994.592 2161.50 2579.5 2069.6 3097.4
## 1994.596 2193.63 2629.7 2117.2 3157.5
## 1994.600 2190.83 2620.7 2115.0 3160.4
## 1994.604 2176.66 2615.3 2096.5 3150.5
```

```
## 1994.608 2188.81 2600.8 2107.1 3167.5
## 1994.612 2182.32 2617.5 2106.3 3171.9
## 1994.615 2160.56 2585.5 2074.5 3168.6
## 1994.619 2166.51 2591.4 2064.2 3167.0
## 1994.623 2156.31 2588.8 2038.9 3138.2
## 1994.627 2133.74 2580.5 2007.0 3142.3
## 1994.631 2134.34 2570.6 2007.0 3142.2
## 1994.635 2152.65 2588.7 2012.4 3147.3
## 1994.638 2166.56 2599.3 2035.0 3190.3
## 1994.642 2151.44 2582.7 2010.5 3182.6
## 1994.646 2143.84 2557.0 2001.3 3191.4
## 1994.650 2113.37 2532.4 1972.6 3171.3
## 1994.654 2121.25 2530.9 2000.6 3175.1
## 1994.658 2132.98 2541.1 2006.3 3205.2
## 1994.662 2153.48 2551.1 2026.5 3234.2
## 1994.665 2190.58 2581.3 2062.7 3265.1
## 1994.669 2215.72 2635.2 2075.3 3265.1
## 1994.673 2205.82 2635.7 2060.4 3249.6
## 1994.677 2207.09 2645.6 2069.1 3251.3
## 1994.681 2185.78 2628.4 2034.9 3216.5
## 1994.685 2197.38 2672.0 2020.4 3222.7
## 1994.688 2173.60 2674.5 1998.2 3241.5
## 1994.692 2158.07 2652.4 1961.5 3205.4
## 1994.696 2167.68 2662.5 1964.2 3203.9
## 1994.700 2178.10 2664.1 1983.4 3180.0
## 1994.704 2155.58 2642.1 1948.8 3139.3
## 1994.708 2155.81 2643.0 1966.8 3128.8
## 1994.712 2157.15 2658.8 1969.4 3121.4
## 1994.715 2118.17 2637.7 1952.9 3079.8
## 1994.719 2129.36 2628.6 1977.3 3112.7
## 1994.723 2097.45 2603.3 1924.6 3065.1
## 1994.727 2100.55 2614.7 1922.9 3079.1
## 1994.731 2059.15 2593.0 1919.3 3037.3
## 1994.735 2067.17 2594.0 1897.2 3014.8
## 1994.738 2072.81 2602.9 1899.4 3021.2
## 1994.742 2097.33 2609.1 1927.4 3028.2
## 1994.746 2057.83 2586.1 1902.7 2999.8
## 1994.750 2056.89 2581.0 1901.3 3008.5
## 1994.754 2070.36 2590.0 1905.0 3038.7
## 1994.758 2016.08 2558.0 1876.2 2992.5
## 1994.762 2002.30 2534.4 1879.3 3026.3
## 1994.765 2002.30 2499.5 1852.8 2983.5
## 1994.769 1988.67 2522.5 1876.1 3001.8
## 1994.773 1946.49 2480.4 1833.7 2956.3
## 1994.777 1965.41 2484.8 1843.4 2984.4
## 1994.781 1977.67 2496.9 1856.4 2998.7
## 1994.785 2048.56 2553.4 1898.3 3032.3
## 1994.788 2087.71 2570.2 1919.0 3073.0
## 1994.792 2072.68 2562.7 1918.1 3100.5
## 1994.796 2108.08 2593.3 1955.6 3141.9
## 1994.800 2118.52 2585.3 1933.0 3106.7
## 1994.804 2095.58 2575.6 1906.4 3120.2
## 1994.808 2069.58 2542.5 1898.6 3085.3
## 1994.812 2055.94 2529.8 1876.3 3060.8
```

```
## 1994.815 2048.15 2530.9 1867.4 3063.2
## 1994.819 2016.60 2508.6 1842.1 3032.8
## 1994.823 2022.64 2525.2 1841.6 3029.1
## 1994.827 1995.85 2494.7 1824.4 3000.9
## 1994.831 2009.45 2477.2 1831.5 2999.9
## 1994.835 2026.37 2458.6 1858.1 3029.6
## 1994.838 2064.86 2490.5 1905.7 3083.8
## 1994.842 2061.58 2506.5 1905.7 3097.4
## 1994.846 2066.18 2503.9 1905.7 3096.3
## 1994.850 2039.91 2500.0 1873.6 3081.3
## 1994.854 2061.37 2534.8 1911.1 3104.4
## 1994.858 2069.39 2541.0 1931.7 3097.6
## 1994.862 2043.30 2557.9 1906.1 3065.8
## 1994.865 2056.36 2543.9 1921.5 3063.8
## 1994.869 2090.78 2590.4 1943.9 3099.6
## 1994.873 2098.04 2602.7 1948.4 3103.5
## 1994.877 2073.67 2597.8 1948.4 3075.9
## 1994.881 2091.04 2590.9 1941.1 3095.3
## 1994.885 2112.21 2591.9 1954.5 3135.4
## 1994.888 2112.21 2609.4 1950.2 3146.5
## 1994.892 2091.94 2600.9 1927.5 3127.5
## 1994.896 2089.48 2606.5 1926.5 3131.0
## 1994.900 2097.20 2607.0 1927.8 3121.0
## 1994.904 2073.29 2571.8 1911.4 3078.7
## 1994.908 2040.05 2546.1 1893.1 3027.5
## 1994.912 2058.79 2568.6 1934.7 3036.6
## 1994.915 2056.27 2572.5 1945.9 3033.5
## 1994.919 2050.82 2579.4 1952.4 3047.1
## 1994.923 2036.24 2584.7 1940.0 3061.1
## 1994.927 2057.08 2594.9 1975.9 3081.4
## 1994.931 2045.54 2576.0 1964.0 3039.6
## 1994.935 2042.38 2577.5 1982.7 3017.3
## 1994.938 2067.26 2611.0 1973.7 3033.5
## 1994.942 2046.99 2589.1 1969.0 3016.1
## 1994.946 2044.04 2584.3 1969.8 3012.5
## 1994.950 2041.85 2589.3 1954.1 3013.8
## 1994.954 2024.19 2576.0 1937.0 2977.3
## 1994.958 2003.64 2562.8 1919.3 2943.4
## 1994.962 2019.13 2566.0 1917.1 2946.4
## 1994.965 2040.94 2581.4 1930.2 2980.6
## 1994.969 2054.23 2598.0 1931.1 2973.4
## 1994.973 2069.90 2604.7 1924.2 3013.6
## 1994.977 2066.59 2600.7 1928.1 3034.4
## 1994.981 2080.16 2614.7 1924.7 3058.1
## 1994.985 2095.50 2636.1 1940.9 3070.4
## 1994.988 2102.25 2649.8 1952.1 3091.7
## 1994.992 2100.98 2651.0 1949.9 3083.4
## 1994.996 2100.98 2651.0 1966.6 3083.4
## 1995.000 2110.77 2673.5 1956.0 3083.4
## 1995.004 2097.34 2656.2 1927.8 3095.8
## 1995.008 2074.68 2628.8 1894.2 3065.6
## 1995.012 2097.51 2628.8 1881.2 3065.5
## 1995.015 2079.19 2628.8 1881.2 3065.5
## 1995.019 2068.92 2612.3 1885.9 3065.7
```

```
## 1995.023 2072.90 2632.4 1901.8 3051.6
## 1995.027 2051.46 2613.1 1871.5 3032.3
## 1995.031 2058.20 2622.3 1886.4 3065.0
## 1995.035 2053.41 2617.3 1864.2 3055.8
## 1995.038 2062.08 2600.4 1859.2 3060.4
## 1995.042 2061.76 2597.0 1849.1 3049.4
## 1995.046 2059.68 2600.5 1844.1 3033.2
## 1995.050 2064.14 2600.2 1854.0 3048.3
## 1995.054 2088.25 2591.6 1872.8 3076.7
## 1995.058 2081.39 2582.8 1856.9 3054.0
## 1995.062 2085.62 2593.6 1860.3 3054.9
## 1995.065 2079.60 2595.5 1837.1 3028.6
## 1995.069 2050.86 2574.6 1813.3 2995.9
## 1995.073 2013.03 2525.3 1772.8 2954.2
## 1995.077 2027.67 2534.8 1780.2 2969.0
## 1995.081 2026.97 2525.5 1802.5 2982.2
## 1995.085 2040.79 2554.7 1826.3 3007.3
## 1995.088 2030.56 2552.4 1814.1 3022.2
## 1995.092 2026.68 2540.2 1813.4 2995.9
## 1995.096 2024.82 2536.9 1797.9 2991.6
## 1995.100 2047.44 2560.8 1827.8 3017.3
## 1995.104 2038.46 2563.7 1816.1 3034.7
## 1995.108 2077.94 2589.4 1842.4 3059.7
## 1995.112 2085.08 2621.4 1872.1 3062.0
## 1995.115 2093.01 2628.0 1870.4 3072.7
## 1995.119 2087.78 2617.4 1850.9 3072.5
## 1995.123 2117.80 2636.9 1874.4 3099.0
## 1995.127 2127.56 2635.4 1869.4 3109.9
## 1995.131 2118.96 2636.0 1850.1 3081.1
## 1995.135 2128.33 2642.4 1856.1 3071.3
## 1995.138 2135.49 2636.0 1861.9 3074.9
## 1995.142 2112.06 2621.0 1835.0 3051.1
## 1995.146 2119.29 2601.0 1822.5 3044.2
## 1995.150 2101.98 2597.2 1802.2 3018.6
## 1995.154 2101.82 2609.6 1805.6 3023.4
## 1995.158 2096.26 2610.0 1804.4 3019.5
## 1995.162 2126.44 2632.1 1827.0 3049.3
## 1995.165 2117.59 2623.3 1805.7 3037.7
## 1995.169 2106.05 2607.5 1802.2 3025.3
## 1995.173 2097.85 2600.4 1776.9 3009.3
## 1995.177 2127.21 2619.2 1808.4 3041.2
## 1995.181 2116.64 2617.2 1807.4 3038.2
## 1995.185 2094.16 2586.5 1795.2 3025.1
## 1995.188 2069.95 2553.2 1773.3 3001.9
## 1995.192 2041.26 2543.1 1748.6 2977.0
## 1995.196 2029.38 2515.8 1756.8 2992.1
## 1995.200 1989.20 2461.5 1727.1 2986.9
## 1995.204 2008.85 2467.7 1743.1 3021.1
## 1995.208 1974.14 2450.3 1721.8 3011.8
## 1995.212 2022.50 2463.3 1769.0 3050.6
## 1995.215 1995.22 2475.0 1738.6 3047.0
## 1995.219 2016.15 2491.7 1785.8 3094.1
## 1995.223 1979.52 2497.5 1788.8 3089.3
## 1995.227 1984.99 2516.0 1811.6 3124.2
```

```
## 1995.231 1984.15 2505.5 1813.8 3135.0
## 1995.235 1978.07 2501.9 1818.0 3139.7
## 1995.238 1935.08 2480.7 1795.7 3136.4
## 1995.242 1935.87 2526.6 1817.3 3153.4
## 1995.246 1928.82 2518.1 1836.1 3149.8
## 1995.250 1911.70 2495.6 1837.2 3128.3
## 1995.254 1918.85 2495.0 1852.4 3142.3
## 1995.258 1949.76 2533.1 1893.0 3176.2
## 1995.262 1914.69 2508.9 1859.5 3137.9
## 1995.265 1934.96 2511.1 1864.0 3143.1
## 1995.269 1965.68 2536.2 1882.8 3188.1
## 1995.273 1972.59 2536.3 1872.9 3190.2
## 1995.277 1976.52 2556.1 1890.2 3200.9
## 1995.281 1978.71 2559.3 1900.4 3210.9
## 1995.285 1980.81 2561.2 1880.9 3204.2
## 1995.288 1979.26 2563.1 1869.3 3190.9
## 1995.292 1991.08 2562.4 1871.9 3209.8
## 1995.296 1982.99 2560.3 1881.1 3208.8
## 1995.300 1982.99 2560.3 1881.1 3208.8
## 1995.304 1982.99 2560.3 1881.1 3208.8
## 1995.308 1954.62 2547.1 1855.7 3194.5
## 1995.312 1943.88 2516.8 1874.9 3170.1
## 1995.315 1955.33 2544.2 1882.0 3174.7
## 1995.319 1987.70 2560.8 1928.4 3199.9
## 1995.323 1978.97 2554.8 1918.5 3209.3
## 1995.327 2007.57 2561.1 1945.9 3214.9
## 1995.331 2028.52 2574.4 1942.3 3226.2
## 1995.335 2024.25 2567.0 1931.0 3217.6
## 1995.338 2017.95 2597.2 1918.5 3216.7
## 1995.342 2017.95 2597.2 1918.5 3220.4
## 1995.346 2036.47 2621.4 1936.9 3248.2
## 1995.350 2037.99 2618.6 1971.1 3262.6
## 1995.354 2034.15 2641.7 1946.2 3264.3
## 1995.358 2021.22 2650.5 1927.4 3251.7
## 1995.362 2030.65 2658.8 1927.4 3251.7
## 1995.365 2050.66 2655.6 1988.7 3261.2
## 1995.369 2064.41 2661.4 1996.7 3290.1
## 1995.373 2086.41 2701.0 2003.6 3317.9
## 1995.377 2102.40 2728.2 2017.3 3310.3
## 1995.381 2092.00 2739.0 1991.5 3310.7
## 1995.385 2109.36 2746.6 2001.3 3300.8
## 1995.388 2088.99 2739.8 2004.7 3297.4
## 1995.392 2083.80 2727.7 1989.8 3285.8
## 1995.396 2064.42 2701.0 1965.5 3261.0
## 1995.400 2096.87 2751.2 1979.5 3284.5
## 1995.404 2083.55 2750.4 1965.3 3291.8
## 1995.408 2105.88 2778.5 1960.7 3327.3
## 1995.412 2105.88 2778.5 1960.7 3328.2
## 1995.415 2065.71 2751.7 1919.1 3311.1
## 1995.419 2069.26 2762.5 1927.8 3311.1
## 1995.423 2081.46 2779.4 1927.3 3309.9
## 1995.427 2099.95 2786.4 1948.0 3319.4
## 1995.431 2119.24 2807.8 1960.8 3340.6
## 1995.435 2132.72 2805.3 1971.3 3345.0
```

```
## 1995.438 2132.72 2805.3 1971.3 3376.6
## 1995.442 2154.17 2809.7 1965.9 3380.0
## 1995.446 2136.72 2819.6 1974.7 3370.8
## 1995.450 2137.21 2806.8 1951.2 3380.8
## 1995.454 2107.16 2795.3 1897.0 3337.7
## 1995.458 2127.79 2802.3 1907.8 3344.6
## 1995.462 2124.25 2800.9 1922.8 3348.0
## 1995.465 2124.84 2798.1 1893.7 3339.8
## 1995.469 2130.78 2800.2 1920.7 3370.4
## 1995.473 2125.06 2775.4 1905.0 3366.1
## 1995.477 2154.13 2803.0 1918.4 3381.3
## 1995.481 2140.36 2805.6 1896.1 3377.2
## 1995.485 2144.88 2816.8 1902.8 3378.3
## 1995.488 2144.88 2843.3 1925.2 3403.8
## 1995.492 2144.88 2837.7 1895.1 3379.4
## 1995.496 2137.36 2830.3 1902.4 3309.2
## 1995.500 2128.99 2845.1 1877.7 3313.2
## 1995.504 2091.30 2836.8 1865.5 3282.7
## 1995.508 2094.68 2845.6 1861.9 3294.0
## 1995.512 2089.04 2825.3 1858.8 3314.6
## 1995.515 2099.68 2827.5 1879.7 3323.7
## 1995.519 2110.13 2847.5 1889.4 3349.2
## 1995.523 2117.63 2843.7 1907.8 3394.9
## 1995.527 2111.35 2833.7 1889.5 3388.3
## 1995.531 2163.37 2848.4 1950.8 3462.9
## 1995.535 2184.39 2842.9 1949.4 3455.0
## 1995.538 2194.15 2847.3 1961.3 3464.0
## 1995.542 2200.32 2867.9 1961.7 3450.6
## 1995.546 2193.72 2869.7 1948.3 3447.2
## 1995.550 2191.25 2863.4 1948.3 3429.2
## 1995.554 2201.36 2892.3 1951.5 3442.6
## 1995.558 2183.71 2875.1 1929.0 3420.7
## 1995.562 2195.31 2856.2 1931.2 3405.3
## 1995.565 2183.52 2822.2 1905.9 3400.4
## 1995.569 2196.54 2830.2 1908.9 3413.1
## 1995.573 2232.02 2836.6 1926.6 3431.6
## 1995.577 2232.23 2833.2 1941.3 3432.9
## 1995.581 2237.73 2827.1 1942.5 3454.3
## 1995.585 2239.36 2824.7 1947.9 3458.3
## 1995.588 2217.91 2833.1 1932.8 3468.9
## 1995.592 2222.51 2826.8 1920.0 3463.3
## 1995.596 2211.26 2826.8 1917.8 3449.9
## 1995.600 2249.60 2852.3 1960.0 3499.9
## 1995.604 2234.86 2814.3 1950.8 3475.6
## 1995.608 2236.68 2807.1 1957.1 3482.4
## 1995.612 2244.56 2800.6 1950.4 3483.5
## 1995.615 2236.89 2797.4 1954.7 3468.8
## 1995.619 2222.28 2781.3 1943.7 3468.3
## 1995.623 2236.72 2802.6 1949.2 3474.7
## 1995.627 2228.44 2820.1 1946.2 3467.5
## 1995.631 2208.41 2807.2 1946.2 3441.4
## 1995.635 2236.73 2838.4 1946.2 3444.4
## 1995.638 2251.64 2880.6 1970.4 3465.1
## 1995.642 2253.93 2880.0 1967.3 3470.6
```

```
## 1995.646 2265.86 2889.5 1971.6 3509.8
## 1995.650 2269.60 2886.7 1984.4 3535.7
## 1995.654 2258.97 2900.8 1963.3 3530.2
## 1995.658 2262.66 2896.8 1957.4 3515.9
## 1995.662 2253.91 2887.1 1939.2 3520.0
## 1995.665 2257.34 2893.8 1937.8 3524.9
## 1995.669 2240.31 2883.3 1890.1 3524.9
## 1995.673 2230.27 2887.3 1899.5 3502.6
## 1995.677 2251.30 2915.7 1921.4 3504.0
## 1995.681 2234.23 2908.8 1883.4 3477.8
## 1995.685 2242.76 2918.3 1881.7 3509.4
## 1995.688 2263.08 2952.7 1900.5 3522.7
## 1995.692 2266.57 2971.1 1902.5 3532.4
## 1995.696 2266.37 2999.6 1884.8 3557.7
## 1995.700 2263.27 2989.1 1861.7 3545.6
## 1995.704 2266.77 2989.2 1854.9 3554.5
## 1995.708 2268.26 2986.3 1869.7 3549.3
## 1995.712 2266.07 2990.5 1873.6 3535.9
## 1995.715 2300.72 3016.8 1898.2 3570.8
## 1995.719 2300.29 3011.6 1892.4 3565.4
## 1995.723 2305.58 3025.4 1880.0 3564.6
## 1995.727 2289.49 3008.1 1871.7 3533.3
## 1995.731 2306.66 3033.5 1882.5 3541.4
## 1995.735 2294.15 3029.0 1863.8 3561.5
## 1995.738 2275.72 3039.1 1853.9 3557.9
## 1995.742 2204.44 2994.7 1790.7 3514.8
## 1995.746 2212.97 3015.3 1800.6 3507.0
## 1995.750 2232.02 3045.5 1816.3 3523.3
## 1995.754 2190.90 3009.8 1791.8 3485.0
## 1995.758 2184.24 3000.6 1767.6 3479.0
## 1995.762 2201.27 3014.8 1788.4 3508.2
## 1995.765 2197.01 3039.0 1780.7 3520.2
## 1995.769 2197.01 3049.0 1800.7 3524.2
## 1995.773 2211.60 3036.5 1803.9 3544.1
## 1995.777 2191.54 3036.6 1800.3 3544.4
## 1995.781 2176.35 3054.0 1809.6 3526.5
## 1995.785 2157.41 3064.0 1785.7 3510.3
## 1995.788 2137.01 3050.0 1778.0 3460.1
## 1995.792 2153.56 3073.0 1794.4 3474.3
## 1995.796 2159.73 3083.7 1803.8 3523.8
## 1995.800 2206.11 3109.2 1817.0 3568.0
## 1995.804 2193.85 3116.3 1790.5 3557.3
## 1995.808 2185.52 3112.3 1779.7 3562.2
## 1995.812 2197.57 3135.4 1770.7 3593.0
## 1995.815 2176.09 3124.5 1757.3 3578.6
## 1995.819 2148.12 3120.4 1740.7 3551.4
## 1995.823 2116.86 3041.7 1721.1 3531.5
## 1995.827 2114.88 3062.3 1724.2 3535.3
## 1995.831 2140.74 3078.9 1764.1 3537.8
## 1995.835 2142.74 3080.0 1754.1 3519.6
## 1995.838 2112.01 3026.6 1742.4 3497.9
## 1995.842 2149.71 3057.9 1795.3 3510.0
## 1995.846 2165.76 3108.2 1814.0 3529.1
## 1995.850 2182.11 3128.5 1814.0 3518.7
```

```
## 1995.854 2180.49 3123.4 1828.7 3523.0
## 1995.858 2169.69 3137.6 1832.1 3500.4
## 1995.862 2168.57 3123.2 1822.6 3514.8
## 1995.865 2174.27 3133.8 1857.4 3522.4
## 1995.869 2184.05 3132.6 1866.3 3537.1
## 1995.873 2182.47 3150.1 1852.6 3541.6
## 1995.877 2174.78 3130.4 1839.8 3523.4
## 1995.881 2195.15 3121.4 1838.2 3536.8
## 1995.885 2197.34 3133.0 1838.2 3547.9
## 1995.888 2196.64 3124.8 1875.2 3571.4
## 1995.892 2199.29 3148.4 1905.1 3610.8
## 1995.896 2196.59 3152.5 1890.5 3609.2
## 1995.900 2204.01 3182.2 1881.4 3628.8
## 1995.904 2201.90 3183.9 1872.9 3604.1
## 1995.908 2194.53 3201.0 1875.5 3632.4
## 1995.912 2197.26 3209.2 1867.1 3602.5
## 1995.915 2210.92 3220.1 1891.0 3624.0
## 1995.919 2247.97 3251.0 1889.8 3649.0
## 1995.923 2242.91 3229.5 1870.3 3648.8
## 1995.927 2249.75 3245.9 1857.3 3655.5
## 1995.931 2254.95 3251.6 1828.3 3664.3
## 1995.935 2266.56 3261.2 1820.9 3664.3
## 1995.938 2261.08 3278.4 1774.9 3669.7
## 1995.942 2269.34 3278.5 1814.9 3664.2
## 1995.946 2274.94 3281.5 1834.8 3662.8
## 1995.950 2260.62 3245.7 1846.8 3639.5
## 1995.954 2277.70 3246.6 1856.3 3630.0
## 1995.958 2277.70 3261.6 1849.6 3652.1
## 1995.962 2278.64 3280.9 1848.9 3654.9
## 1995.965 2283.26 3273.4 1833.8 3662.4
## 1995.969 2286.21 3272.2 1875.0 3671.6
## 1995.973 2283.84 3289.8 1859.3 3642.6
## 1995.977 2240.24 3251.6 1820.5 3596.1
## 1995.981 2241.43 3217.7 1810.2 3576.9
## 1995.985 2268.07 3254.3 1831.2 3613.7
## 1995.988 2268.35 3255.0 1834.4 3633.3
## 1995.992 2280.81 3277.9 1873.4 3658.3
## 1995.996 2280.81 3277.9 1873.4 3658.3
## 1996.000 2280.81 3277.9 1866.7 3658.3
## 1996.004 2280.44 3317.1 1877.0 3676.4
## 1996.008 2273.90 3297.7 1879.1 3676.7
## 1996.012 2260.69 3297.7 1872.0 3689.3
## 1996.015 2260.69 3297.7 1872.0 3689.3
## 1996.019 2307.70 3297.7 1908.4 3687.9
## 1996.023 2326.18 3384.5 1943.0 3715.6
## 1996.027 2332.81 3395.8 1931.2 3714.1
## 1996.031 2315.66 3376.1 1917.7 3704.5
## 1996.035 2336.76 3368.1 1916.6 3720.6
## 1996.038 2351.47 3361.5 1916.3 3720.6
## 1996.042 2340.31 3314.8 1910.1 3671.5
## 1996.046 2330.98 3284.1 1897.9 3654.9
## 1996.050 2353.89 3292.9 1907.6 3657.3
## 1996.054 2361.38 3233.9 1924.4 3662.7
## 1996.058 2379.43 3254.8 1952.1 3710.6
```

```
## 1996.062 2375.63 3219.3 1966.0 3704.2
## 1996.065 2389.62 3257.8 1960.1 3748.7
## 1996.069 2400.58 3253.1 1964.3 3748.4
## 1996.073 2391.74 3249.9 1954.4 3754.2
## 1996.077 2393.12 3219.0 1934.1 3735.0
## 1996.081 2436.68 3221.3 1946.0 3758.2
## 1996.085 2437.02 3211.2 1950.2 3734.2
## 1996.088 2449.71 3191.4 1966.7 3734.7
## 1996.092 2437.70 3198.2 1980.7 3734.6
## 1996.096 2456.09 3236.8 2003.1 3735.3
## 1996.100 2463.00 3248.7 2021.0 3759.3
## 1996.104 2472.53 3279.9 2024.1 3752.8
## 1996.108 2459.81 3270.0 2022.2 3781.3
## 1996.112 2416.84 3221.7 1985.6 3746.6
## 1996.115 2437.98 3253.8 1988.5 3747.5
## 1996.119 2442.43 3262.7 1983.3 3726.1
## 1996.123 2411.49 3245.6 1956.2 3708.4
## 1996.127 2435.07 3242.7 1960.7 3716.3
## 1996.131 2428.59 3253.1 1967.7 3726.6
## 1996.135 2436.09 3260.1 1983.3 3747.6
## 1996.138 2427.77 3266.1 1956.4 3745.0
## 1996.142 2426.51 3272.2 1964.2 3779.8
## 1996.146 2423.60 3280.3 1952.5 3770.9
## 1996.150 2387.60 3270.6 1939.7 3744.3
## 1996.154 2373.01 3243.5 1932.4 3714.6
## 1996.158 2401.59 3253.0 1936.9 3725.6
## 1996.162 2421.93 3264.4 1953.3 3740.0
## 1996.165 2449.52 3296.2 1976.9 3740.3
## 1996.169 2438.73 3298.6 1960.9 3704.2
## 1996.173 2449.09 3309.9 1974.5 3715.9
## 1996.177 2486.95 3360.5 1996.9 3738.2
## 1996.181 2485.18 3354.8 1990.8 3727.6
## 1996.185 2488.85 3385.5 2017.2 3752.7
## 1996.188 2486.83 3400.6 2015.3 3768.6
## 1996.192 2472.52 3383.4 2001.9 3777.1
## 1996.196 2471.38 3408.3 2005.9 3758.9
## 1996.200 2479.38 3581.9 2008.0 3758.2
## 1996.204 2448.80 3549.7 1975.5 3710.3
## 1996.208 2419.72 3506.2 1948.9 3674.5
## 1996.212 2415.29 3540.5 1932.1 3639.5
## 1996.215 2417.00 3558.3 1944.3 3640.3
## 1996.219 2432.46 3578.4 1962.4 3681.8
## 1996.223 2458.00 3561.1 1950.1 3644.8
## 1996.227 2472.55 3583.6 1965.0 3669.6
## 1996.231 2484.74 3605.1 1967.2 3693.0
## 1996.235 2491.73 3611.1 1969.8 3685.4
## 1996.238 2505.32 3629.3 1976.9 3698.3
## 1996.242 2479.84 3647.7 1974.4 3707.0
## 1996.246 2514.80 3677.0 2003.8 3681.9
## 1996.250 2505.78 3658.1 2008.0 3660.9
## 1996.254 2523.81 3671.0 2030.5 3672.4
## 1996.258 2502.94 3640.3 2020.0 3672.6
## 1996.262 2489.35 3646.5 2044.8 3699.7
## 1996.265 2500.75 3654.3 2055.6 3718.4
```

```
## 1996.269 2508.11 3648.3 2070.4 3728.5
## 1996.273 2489.52 3606.7 2064.0 3725.1
## 1996.277 2498.75 3611.1 2075.0 3755.6
## 1996.281 2498.75 3611.1 2075.0 3755.6
## 1996.285 2498.75 3611.1 2075.0 3755.6
## 1996.288 2510.81 3594.4 2081.7 3758.6
## 1996.292 2525.59 3601.5 2093.9 3767.4
## 1996.296 2508.12 3566.9 2072.5 3744.2
## 1996.300 2526.74 3575.5 2074.7 3766.8
## 1996.304 2540.79 3589.6 2080.6 3790.5
## 1996.308 2547.32 3607.5 2097.3 3825.3
## 1996.312 2519.82 3603.9 2075.1 3805.6
## 1996.315 2524.18 3601.2 2086.0 3820.7
## 1996.319 2535.86 3628.1 2092.5 3857.1
## 1996.323 2549.27 3673.2 2116.5 3852.7
## 1996.327 2549.12 3647.3 2112.0 3833.0
## 1996.331 2524.84 3668.4 2122.1 3817.6
## 1996.335 2538.68 3668.1 2116.4 3819.3
## 1996.338 2539.88 3696.0 2138.4 3832.8
## 1996.342 2505.97 3658.2 2130.8 3809.2
## 1996.346 2492.63 3651.0 2146.8 3817.9
## 1996.350 2492.63 3651.0 2146.8 3806.0
## 1996.354 2465.49 3635.8 2136.8 3776.4
## 1996.358 2472.43 3611.2 2115.4 3751.6
## 1996.362 2473.52 3591.6 2090.4 3751.6
## 1996.365 2476.79 3583.6 2083.7 3723.0
## 1996.369 2466.21 3534.1 2083.7 3707.3
## 1996.373 2470.57 3521.6 2085.4 3728.3
## 1996.377 2499.02 3556.9 2114.8 3754.4
## 1996.381 2496.33 3557.8 2100.9 3739.2
## 1996.385 2528.20 3582.4 2122.1 3759.7
## 1996.388 2534.40 3572.5 2124.6 3776.2
## 1996.392 2534.40 3572.5 2124.6 3753.6
## 1996.396 2552.29 3593.0 2136.9 3789.6
## 1996.400 2541.98 3584.0 2120.6 3778.2
## 1996.404 2564.12 3587.3 2129.7 3789.4
## 1996.408 2548.79 3550.0 2103.5 3764.2
## 1996.412 2546.55 3547.4 2114.5 3747.0
## 1996.415 2549.53 3572.2 2117.7 3752.1
## 1996.419 2549.53 3572.2 2117.7 3752.1
## 1996.423 2559.15 3583.8 2132.9 3760.2
## 1996.427 2548.53 3558.2 2117.1 3775.7
## 1996.431 2535.78 3537.7 2108.4 3746.7
## 1996.435 2523.81 3556.1 2110.1 3747.8
## 1996.438 2543.99 3544.6 2121.1 3739.2
## 1996.442 2550.42 3568.1 2111.0 3755.2
## 1996.446 2551.03 3572.0 2115.4 3753.4
## 1996.450 2559.02 3585.5 2133.2 3760.3
## 1996.454 2536.03 3547.9 2102.0 3706.8
## 1996.458 2552.96 3575.8 2120.8 3728.8
## 1996.462 2571.10 3575.6 2137.5 3755.7
## 1996.465 2569.90 3600.9 2137.3 3769.2
## 1996.469 2566.13 3607.4 2126.2 3761.7
## 1996.473 2544.90 3593.9 2111.8 3753.6
```

```
## 1996.477 2549.71 3600.1 2113.0 3761.5
## 1996.481 2554.12 3628.3 2107.9 3756.4
## 1996.485 2546.04 3643.6 2100.7 3753.2
## 1996.488 2532.22 3655.4 2077.1 3727.5
## 1996.492 2547.78 3687.3 2084.2 3722.3
## 1996.496 2562.19 3701.5 2097.6 3710.8
## 1996.500 2578.36 3699.6 2118.4 3679.5
## 1996.504 2572.06 3723.5 2113.3 3695.5
## 1996.508 2551.80 3703.0 2112.9 3678.8
## 1996.512 2570.44 3732.9 2123.7 3711.0
## 1996.515 2573.44 3728.2 2118.8 3725.6
## 1996.519 2565.32 3750.8 2111.8 3725.7
## 1996.523 2566.32 3757.0 2114.0 3714.1
## 1996.527 2578.74 3771.3 2126.8 3760.6
## 1996.531 2568.79 3731.2 2098.8 3743.2
## 1996.535 2561.51 3732.8 2079.1 3741.5
## 1996.538 2562.24 3773.4 2076.6 3752.3
## 1996.542 2573.00 3788.0 2081.9 3765.8
## 1996.546 2561.95 3810.0 2073.4 3749.0
## 1996.550 2548.97 3785.8 2050.6 3728.3
## 1996.554 2529.50 3755.4 2029.5 3698.3
## 1996.558 2475.98 3678.1 1989.5 3632.3
## 1996.562 2497.69 3656.2 1995.1 3658.2
## 1996.565 2505.56 3649.2 2007.3 3693.4
## 1996.569 2498.35 3661.5 1992.8 3710.5
## 1996.573 2468.32 3566.1 1960.3 3681.3
## 1996.577 2488.82 3585.2 1982.2 3708.4
## 1996.581 2459.13 3482.6 1954.1 3668.8
## 1996.585 2464.51 3537.4 1974.7 3684.7
## 1996.588 2469.51 3537.8 1962.9 3673.3
## 1996.592 2472.25 3549.5 1961.1 3678.8
## 1996.596 2466.84 3518.2 1968.5 3668.5
## 1996.600 2491.50 3494.4 1995.9 3703.2
## 1996.604 2504.16 3494.4 2009.9 3734.4
## 1996.608 2520.26 3604.6 2023.4 3770.6
## 1996.612 2520.52 3623.3 2013.2 3788.3
## 1996.615 2527.73 3629.0 1999.3 3788.4
## 1996.619 2541.41 3662.6 1996.7 3811.1
## 1996.623 2534.63 3653.4 1997.4 3811.4
## 1996.627 2532.96 3643.2 1985.4 3810.7
## 1996.631 2529.14 3623.1 1978.2 3803.3
## 1996.635 2545.65 3630.2 1980.6 3823.4
## 1996.638 2544.61 3650.7 1979.5 3830.3
## 1996.642 2542.75 3646.3 1979.5 3837.4
## 1996.646 2567.96 3670.5 1979.5 3872.9
## 1996.650 2556.25 3664.4 1986.2 3863.7
## 1996.654 2562.12 3698.2 2019.3 3883.2
## 1996.658 2534.44 3683.8 2000.6 3872.1
## 1996.662 2559.42 3713.0 2017.8 3891.1
## 1996.665 2562.12 3725.4 2020.8 3907.5
## 1996.669 2554.42 3714.6 2020.4 3907.5
## 1996.673 2563.59 3722.4 2018.0 3905.7
## 1996.677 2556.64 3692.6 2002.9 3918.7
## 1996.681 2548.84 3682.6 1977.6 3885.0
```

```
## 1996.685 2534.49 3646.3 1970.6 3867.6
## 1996.688 2538.34 3654.7 1977.0 3884.4
## 1996.692 2528.73 3623.9 1971.4 3855.9
## 1996.696 2526.18 3634.2 1984.8 3872.7
## 1996.700 2532.55 3627.1 1996.2 3887.2
## 1996.704 2542.74 3637.8 2004.8 3893.0
## 1996.708 2549.71 3684.4 2020.3 3910.8
## 1996.712 2568.77 3694.2 2042.1 3916.1
## 1996.715 2568.70 3678.9 2038.1 3905.6
## 1996.719 2588.04 3687.2 2065.4 3932.6
## 1996.723 2614.50 3716.8 2080.4 3967.9
## 1996.727 2630.24 3722.7 2086.2 3977.2
## 1996.731 2626.43 3690.0 2080.9 3972.3
## 1996.735 2621.20 3690.1 2072.7 3955.7
## 1996.738 2625.46 3694.9 2082.3 3974.3
## 1996.742 2641.50 3694.9 2079.5 3964.1
## 1996.746 2624.18 3635.5 2067.1 3919.7
## 1996.750 2643.42 3661.2 2081.5 3910.5
## 1996.754 2663.10 3697.7 2103.4 3935.7
## 1996.758 2664.96 3699.5 2104.1 3933.2
## 1996.762 2659.86 3696.6 2107.1 3946.4
## 1996.765 2655.49 3736.4 2132.8 3953.7
## 1996.769 2654.34 3737.5 2123.2 3992.2
## 1996.773 2685.29 3760.2 2141.8 4015.1
## 1996.777 2685.29 3771.6 2136.1 4000.0
## 1996.781 2704.25 3771.6 2152.7 4024.8
## 1996.785 2705.21 3813.7 2151.6 4031.5
## 1996.788 2702.60 3818.1 2161.5 4035.6
## 1996.792 2685.23 3807.9 2146.7 4009.3
## 1996.796 2683.52 3797.3 2135.6 3994.7
## 1996.800 2692.69 3805.2 2147.1 4028.1
## 1996.804 2700.83 3813.7 2143.6 4038.7
## 1996.808 2718.73 3822.2 2168.3 4050.8
## 1996.812 2705.06 3790.2 2158.5 4024.4
## 1996.815 2717.50 3793.2 2165.3 4042.1
## 1996.819 2727.56 3803.3 2185.2 4053.1
## 1996.823 2733.67 3788.2 2180.2 4073.1
## 1996.827 2721.74 3775.3 2175.6 4057.2
## 1996.831 2678.89 3742.9 2148.9 4028.4
## 1996.835 2681.94 3753.6 2151.6 3999.4
## 1996.838 2690.79 3758.7 2162.4 4022.4
## 1996.842 2703.33 3763.5 2150.4 4025.3
## 1996.846 2675.50 3732.0 2125.7 3993.5
## 1996.850 2664.72 3723.1 2124.8 3963.9
## 1996.854 2671.40 3725.3 2140.5 3979.1
## 1996.858 2670.19 3736.1 2140.5 3948.5
## 1996.862 2678.73 3749.2 2142.2 3928.1
## 1996.865 2716.16 3784.8 2187.3 3921.1
## 1996.869 2735.28 3815.4 2213.4 3935.7
## 1996.873 2724.25 3811.5 2211.8 3900.4
## 1996.877 2732.29 3812.0 2205.2 3910.8
## 1996.881 2730.44 3827.6 2205.2 3914.4
## 1996.885 2764.00 3829.8 2229.1 3934.3
## 1996.888 2770.61 3825.7 2217.2 3926.9
```

```
## 1996.892 2784.39 3856.4 2218.2 3926.1
## 1996.896 2800.60 3897.9 2240.3 3958.2
## 1996.900 2768.68 3888.3 2228.8 3962.1
## 1996.904 2781.54 3892.6 2240.1 3978.1
## 1996.908 2766.08 3883.3 2233.4 3962.8
## 1996.912 2765.29 3861.5 2233.6 3953.8
## 1996.915 2769.47 3882.8 2255.5 4018.7
## 1996.919 2800.52 3891.7 2277.1 4054.6
## 1996.923 2808.62 3878.2 2275.1 4068.4
## 1996.927 2793.86 3845.3 2270.8 4049.2
## 1996.931 2829.68 3884.1 2290.3 4050.2
## 1996.935 2848.84 3902.5 2315.7 4058.0
## 1996.938 2853.46 3874.0 2318.6 4038.5
## 1996.942 2900.76 3924.5 2349.1 4061.5
## 1996.946 2880.89 3910.6 2308.7 4045.2
## 1996.950 2894.43 3913.8 2292.5 4051.2
## 1996.954 2832.53 3835.5 2240.7 3963.0
## 1996.958 2870.30 3874.0 2255.8 4011.6
## 1996.962 2890.95 3885.4 2251.4 4035.7
## 1996.965 2836.36 3857.6 2213.3 3982.5
## 1996.969 2846.94 3860.0 2212.1 3990.7
## 1996.973 2815.77 3839.3 2203.4 3972.4
## 1996.977 2841.16 3869.2 2222.6 3993.8
## 1996.981 2808.50 3850.4 2193.7 3979.6
## 1996.985 2814.23 3874.0 2218.9 4018.2
## 1996.988 2824.83 3880.8 2248.7 4051.3
## 1996.992 2835.54 3890.1 2278.5 4077.6
## 1996.996 2844.09 3875.5 2287.4 4087.2
## 1997.000 2844.09 3869.8 2289.6 4092.5
## 1997.004 2844.09 3869.8 2289.6 4092.5
## 1997.008 2844.09 3869.8 2303.8 4092.5
## 1997.012 2859.22 3922.2 2307.0 4091.0
## 1997.015 2880.07 3948.3 2318.6 4115.7
## 1997.019 2880.07 3942.2 2315.7 4118.5
## 1997.023 2880.07 3942.2 2315.7 4118.5
## 1997.027 2820.81 3942.2 2257.0 4057.4
## 1997.031 2863.26 3940.1 2282.8 4089.5
## 1997.035 2890.20 3923.8 2306.7 4106.5
## 1997.038 2876.34 3922.9 2301.7 4078.8
## 1997.042 2904.08 3944.9 2331.6 4087.5
## 1997.046 2936.69 3966.2 2349.1 4087.0
## 1997.050 2915.81 3947.4 2327.5 4056.6
## 1997.054 2956.78 3975.5 2361.3 4107.3
## 1997.058 2978.84 3983.6 2402.1 4168.2
## 1997.062 2976.56 3979.6 2388.0 4158.9
## 1997.065 2996.12 4007.1 2407.8 4197.5
## 1997.069 3006.87 4019.9 2425.1 4207.7
## 1997.073 2999.19 4009.5 2406.1 4194.0
## 1997.077 3000.66 4023.1 2409.9 4195.5
## 1997.081 3026.63 4115.4 2442.5 4219.1
## 1997.085 3037.28 4161.0 2461.3 4219.1
## 1997.088 2982.63 4125.5 2430.3 4218.8
## 1997.092 2992.55 4127.3 2435.2 4212.0
## 1997.096 3028.27 4182.3 2482.8 4237.4
```

```
## 1997.100 2997.95 4169.7 2465.0 4207.5
## 1997.104 3018.58 4209.1 2503.1 4228.4
## 1997.108 3037.70 4272.2 2516.6 4275.8
## 1997.112 3064.70 4282.8 2508.6 4257.8
## 1997.115 3067.48 4296.5 2503.1 4260.9
## 1997.119 3114.73 4305.5 2541.3 4281.5
## 1997.123 3124.78 4309.8 2558.4 4265.9
## 1997.127 3161.36 4357.9 2597.5 4307.8
## 1997.131 3185.72 4384.3 2595.4 4307.7
## 1997.135 3191.45 4408.4 2582.1 4304.3
## 1997.138 3211.01 4444.1 2599.3 4304.3
## 1997.142 3256.86 4436.3 2628.4 4327.1
## 1997.146 3249.17 4464.2 2627.4 4341.0
## 1997.150 3260.30 4514.6 2634.5 4337.8
## 1997.154 3230.83 4490.7 2617.5 4332.3
## 1997.158 3209.04 4525.5 2594.8 4357.4
## 1997.162 3197.09 4530.8 2575.2 4356.1
## 1997.165 3203.79 4522.5 2562.8 4336.8
## 1997.169 3180.63 4463.2 2567.9 4331.1
## 1997.173 3233.34 4503.9 2607.7 4344.7
## 1997.177 3245.02 4539.0 2602.2 4329.3
## 1997.181 3272.58 4519.7 2629.4 4339.2
## 1997.185 3261.04 4487.6 2607.8 4308.3
## 1997.188 3258.74 4460.1 2600.3 4307.1
## 1997.192 3345.09 4513.7 2651.7 4357.7
## 1997.196 3375.45 4547.1 2666.2 4360.1
## 1997.200 3396.55 4605.2 2698.9 4399.3
## 1997.204 3419.51 4638.9 2708.3 4420.3
## 1997.208 3426.77 4684.4 2709.2 4437.4
## 1997.212 3430.95 4677.1 2686.2 4444.3
## 1997.215 3382.40 4676.2 2641.7 4422.5
## 1997.219 3367.82 4609.9 2632.1 4397.7
## 1997.223 3404.29 4636.2 2645.6 4424.3
## 1997.227 3337.11 4556.5 2588.4 4373.3
## 1997.231 3289.59 4519.9 2574.0 4356.8
## 1997.235 3305.72 4535.1 2596.8 4332.2
## 1997.238 3247.03 4442.9 2553.7 4258.1
## 1997.242 3288.52 4491.3 2587.1 4254.8
## 1997.246 3302.57 4497.3 2579.3 4214.8
## 1997.250 3374.93 4558.6 2624.3 4270.7
## 1997.254 3439.22 4620.5 2648.7 4301.5
## 1997.258 3407.83 4659.2 2656.7 4312.9
## 1997.262 3407.83 4659.2 2656.7 4312.9
## 1997.265 3407.83 4659.2 2656.7 4312.9
## 1997.269 3281.46 4501.7 2581.8 4248.1
## 1997.273 3210.94 4488.7 2530.3 4236.6
## 1997.277 3212.82 4463.9 2514.5 4214.6
## 1997.281 3235.35 4471.5 2518.0 4236.6
## 1997.285 3342.77 4588.0 2572.3 4271.7
## 1997.288 3328.13 4582.6 2579.0 4269.3
## 1997.292 3364.76 4634.9 2617.6 4292.3
## 1997.296 3352.58 4626.6 2608.0 4313.2
## 1997.300 3319.24 4604.2 2574.6 4270.7
## 1997.304 3297.52 4586.3 2566.1 4251.7
```

```
## 1997.308 3369.26 4643.4 2620.6 4286.8
## 1997.312 3347.54 4625.6 2621.0 4294.6
## 1997.315 3361.80 4665.7 2615.2 4298.9
## 1997.319 3361.20 4699.1 2547.6 4310.5
## 1997.323 3328.41 4740.1 2522.7 4328.7
## 1997.327 3348.90 4752.3 2514.7 4346.1
## 1997.331 3366.87 4781.1 2533.6 4387.7
## 1997.335 3396.49 4836.1 2539.8 4388.5
## 1997.338 3357.57 4772.3 2536.3 4369.7
## 1997.342 3372.96 4793.3 2550.3 4389.7
## 1997.346 3425.86 4855.1 2602.9 4433.2
## 1997.350 3438.09 4897.6 2639.5 4436.0
## 1997.354 3438.09 4897.6 2639.5 4445.0
## 1997.358 3491.08 4953.5 2655.3 4455.6
## 1997.362 3565.69 5029.6 2672.8 4455.6
## 1997.365 3548.52 4988.4 2651.9 4519.3
## 1997.369 3537.45 5016.0 2643.3 4537.5
## 1997.373 3537.45 5016.0 2643.3 4580.4
## 1997.377 3533.21 5004.7 2633.9 4630.9
## 1997.381 3593.14 5042.5 2693.1 4669.6
## 1997.385 3559.29 5084.2 2719.6 4691.0
## 1997.388 3588.57 5134.3 2774.6 4686.9
## 1997.392 3564.85 5141.7 2776.0 4681.2
## 1997.396 3569.26 5157.5 2784.3 4693.9
## 1997.400 3569.26 5157.5 2784.3 4645.2
## 1997.404 3516.20 5081.0 2751.1 4607.5
## 1997.408 3600.40 5178.6 2786.4 4642.0
## 1997.412 3575.44 5176.4 2741.7 4651.8
## 1997.415 3621.72 5181.0 2762.9 4661.8
## 1997.419 3669.31 5196.7 2654.7 4661.8
## 1997.423 3665.43 5190.0 2680.3 4681.6
## 1997.427 3626.60 5133.1 2583.2 4677.5
## 1997.431 3635.38 5132.1 2579.2 4672.3
## 1997.435 3562.73 5041.6 2583.9 4621.3
## 1997.438 3596.40 5150.0 2601.5 4562.8
## 1997.442 3655.59 5207.2 2624.5 4557.8
## 1997.446 3651.59 5238.5 2635.4 4557.1
## 1997.450 3684.60 5251.2 2690.9 4576.2
## 1997.454 3700.53 5320.0 2719.3 4645.0
## 1997.458 3668.61 5368.8 2686.2 4686.7
## 1997.462 3671.16 5361.9 2664.2 4739.6
## 1997.465 3671.87 5308.6 2696.2 4724.8
## 1997.469 3737.16 5364.2 2760.3 4757.4
## 1997.473 3752.37 5384.6 2808.5 4783.1
## 1997.477 3750.02 5362.0 2795.9 4745.1
## 1997.481 3721.18 5345.9 2762.6 4682.2
## 1997.485 3730.56 5405.0 2751.7 4657.0
## 1997.488 3777.56 5510.3 2739.7 4653.7
## 1997.492 3788.54 5561.8 2757.1 4593.9
## 1997.496 3748.79 5587.8 2762.2 4575.8
## 1997.500 3761.07 5576.1 2784.8 4596.3
## 1997.504 3819.52 5662.4 2867.4 4640.0
## 1997.508 3820.16 5669.9 2893.6 4657.9
## 1997.512 3809.92 5700.3 2891.0 4640.3
```

```
## 1997.515 3766.89 5620.6 2858.3 4604.6
## 1997.519 3834.84 5654.8 2944.0 4728.3
## 1997.523 3867.53 5674.3 2909.5 4751.4
## 1997.527 3939.73 5804.9 2937.0 4831.7
## 1997.531 3946.73 5846.5 2934.5 4812.8
## 1997.535 4003.35 5947.0 2947.7 4810.7
## 1997.538 4030.10 6012.6 2929.8 4758.5
## 1997.542 4026.97 5977.1 2950.6 4762.4
## 1997.546 4000.65 5885.4 2929.1 4767.8
## 1997.550 4074.30 5801.5 2941.6 4799.5
## 1997.554 4142.19 5845.8 2941.6 4857.4
## 1997.558 4139.68 5844.7 2950.7 4899.3
## 1997.562 4223.69 5927.5 2988.0 4964.2
## 1997.565 4203.91 5868.3 2958.6 4949.0
## 1997.569 4131.94 5737.1 2876.7 4877.2
## 1997.573 4139.96 5620.5 2874.1 4805.7
## 1997.577 4297.64 5677.1 2921.1 4846.7
## 1997.581 4384.82 5869.9 3003.5 4874.5
## 1997.585 4320.52 5849.2 2973.5 4862.9
## 1997.588 4368.54 5847.0 3025.9 4851.5
## 1997.592 4400.30 5888.0 3022.2 4862.6
## 1997.596 4377.70 5842.1 3023.6 4876.6
## 1997.600 4458.66 5929.5 3069.3 4927.3
## 1997.604 4405.52 5898.2 3075.7 4907.5
## 1997.608 4336.98 5898.2 3049.5 4899.3
## 1997.612 4302.50 5771.0 2992.4 4895.7
## 1997.615 4325.86 5765.2 2984.1 4960.6
## 1997.619 4364.25 5812.1 3037.1 5026.2
## 1997.623 4428.08 5922.1 3056.3 5086.8
## 1997.627 4342.31 5864.8 2996.3 5031.3
## 1997.631 4333.15 5825.6 2983.4 5031.9
## 1997.635 4377.51 5808.4 2998.6 5075.8
## 1997.638 4237.06 5682.1 2924.0 5003.6
## 1997.642 4195.53 5579.5 2921.8 4991.3
## 1997.646 4077.59 5498.5 2921.8 4865.8
## 1997.650 4080.55 5405.6 2870.1 4835.0
## 1997.654 4190.45 5580.1 2936.2 4914.2
## 1997.658 4251.93 5690.1 2979.3 4958.4
## 1997.662 4204.81 5668.8 2957.2 4978.0
## 1997.665 4090.14 5475.8 2904.2 4901.1
## 1997.669 4076.75 5473.9 2898.6 4901.1
## 1997.673 3993.70 5363.3 2869.3 4886.3
## 1997.677 3992.03 5409.6 2871.7 4906.9
## 1997.681 3897.43 5217.3 2828.4 4845.4
## 1997.685 3919.79 5216.7 2770.5 4817.5
## 1997.688 4001.81 5271.5 2805.8 4870.2
## 1997.692 4127.28 5447.5 2921.2 4952.2
## 1997.696 4062.13 5478.6 2918.0 4976.9
## 1997.700 4093.43 5478.1 2927.0 4991.3
## 1997.704 4073.71 5532.9 2924.5 4994.2
## 1997.708 4131.26 5505.3 2940.9 4985.2
## 1997.712 4104.57 5445.1 2919.7 4950.5
## 1997.715 4028.00 5356.7 2874.6 4905.2
## 1997.719 3890.24 5280.8 2843.6 4854.8
```

```
## 1997.723 3796.61 5281.9 2834.1 4848.2
## 1997.727 3869.53 5321.7 2898.6 4902.9
## 1997.731 3995.69 5417.8 2940.6 4976.4
## 1997.735 3970.44 5550.4 2944.0 5013.1
## 1997.738 4004.04 5629.0 2978.4 5046.2
## 1997.742 3983.06 5611.0 2977.2 5023.8
## 1997.746 4096.85 5705.1 3017.5 5075.7
## 1997.750 4091.77 5730.4 2997.2 5027.5
## 1997.754 4150.95 5732.5 3023.7 5077.2
## 1997.758 4104.93 5667.1 3005.4 5065.5
## 1997.762 4135.09 5716.6 2985.6 5226.3
## 1997.765 4116.52 5691.8 2989.0 5220.3
## 1997.769 4154.89 5673.6 3008.3 5244.2
## 1997.773 4262.98 5754.7 3054.9 5317.1
## 1997.777 4266.17 5825.0 3052.1 5296.1
## 1997.781 4266.17 5929.0 3094.0 5330.8
## 1997.785 4326.35 5897.4 3078.0 5300.0
## 1997.788 4311.13 5846.9 3064.4 5305.6
## 1997.792 4267.40 5822.3 3024.1 5262.1
## 1997.796 4179.92 5732.2 2960.7 5217.8
## 1997.800 4164.62 5699.5 2955.1 5227.3
## 1997.804 4225.27 5792.8 3002.9 5300.1
## 1997.808 4215.23 5836.3 3002.5 5298.9
## 1997.812 4168.62 5815.9 2992.2 5263.7
## 1997.815 4149.92 5806.8 2992.9 5287.9
## 1997.819 4049.16 5751.6 2958.0 5271.1
## 1997.823 4069.25 5777.2 2946.7 5211.0
## 1997.827 4172.47 5862.9 2989.9 5225.9
## 1997.831 4124.86 5803.2 2958.1 5148.8
## 1997.835 3976.38 5651.8 2856.9 4991.5
## 1997.838 3981.44 5689.5 2849.0 4970.2
## 1997.842 3871.39 5533.5 2769.6 4840.7
## 1997.846 3645.69 5279.7 2651.3 4755.4
## 1997.850 3806.66 5479.0 2818.0 4871.8
## 1997.854 3748.88 5370.9 2739.5 4801.9
## 1997.858 3753.66 5467.2 2739.3 4842.3
## 1997.862 3847.73 5581.6 2788.0 4906.4
## 1997.865 3784.80 5538.2 2774.9 4897.4
## 1997.869 3841.39 5601.6 2822.4 4908.3
## 1997.873 3813.88 5557.4 2781.8 4863.8
## 1997.877 3715.38 5438.6 2707.1 4764.3
## 1997.881 3728.37 5459.7 2707.1 4806.8
## 1997.885 3734.79 5483.9 2707.1 4793.7
## 1997.888 3697.48 5434.0 2694.5 4720.4
## 1997.892 3701.94 5418.2 2700.7 4711.0
## 1997.896 3676.65 5437.0 2698.9 4741.8
## 1997.900 3816.71 5565.0 2773.0 4867.0
## 1997.904 3844.14 5574.2 2782.6 4845.4
## 1997.908 3876.90 5571.7 2790.6 4830.1
## 1997.912 3931.81 5650.4 2821.2 4908.4
## 1997.915 3941.91 5725.5 2861.7 4985.8
## 1997.919 3832.10 5645.7 2802.5 4898.6
## 1997.923 3850.14 5666.3 2786.3 4863.5
## 1997.927 3926.93 5738.3 2811.7 4891.2
```

```
## 1997.931 3961.97 5772.4 2829.0 4889.0
## 1997.935 3972.08 5775.9 2854.4 4831.8
## 1997.938 4125.92 5875.1 2918.5 4921.8
## 1997.942 4096.40 5919.9 2913.1 4977.6
## 1997.946 4074.55 5922.7 2902.4 4970.7
## 1997.950 4159.72 5969.5 2914.5 5082.3
## 1997.954 4191.81 6009.0 2910.1 5142.9
## 1997.958 4208.14 6095.3 2932.5 5187.4
## 1997.962 4187.13 6103.2 2959.4 5177.1
## 1997.965 4116.70 6056.6 2932.2 5130.7
## 1997.969 4016.70 6021.8 2828.5 5035.9
## 1997.973 4061.91 6018.7 2830.3 5045.2
## 1997.977 4029.08 5986.6 2838.3 5121.8
## 1997.981 4150.31 6092.7 2912.2 5203.4
## 1997.985 4154.57 6122.1 2893.3 5190.8
## 1997.988 4162.92 6115.1 2894.5 5168.3
## 1997.992 4055.35 5989.9 2822.9 5020.2
## 1997.996 4125.54 6049.3 2869.7 5018.2
## 1998.000 4132.79 6044.7 2858.1 5049.8
## 1998.004 4132.79 6046.7 2874.1 5013.9
## 1998.008 4132.79 6046.7 2874.1 5013.9
## 1998.012 4132.79 6046.7 2875.1 5013.9
## 1998.015 4266.02 6190.4 2939.5 5112.4
## 1998.019 4224.30 6267.6 2975.5 5132.3
## 1998.023 4224.30 6265.5 2998.9 5135.5
## 1998.027 4224.30 6265.5 2998.9 5135.5
## 1998.031 4364.32 6265.5 3038.7 5193.5
## 1998.035 4416.95 6397.0 3072.8 5262.5
## 1998.038 4360.05 6375.7 3037.7 5264.4
## 1998.042 4339.98 6390.0 3006.7 5224.1
## 1998.046 4293.64 6330.2 2954.9 5237.1
## 1998.050 4237.75 6251.8 2919.8 5138.3
## 1998.054 4134.64 6062.1 2862.5 5068.8
## 1998.058 4150.01 6169.3 2902.9 5083.9
## 1998.062 4145.41 6149.8 2919.8 5106.9
## 1998.065 4140.22 6148.5 2932.8 5165.8
## 1998.069 4216.24 6274.0 2976.1 5263.1
## 1998.073 4290.05 6340.4 2987.0 5273.6
## 1998.077 4310.83 6397.5 3008.3 5278.2
## 1998.081 4250.47 6391.4 2998.1 5272.3
## 1998.085 4238.77 6356.1 2988.6 5253.1
## 1998.088 4222.16 6391.0 2966.2 5181.4
## 1998.092 4266.34 6411.0 3000.5 5237.2
## 1998.096 4316.05 6424.0 3052.0 5326.3
## 1998.100 4385.29 6508.7 3088.3 5372.6
## 1998.104 4444.53 6530.4 3133.8 5422.4
## 1998.108 4442.53 6582.6 3172.1 5458.5
## 1998.112 4529.88 6688.0 3187.5 5599.0
## 1998.115 4529.18 6720.7 3188.4 5612.8
## 1998.119 4509.25 6708.9 3166.3 5595.8
## 1998.123 4494.72 6772.0 3189.6 5606.4
## 1998.127 4536.91 6857.1 3216.7 5629.7
## 1998.131 4519.56 6828.4 3220.9 5600.9
## 1998.135 4558.62 6860.8 3235.8 5613.3
```

```
## 1998.138 4552.46 6931.6 3240.0 5607.9
## 1998.142 4509.37 6856.0 3178.7 5552.5
## 1998.146 4522.42 6898.9 3187.7 5582.3
## 1998.150 4535.56 6905.3 3225.1 5619.9
## 1998.154 4627.42 6990.5 3280.5 5709.5
## 1998.158 4611.66 6966.2 3281.7 5723.4
## 1998.162 4581.08 6953.2 3250.6 5718.5
## 1998.165 4583.03 6986.7 3262.5 5718.5
## 1998.169 4610.66 6986.1 3273.5 5702.8
## 1998.173 4604.55 6945.0 3262.3 5651.0
## 1998.177 4704.58 7065.4 3348.2 5745.1
## 1998.181 4695.78 7118.6 3397.0 5764.8
## 1998.185 4693.86 7153.1 3421.9 5767.3
## 1998.188 4781.62 7273.0 3446.7 5820.6
## 1998.192 4759.62 7259.5 3414.9 5807.7
## 1998.196 4690.52 7130.5 3381.3 5733.1
## 1998.200 4676.42 7077.3 3395.8 5695.6
## 1998.204 4762.71 7197.2 3483.2 5782.9
## 1998.208 4828.89 7187.5 3525.9 5818.9
## 1998.212 4852.22 7246.5 3521.5 5828.5
## 1998.215 4862.41 7276.7 3539.4 5829.8
## 1998.219 4838.67 7267.9 3526.6 5794.8
## 1998.223 4872.24 7328.0 3540.2 5782.3
## 1998.227 4905.59 7261.2 3598.3 5785.1
## 1998.231 4945.91 7236.5 3661.3 5834.9
## 1998.235 4908.55 7132.4 3652.5 5903.6
## 1998.238 4949.91 7143.8 3688.7 5997.9
## 1998.242 5045.16 7300.5 3688.9 5956.3
## 1998.246 5014.13 7341.0 3680.1 5947.0
## 1998.250 5064.35 7407.4 3738.5 5983.7
## 1998.254 5114.13 7472.1 3818.7 5967.8
## 1998.258 5029.00 7415.9 3783.8 5905.6
## 1998.262 5066.90 7530.3 3810.2 5939.3
## 1998.265 5069.89 7536.3 3800.2 5911.9
## 1998.269 5097.25 7585.5 3875.3 5932.2
## 1998.273 5135.35 7615.5 3883.3 6017.6
## 1998.277 5179.04 7638.8 3935.9 6052.8
## 1998.281 5254.32 7725.9 3932.0 6064.2
## 1998.285 5345.89 7827.7 3986.8 6105.8
## 1998.288 5309.67 7744.3 3903.3 6094.0
## 1998.292 5267.35 7588.1 3873.9 6055.2
## 1998.296 5312.25 7624.1 3894.5 6105.5
## 1998.300 5312.25 7624.1 3894.5 6105.5
## 1998.304 5312.25 7624.1 3894.5 6105.5
## 1998.308 5367.98 7662.9 3867.7 6104.1
## 1998.312 5359.24 7616.3 3884.6 6074.1
## 1998.315 5292.97 7500.1 3845.9 6002.0
## 1998.319 5326.63 7453.7 3861.6 5922.2
## 1998.323 5407.93 7500.1 3885.7 5954.1
## 1998.327 5373.80 7369.1 3860.4 5955.0
## 1998.331 5312.28 7308.9 3835.1 5931.1
## 1998.335 5262.57 7265.5 3822.1 5898.1
## 1998.338 5144.42 7232.3 3788.7 5863.9
## 1998.342 5002.71 7053.5 3689.4 5722.4
```

```
## 1998.346 5110.88 7180.1 3777.2 5806.6
## 1998.350 5083.80 7241.8 3726.2 5833.1
## 1998.354 5241.23 7401.4 3867.9 5928.3
## 1998.358 5241.23 7401.4 3867.9 6011.3
## 1998.362 5337.75 7640.8 3979.3 6011.3
## 1998.365 5226.20 7596.2 3945.5 5986.5
## 1998.369 5264.62 7610.8 3947.5 5992.4
## 1998.373 5164.89 7536.0 3912.8 5938.0
## 1998.377 5270.61 7587.1 3912.8 5969.8
## 1998.381 5348.75 7677.5 4007.3 6028.3
## 1998.385 5307.82 7627.3 3986.1 5956.7
## 1998.388 5371.99 7582.8 4018.5 5972.9
## 1998.392 5374.11 7550.6 4012.0 5948.5
## 1998.396 5414.31 7519.4 3990.2 5917.8
## 1998.400 5343.66 7371.4 3945.3 5826.2
## 1998.404 5441.00 7483.2 3980.8 5877.8
## 1998.408 5514.51 7495.8 4047.9 5907.4
## 1998.412 5514.51 7495.8 4047.9 5935.6
## 1998.415 5530.19 7542.7 4049.8 5955.6
## 1998.419 5592.46 7657.1 4108.7 5955.6
## 1998.423 5639.89 7731.9 4115.9 5970.7
## 1998.427 5466.88 7633.5 4017.4 5870.2
## 1998.431 5507.36 7605.0 4014.9 5862.3
## 1998.435 5556.99 7656.1 4041.2 5870.7
## 1998.438 5556.99 7656.1 4041.2 5837.9
## 1998.442 5583.83 7657.5 4087.0 5842.3
## 1998.446 5640.42 7676.3 4149.4 5898.4
## 1998.450 5605.38 7592.9 4119.0 5860.8
## 1998.454 5724.75 7699.5 4185.1 5947.3
## 1998.458 5787.05 7743.4 4204.6 6037.8
## 1998.462 5773.77 7716.8 4201.9 6019.8
## 1998.465 5799.22 7652.6 4208.6 5987.4
## 1998.469 5799.22 7498.4 4141.6 5852.5
## 1998.473 5631.34 7417.4 4050.8 5769.8
## 1998.477 5581.24 7342.7 4005.3 5715.7
## 1998.481 5621.71 7388.7 4013.3 5729.7
## 1998.485 5742.83 7562.7 4092.9 5832.7
## 1998.488 5689.89 7488.0 4052.3 5812.1
## 1998.492 5644.22 7518.6 4027.3 5748.1
## 1998.496 5648.11 7511.8 4018.6 5712.4
## 1998.500 5748.34 7624.8 4065.0 5772.0
## 1998.504 5784.40 7667.9 4126.3 5804.9
## 1998.508 5886.72 7794.7 4203.8 5858.9
## 1998.512 5870.49 7816.9 4215.7 5877.4
## 1998.515 5933.73 7881.9 4248.2 5884.5
## 1998.519 5841.83 7882.0 4203.5 5832.5
## 1998.523 5910.51 8038.2 4260.7 5919.9
## 1998.527 5905.15 8047.3 4252.1 5960.2
## 1998.531 5961.45 8099.0 4304.4 5988.4
## 1998.535 5942.06 8166.0 4311.1 5990.3
## 1998.538 5975.88 8160.0 4333.1 6003.4
## 1998.542 6018.89 8227.2 4339.9 6009.6
## 1998.546 6000.84 8205.0 4319.2 5969.7
## 1998.550 6001.24 8192.4 4256.4 5927.9
```

```
## 1998.554 6023.31 8141.9 4256.4 5958.2
## 1998.558 6101.90 8180.5 4256.4 6100.2
## 1998.562 6106.10 8158.1 4344.3 6151.5
## 1998.565 6108.00 8126.5 4358.1 6116.8
## 1998.569 6162.86 8288.2 4388.5 6174.0
## 1998.573 6186.09 8400.8 4368.9 6179.0
## 1998.577 6184.10 8412.0 4322.1 6132.7
## 1998.581 6081.11 8340.7 4220.1 5989.6
## 1998.585 6043.82 8229.2 4235.9 5976.2
## 1998.588 6040.58 8205.7 4205.4 5892.3
## 1998.592 5854.35 7998.7 4139.5 5836.1
## 1998.596 5867.52 8093.0 4122.4 5835.8
## 1998.600 5828.74 8102.7 4139.2 5844.1
## 1998.604 5906.33 8205.5 4197.6 5910.7
## 1998.608 5861.19 8239.5 4177.3 5837.0
## 1998.612 5774.38 8139.2 4095.0 5809.7
## 1998.615 5718.70 8170.2 4047.9 5736.1
## 1998.619 5614.77 7943.2 3976.4 5632.5
## 1998.623 5528.12 7846.2 3968.6 5594.1
## 1998.627 5598.32 7952.9 4041.9 5680.4
## 1998.631 5460.43 7721.3 3939.5 5587.6
## 1998.635 5285.78 7447.9 3846.0 5432.8
## 1998.638 5386.94 7607.5 3945.7 5462.2
## 1998.642 5355.03 7552.6 3951.7 5399.5
## 1998.646 5473.72 7676.3 3995.0 5455.0
```

```
DNase
```

```
##     Run        conc density
## 1     1  0.04882812   0.017
## 2     1  0.04882812   0.018
## 3     1  0.19531250   0.121
## 4     1  0.19531250   0.124
## 5     1  0.39062500   0.206
## 6     1  0.39062500   0.215
## 7     1  0.78125000   0.377
## 8     1  0.78125000   0.374
## 9     1  1.56250000   0.614
## 10    1  1.56250000   0.609
## 11    1  3.12500000   1.019
## 12    1  3.12500000   1.001
## 13    1  6.25000000   1.334
## 14    1  6.25000000   1.364
## 15    1 12.50000000   1.730
## 16    1 12.50000000   1.710
## 17    2  0.04882812   0.045
## 18    2  0.04882812   0.050
## 19    2  0.19531250   0.137
## 20    2  0.19531250   0.123
## 21    2  0.39062500   0.225
## 22    2  0.39062500   0.207
## 23    2  0.78125000   0.401
## 24    2  0.78125000   0.383
## 25    2  1.56250000   0.672
```

```
## 26    2  1.56250000   0.681
## 27    2  3.12500000   1.116
## 28    2  3.12500000   1.078
## 29    2  6.25000000   1.554
## 30    2  6.25000000   1.526
## 31    2 12.50000000   1.932
## 32    2 12.50000000   1.914
## 33    3  0.04882812   0.070
## 34    3  0.04882812   0.068
## 35    3  0.19531250   0.173
## 36    3  0.19531250   0.165
## 37    3  0.39062500   0.277
## 38    3  0.39062500   0.248
## 39    3  0.78125000   0.434
## 40    3  0.78125000   0.426
## 41    3  1.56250000   0.703
## 42    3  1.56250000   0.689
## 43    3  3.12500000   1.067
## 44    3  3.12500000   1.077
## 45    3  6.25000000   1.629
## 46    3  6.25000000   1.479
## 47    3 12.50000000   2.003
## 48    3 12.50000000   1.884
## 49    4  0.04882812   0.011
## 50    4  0.04882812   0.016
## 51    4  0.19531250   0.118
## 52    4  0.19531250   0.108
## 53    4  0.39062500   0.200
## 54    4  0.39062500   0.206
## 55    4  0.78125000   0.364
## 56    4  0.78125000   0.360
## 57    4  1.56250000   0.620
## 58    4  1.56250000   0.640
## 59    4  3.12500000   0.979
## 60    4  3.12500000   0.973
## 61    4  6.25000000   1.424
## 62    4  6.25000000   1.399
## 63    4 12.50000000   1.740
## 64    4 12.50000000   1.732
## 65    5  0.04882812   0.035
## 66    5  0.04882812   0.035
## 67    5  0.19531250   0.132
## 68    5  0.19531250   0.135
## 69    5  0.39062500   0.224
## 70    5  0.39062500   0.220
## 71    5  0.78125000   0.385
## 72    5  0.78125000   0.390
## 73    5  1.56250000   0.658
## 74    5  1.56250000   0.647
## 75    5  3.12500000   1.060
## 76    5  3.12500000   1.031
## 77    5  6.25000000   1.425
## 78    5  6.25000000   1.409
## 79    5 12.50000000   1.750
```

```
## 80    5 12.50000000   1.738
## 81    6  0.04882812   0.086
## 82    6  0.04882812   0.103
## 83    6  0.19531250   0.191
## 84    6  0.19531250   0.189
## 85    6  0.39062500   0.272
## 86    6  0.39062500   0.277
## 87    6  0.78125000   0.440
## 88    6  0.78125000   0.426
## 89    6  1.56250000   0.686
## 90    6  1.56250000   0.676
## 91    6  3.12500000   1.062
## 92    6  3.12500000   1.072
## 93    6  6.25000000   1.424
## 94    6  6.25000000   1.459
## 95    6 12.50000000   1.768
## 96    6 12.50000000   1.806
## 97    7  0.04882812   0.094
## 98    7  0.04882812   0.092
## 99    7  0.19531250   0.182
## 100   7  0.19531250   0.182
## 101   7  0.39062500   0.282
## 102   7  0.39062500   0.273
## 103   7  0.78125000   0.444
## 104   7  0.78125000   0.439
## 105   7  1.56250000   0.686
## 106   7  1.56250000   0.668
## 107   7  3.12500000   1.052
## 108   7  3.12500000   1.035
## 109   7  6.25000000   1.409
## 110   7  6.25000000   1.392
## 111   7 12.50000000   1.759
## 112   7 12.50000000   1.739
## 113   8  0.04882812   0.054
## 114   8  0.04882812   0.054
## 115   8  0.19531250   0.152
## 116   8  0.19531250   0.148
## 117   8  0.39062500   0.226
## 118   8  0.39062500   0.222
## 119   8  0.78125000   0.392
## 120   8  0.78125000   0.383
## 121   8  1.56250000   0.658
## 122   8  1.56250000   0.644
## 123   8  3.12500000   1.043
## 124   8  3.12500000   1.002
## 125   8  6.25000000   1.466
## 126   8  6.25000000   1.381
## 127   8 12.50000000   1.743
## 128   8 12.50000000   1.724
## 129   9  0.04882812   0.032
## 130   9  0.04882812   0.043
## 131   9  0.19531250   0.142
## 132   9  0.19531250   0.155
## 133   9  0.39062500   0.239
```

```
## 134   9  0.39062500   0.242
## 135   9  0.78125000   0.420
## 136   9  0.78125000   0.395
## 137   9  1.56250000   0.624
## 138   9  1.56250000   0.705
## 139   9  3.12500000   1.046
## 140   9  3.12500000   1.026
## 141   9  6.25000000   1.398
## 142   9  6.25000000   1.405
## 143   9 12.50000000   1.693
## 144   9 12.50000000   1.729
## 145  10  0.04882812   0.052
## 146  10  0.04882812   0.094
## 147  10  0.19531250   0.164
## 148  10  0.19531250   0.166
## 149  10  0.39062500   0.259
## 150  10  0.39062500   0.256
## 151  10  0.78125000   0.439
## 152  10  0.78125000   0.439
## 153  10  1.56250000   0.690
## 154  10  1.56250000   0.701
## 155  10  3.12500000   1.042
## 156  10  3.12500000   1.075
## 157  10  6.25000000   1.340
## 158  10  6.25000000   1.406
## 159  10 12.50000000   1.699
## 160  10 12.50000000   1.708
## 161  11  0.04882812   0.047
## 162  11  0.04882812   0.057
## 163  11  0.19531250   0.159
## 164  11  0.19531250   0.155
## 165  11  0.39062500   0.246
## 166  11  0.39062500   0.252
## 167  11  0.78125000   0.427
## 168  11  0.78125000   0.411
## 169  11  1.56250000   0.704
## 170  11  1.56250000   0.684
## 171  11  3.12500000   0.994
## 172  11  3.12500000   0.980
## 173  11  6.25000000   1.421
## 174  11  6.25000000   1.385
## 175  11 12.50000000   1.715
## 176  11 12.50000000   1.721
```

```
Formaldehyde
```

```
##   carb optden
## 1  0.1  0.086
## 2  0.3  0.269
## 3  0.5  0.446
## 4  0.6  0.538
## 5  0.7  0.626
## 6  0.9  0.782
```

```
Orange
```

```
##    Tree  age circumference
## 1     1  118            30
## 2     1  484            58
## 3     1  664            87
## 4     1 1004           115
## 5     1 1231           120
## 6     1 1372           142
## 7     1 1582           145
## 8     2  118            33
## 9     2  484            69
## 10    2  664           111
## 11    2 1004           156
## 12    2 1231           172
## 13    2 1372           203
## 14    2 1582           203
## 15    3  118            30
## 16    3  484            51
## 17    3  664            75
## 18    3 1004           108
## 19    3 1231           115
## 20    3 1372           139
## 21    3 1582           140
## 22    4  118            32
## 23    4  484            62
## 24    4  664           112
## 25    4 1004           167
## 26    4 1231           179
## 27    4 1372           209
## 28    4 1582           214
## 29    5  118            30
## 30    5  484            49
## 31    5  664            81
## 32    5 1004           125
## 33    5 1231           142
## 34    5 1372           174
## 35    5 1582           177
```

```
UCBAdmissions
```

```
## , , Dept = A
##
##           Gender
## Admit      Male Female
##   Admitted  512     89
##   Rejected  313     19
##
## , , Dept = B
##
##           Gender
## Admit      Male Female
##   Admitted  353     17
```

```
##   Rejected  207      8
##
## , , Dept = C
##
##           Gender
## Admit      Male Female
##   Admitted  120    202
##   Rejected  205    391
##
## , , Dept = D
##
##           Gender
## Admit      Male Female
##   Admitted  138    131
##   Rejected  279    244
##
## , , Dept = E
##
##           Gender
## Admit      Male Female
##   Admitted   53     94
##   Rejected  138    299
##
## , , Dept = F
##
##           Gender
## Admit      Male Female
##   Admitted   22     24
##   Rejected  351    317
```

Answer: b,c,d,e

4.3 Manipulating data frames

The dplyr package from the tidyverse introduces functions that perform some of the most common operations when working with data frames and uses names for these functions that are relatively easy to remember. For instance, to change the data table by adding a new column, we use mutate. To filter the data table to a subset of rows, we use filter. Finally, to subset the data by selecting specific columns, we use select.

4.3.1 Adding a column with mutate

We want all the necessary information for our analysis to be included in the data table. So the first task is to add the murder rates to our murders data frame. The function mutate takes the data frame as a first argument and the name and values of the variable as a second argument using the convention name = values. So, to add murder rates, we use:

```
library(dslabs)
data("murders")
murders<-mutate(murders, rate=total/population*100000)
```

Notice that here we used total and population inside the function, which are objects that are not defined in our workspace. But why don't we get an error?

This is one of dplyr's main features. Functions in this package, such as mutate, know to look for variables in the data frame provided in the first argument. In the call to mutate above, total will have the values in murders$total. This approach makes the code much more readable.

We can see that the new column is added:

```
head(murders)
```

```
##        state abb region population total     rate
## 1    Alabama  AL  South    4779736   135 2.824424
## 2     Alaska  AK   West     710231    19 2.675186
## 3    Arizona  AZ   West    6392017   232 3.629527
## 4   Arkansas  AR  South    2915918    93 3.189390
## 5 California  CA   West   37253956  1257 3.374138
## 6   Colorado  CO   West    5029196    65 1.292453
```

Although we have overwritten the original murders object, this does not change the object that loaded with data(murders). If we load the murders data again, the original will overwrite our mutated version.

4.3.2 Subsetting with filter

Now suppose that we want to filter the data table to only show the entries for which the murder rate is lower than 0.71. To do this we use the filter function, which takes the data table as the first argument and then the conditional statement as the second. Like mutate, we can use the unquoted variable names from murders inside the function and it will know we mean the columns and not objects in the workspace.

```
filter(murders,rate<=0.71)
```

```
##           state abb        region population total      rate
## 1        Hawaii  HI          West    1360301     7 0.5145920
## 2          Iowa  IA North Central    3046355    21 0.6893484
## 3 New Hampshire  NH     Northeast    1316470     5 0.3798036
## 4  North Dakota  ND North Central     672591     4 0.5947151
## 5       Vermont  VT     Northeast     625741     2 0.3196211
```

4.3.3 Selecting column with select

Although our data table only has six columns, some data tables include hundreds. If we want to view just a few, we can use the dplyr select function. In the code below we select three columns, assign this to a new object and then filter the new object:

```
new_table<-select(murders,state,region,rate)
filter(new_table,rate<=0.71)
```

```
##           state        region      rate
## 1        Hawaii          West 0.5145920
## 2          Iowa North Central 0.6893484
## 3 New Hampshire     Northeast 0.3798036
## 4  North Dakota North Central 0.5947151
## 5       Vermont     Northeast 0.3196211
```

In the call to select, the first argument murders is an object, but state, region, and rate are variable names.

4.4 Exercises

1. Load the dplyr package and the murders dataset.

```
library(dplyr)
library(dslabs)
data(murders)
```

You can add columns using the dplyr function mutate. This function is aware of the column names and inside the function you can call them unquoted:

```
murders<-mutate(murders,population_in_millions=population/10^6)
```

We can write population rather than murders$population. The function mutate knows we are grabbing columns from murders.

Use the function mutate to add a murders column named rate with the per 100,000 murder rate as in the example code above. Make sure you redefine murders as done in the example code above (murders <- [your code]) so we can keep using this variable.

```
murders<-mutate(murders,rate=total/population*100000)
```

2. If rank(x) gives you the ranks of x from lowest to highest, rank(-x) gives you the ranks from highest to lowest. Use the function mutate to add a column rank containing the rank, from highest to lowest murder rate. Make sure you redefine murders so we can keep using this variable.

```
murders<-mutate(murders,rank=rank(-rate))
```

3. With dplyr, we can use select to show only certain columns. For example, with this code we would only show the states and population sizes:

```
select(murders,state,population)%>%head()
```

```
##        state population
## 1    Alabama    4779736
## 2     Alaska     710231
## 3    Arizona    6392017
## 4   Arkansas    2915918
## 5 California   37253956
## 6   Colorado    5029196
```

Use select to show the state names and abbreviations in murders. Do not redefine murders, just show the results.

```
select(murders,state,abb)%>%head()
```

```
##        state abb
## 1    Alabama  AL
## 2     Alaska  AK
## 3    Arizona  AZ
## 4   Arkansas  AR
## 5 California  CA
## 6   Colorado  CO
```

4. The dplyr function filter is used to choose specific rows of the data frame to keep. Unlike select which is for columns, filter is for rows. For example, you can show just the New York row like this:

```
filter(murders,state=="New York")
```

```
##      state abb    region population total population_in_millions    rate rank
## 1 New York  NY Northeast   19378102   517                19.3781 2.66796   29
```

You can use other logical vectors to filter rows.

Use filter to show the top 5 states with the highest murder rates. After we add murder rate and rank, do not change the murders dataset, just show the result. Remember that you can filter based on the rank column.

```
filter(murders,rank<=5)
```

```
##                  state abb        region population total
## 1 District of Columbia  DC         South     601723    99
## 2            Louisiana  LA         South    4533372   351
## 3             Maryland  MD         South    5773552   293
## 4             Missouri  MO North Central    5988927   321
## 5       South Carolina  SC         South    4625364   207
##   population_in_millions      rate rank
## 1               0.601723 16.452753    1
## 2               4.533372  7.742581    2
## 3               5.773552  5.074866    4
## 4               5.988927  5.359892    3
## 5               4.625364  4.475323    5
```

5. We can remove rows using the != operator. For example, to remove Florida, we would do this:

```
no_florida<-filter(murders,state!="Florida")
```

Create a new data frame called no_south that removes states from the South region. How many states are in this category? You can use the function nrow for this.

```
no_south<-filter(murders,region!="South")
nrow(no_south)
```

```
## [1] 34
```

6. We can also use %in% to filter with dplyr. You can therefore see the data from New York and Texas like this:

```
filter(murders, state%in%c("New York","Texas"))
```

```
##      state abb    region population total population_in_millions    rate rank
## 1 New York  NY Northeast   19378102   517               19.37810 2.66796   29
## 2    Texas  TX     South   25145561   805               25.14556 3.20136   16
```

Create a new data frame called murders_nw with only the states from the Northeast and the West. How many states are in this category?

```
murders_nw<-filter(murders,region%in%c("Northeast","West"))
nrow(murders_nw)
```

```
## [1] 22
```

7. Suppose you want to live in the Northeast or West and want the murder rate to be less than 1. We want to see the data for the states satisfying these options. Note that you can use logical operators with filter. Here is an example in which we filter to keep only small states in the Northeast region.

```
filter(murders,population<5000000&region=="Northeast")
```

```
##           state abb    region population total population_in_millions      rate
## 1   Connecticut  CT Northeast    3574097    97               3.574097 2.7139722
## 2         Maine  ME Northeast    1328361    11               1.328361 0.8280881
## 3 New Hampshire  NH Northeast    1316470     5               1.316470 0.3798036
## 4  Rhode Island  RI Northeast    1052567    16               1.052567 1.5200933
## 5       Vermont  VT Northeast     625741     2               0.625741 0.3196211
##   rank
## 1   25
## 2   44
## 3   50
## 4   35
## 5   51
```

Make sure murders has been defined with rate and rank and still has all states. Create a table called my_states that contains rows for states satisfying both the conditions: it is in the Northeast or West and the murder rate is less than 1. Use select to show only the state name, the rate, and the rank.

```
my_states<-filter(murders,region%in%c("Northeast","West") & rate<1)
select(my_states,state,rate,rank)
```

```
##           state      rate rank
## 1        Hawaii 0.5145920   49
## 2         Idaho 0.7655102   46
## 3         Maine 0.8280881   44
## 4 New Hampshire 0.3798036   50
## 5        Oregon 0.9396843   42
## 6          Utah 0.7959810   45
## 7       Vermont 0.3196211   51
## 8       Wyoming 0.8871131   43
```

4.5 The pipe: %>%

With dplyr we can perform a series of operations, for example select and then filter, by sending the results of one function to another using what is called the pipe operator: %>%. Some details are included below.

We wrote code above to show three variables (state, region, rate) for states that have murder rates below 0.71. To do this, we defined the intermediate object new_table. In dplyr we can write code that looks more like a description of what we want to do without intermediate objects:

original data->select->filter

For such an operation, we can use the pipe %>%. The code looks like this:

```r
murders%>% select(state,region,rate)%>% filter(rate<=0.71)
```

```
##           state        region      rate
## 1        Hawaii          West 0.5145920
## 2          Iowa North Central 0.6893484
## 3 New Hampshire     Northeast 0.3798036
## 4  North Dakota North Central 0.5947151
## 5       Vermont     Northeast 0.3196211
```

This line of code is equivalent to the two lines of code above. What is going on here?

In general, the pipe sends the result of the left side of the pipe to be the first argument of the function on the right side of the pipe. Here is a very simple example:

```r
16%>%sqrt()
```

```
## [1] 4
```

We can continue to pipe values along:

```r
16%>% sqrt()%>% log2()
```

```
## [1] 2
```

The above statement is equivalent to log2(sqrt(16)).

Remember that the pipe sends values to the first argument, so we can define other arguments as if the first argument is already defined:

```r
16%>% sqrt()%>% log(base = 2)
```

```
## [1] 2
```

Therefore, when using the pipe with data frames and dplyr, we no longer need to specify the required first argument since the dplyr functions we have described all take the data as the first argument. In the code we wrote:

```r
murders%>%select(state,region,rate)%>%filter(rate<=0.71)
```

```
##           state        region      rate
## 1        Hawaii          West 0.5145920
## 2          Iowa North Central 0.6893484
## 3 New Hampshire     Northeast 0.3798036
## 4  North Dakota North Central 0.5947151
## 5       Vermont     Northeast 0.3196211
```

murders is the first argument of the select function, and the new data frame (formerly new_table) is the first argument of the filter function.

Note that the pipe works well with functions where the first argument is the input data. Functions in tidyverse packages like dplyr have this format and can be used easily with the pipe.

4.6 Exercises

1. The pipe %>% can be used to perform operations sequentially without having to define intermediate objects. Start by redefining murder to include rate and rank.

```
murders<-mutate(murders,rate=total/population*100000,
                rank=rank(-rate))
```

In the solution to the previous exercise, we did the following:

```
my_states<-filter(murders,region%in%c("Northeast","West")&rate<1)
select(my_states,state,rate,rank)
```

```
##           state      rate rank
## 1        Hawaii 0.5145920   49
## 2         Idaho 0.7655102   46
## 3         Maine 0.8280881   44
## 4 New Hampshire 0.3798036   50
## 5        Oregon 0.9396843   42
## 6          Utah 0.7959810   45
## 7       Vermont 0.3196211   51
## 8       Wyoming 0.8871131   43
```

The pipe %>% permits us to perform both operations sequentially without having to define an intermediate variable my_states. We therefore could have mutated and selected in the same line like this:

```
mutate(murders,rate=total/population*100000,
       rank=rank(-rate))%>%
  select(state,rate,rank)
```

```
##                   state       rate rank
## 1               Alabama  2.8244238   23
## 2                Alaska  2.6751860   27
## 3               Arizona  3.6295273   10
## 4              Arkansas  3.1893901   17
## 5            California  3.3741383   14
## 6              Colorado  1.2924531   38
## 7           Connecticut  2.7139722   25
## 8              Delaware  4.2319369    6
## 9  District of Columbia 16.4527532    1
## 10              Florida  3.3980688   13
## 11              Georgia  3.7903226    9
## 12               Hawaii  0.5145920   49
## 13                Idaho  0.7655102   46
## 14             Illinois  2.8369608   22
## 15              Indiana  2.1900730   31
## 16                 Iowa  0.6893484   47
## 17               Kansas  2.2081106   30
## 18             Kentucky  2.6732010   28
## 19            Louisiana  7.7425810    2
## 20                Maine  0.8280881   44
## 21             Maryland  5.0748655    4
```

```
## 22         Massachusetts  1.8021791   32
## 23              Michigan  4.1786225    7
## 24             Minnesota  0.9992600   40
## 25           Mississippi  4.0440846    8
## 26              Missouri  5.3598917    3
## 27               Montana  1.2128379   39
## 28              Nebraska  1.7521372   33
## 29                Nevada  3.1104763   19
## 30         New Hampshire  0.3798036   50
## 31            New Jersey  2.7980319   24
## 32            New Mexico  3.2537239   15
## 33              New York  2.6679599   29
## 34        North Carolina  2.9993237   20
## 35          North Dakota  0.5947151   48
## 36                  Ohio  2.6871225   26
## 37              Oklahoma  2.9589340   21
## 38                Oregon  0.9396843   42
## 39          Pennsylvania  3.5977513   11
## 40          Rhode Island  1.5200933   35
## 41        South Carolina  4.4753235    5
## 42          South Dakota  0.9825837   41
## 43             Tennessee  3.4509357   12
## 44                 Texas  3.2013603   16
## 45                  Utah  0.7959810   45
## 46               Vermont  0.3196211   51
## 47              Virginia  3.1246001   18
## 48            Washington  1.3829942   37
## 49         West Virginia  1.4571013   36
## 50             Wisconsin  1.7056487   34
## 51               Wyoming  0.8871131   43
```

Notice that select no longer has a data frame as the first argument. The first argument is assumed to be the result of the operation conducted right before the %>%.

Repeat the previous exercise, but now instead of creating a new object, show the result and only include the state, rate, and rank columns. Use a pipe %>% to do this in just one line.

```
murders%>%filter(region%in%c("Northeast","West")&rate<1)%>%
  select(state,rate,rank)
```

```
##           state      rate rank
## 1        Hawaii 0.5145920   49
## 2         Idaho 0.7655102   46
## 3         Maine 0.8280881   44
## 4 New Hampshire 0.3798036   50
## 5        Oregon 0.9396843   42
## 6          Utah 0.7959810   45
## 7       Vermont 0.3196211   51
## 8       Wyoming 0.8871131   43
```

2. Reset murders to the original table by using data(murders). Use a pipe to create a new data frame called my_states that considers only states in the Northeast or West which have a murder rate lower than 1, and contains only the state, rate and rank columns. The pipe should also have four components separated by three %>%. The code should look something like this:

```
data(murders)
my_states<-murders%>%
  mutate(rate=total/population*100000,rank=rank(-rate))%>%
  filter(region%in%c("Northeast","West")&rate<1)%>%
  select(state,rate,rank)
```

4.7 Summarizing data

An important part of exploratory data analysis is summarizing data. The average and standard deviation are two examples of widely used summary statistics. More informative summaries can often be achieved by first splitting data into groups. In this section, we cover two new dplyr verbs that make these computations easier: summarize and group_by. We learn to access resulting values using the pull function.

4.7.1 summarize

The summarize function in dplyr provides a way to compute summary statistics with intuitive and readable code. We start with a simple example based on heights. The heights dataset includes heights and sex reported by students in an in-class survey.

```
library(dplyr)
library(dslabs)
data("heights")
```

The following code computes the average and standard deviation for females:

```
s<-heights%>%
  filter(sex=="Female")%>%
  summarize(average=mean(height),
            standard_deviation=sd(height))
s
```

```
##    average standard_deviation
## 1 64.93942           3.760656
```

This takes our original data table as input, filters it to keep only females, and then produces a new summarized table with just the average and the standard deviation of heights. We get to choose the names of the columns of the resulting table. For example, above we decided to use average and standard_deviation, but we could have used other names just the same.

Because the resulting table stored in s is a data frame, we can access the components with the accessor $:

```
s$average
```

```
## [1] 64.93942
```

```
s$standard_deviation
```

```
## [1] 3.760656
```

As with most other dplyr functions, summarize is aware of the variable names and we can use them directly. So when inside the call to the summarize function we write mean(height), the function is accessing the column with the name "height" and then computing the average of the resulting numeric vector. We can compute any other summary that operates on vectors and returns a single value.

For another example of how we can use the summarize function, let's compute the average murder rate for the United States. Remember our data table includes total murders and population size for each state and we have already used dplyr to add a murder rate column:

```
murders<-murders%>%mutate(rate=total/population*100000)
```

Remember that the US murder rate is not the average of the state murder rates:

```
summarize(murders,mean(rate))
```

```
##   mean(rate)
## 1   2.779125
```

This is because in the computation above the small states are given the same weight as the large ones. The US murder rate is the total number of murders in the US divided by the total US population. So the correct computation is:

```
us_murder_rate<-murders%>%
  summarize(rate=sum(total)/sum(population)*100000)
us_murder_rate
```

```
##       rate
## 1 3.034555
```

This computation counts larger states proportionally to their size which results in a larger value.

4.7.2 Multiple summaries

Suppose we want three summaries from the same variable such as the median, minimum, and maximum heights. We can use summarize like this:

But we can obtain these three values with just one line using the quantile function: quantile(x, c(0.5, 0, 1)) returns the median (50th percentile), the min (0th percentile), and max (100th percentile) of the vector x. We can use it with summarize like this:

```
heights%>%
  filter(sex=="Female")%>%
  summarize(median_min_max=quantile(height,c(0.5,0,1)))
```

```
##   median_min_max
## 1       64.98031
## 2       51.00000
## 3       79.00000
```

However, notice that the summaries are returned in a row each. To obtain the results in different columns, we have to define a function that returns a data frame like this:

```
median_min_max<-function(x){
  qs<-quantile(x,c(0.5,0,1))
  data.frame(median=qs[1],minimum=qs[2],maximum=qs[3])
}
heights%>%
  filter(sex=="Female")%>%
  summarize(median_min_max(height))
```

```
##     median minimum maximum
## 1 64.98031      51      79
```

In the next section we learn how useful this approach can be when summarizing by group.

4.7.3 Group then summarize with group_by

A common operation in data exploration is to first split data into groups and then compute summaries for each group. For example, we may want to compute the average and standard deviation for men's and women's heights separately. The group_by function helps us do this.

If we type this:

```
heights%>%group_by(sex)
```

```
## # A tibble: 1,050 x 2
## # Groups:   sex [2]
##    sex    height
##    <fct>   <dbl>
##  1 Male       75
##  2 Male       70
##  3 Male       68
##  4 Male       74
##  5 Male       61
##  6 Female     65
##  7 Female     66
##  8 Female     62
##  9 Female     66
## 10 Male       67
## # ... with 1,040 more rows
```

The result does not look very different from heights, except we see Groups: sex [2] when we print the object. Although not immediately obvious from its appearance, this is now a special data frame called a grouped data frame, and dplyr functions, in particular summarize, will behave differently when acting on this object. Conceptually, you can think of this table as many tables, with the same columns but not necessarily the same number of rows, stacked together in one object. When we summarize the data after grouping, this is what happens:

```
heights%>%
  group_by(sex)%>%
  summarise(average=mean(height),standard_deviation=sd(height))
```

```
## # A tibble: 2 x 3
##   sex    average standard_deviation
##   <fct>    <dbl>              <dbl>
## 1 Female    64.9               3.76
## 2 Male      69.3               3.61
```

The summarize function applies the summarization to each group separately.

For another example, let's compute the median, minimum, and maximum murder rate in the four regions of the country using the median_min_max defined above:

```
murders%>%
  group_by(region)%>%
  summarize(median_min_max(rate))
```

```
## # A tibble: 4 x 4
##   region        median minimum maximum
##   <fct>          <dbl>   <dbl>   <dbl>
## 1 Northeast       1.80   0.320    3.60
## 2 South           3.40   1.46    16.5
## 3 North Central   1.97   0.595    5.36
## 4 West            1.29   0.515    3.63
```

4.8 pull

The us_murdre_rate object defined above represents just one number. Yet we are storing it in a data frame:

```
class(us_murder_rate)
```

```
## [1] "data.frame"
```

since, as most dplyr functions, summarize always returns a data frame.

This might be problematic if we want to use this result with functions that require a numeric value. Here we show a useful trick for accessing values stored in data when using pipes: when a data object is piped that object and its columns can be accessed using the pull function. To understand what we mean take a look at this line of code:

```
us_murder_rate%>%pull(rate)
```

```
## [1] 3.034555
```

This returns the value in the rate column of us_murder_rate making it equivalent to us_murder_rate$rate.

To get a number from the original data table with one line of code we can type:

```
us_murder_rate<-murders%>%
  summarize(rate=sum(total)/sum(population)*100000)%>%
  pull(rate)

us_murder_rate
```

```
## [1] 3.034555
```

which is now a numeric:

```
class(us_murder_rate)
```

```
## [1] "numeric"
```

4.9 Sortind date frames

When examining a dataset, it is often convenient to sort the table by the different columns. We know about the order and sort function, but for ordering entire tables, the dplyr function arrange is useful. For example, here we order the states by population size:

```
murders%>%
  arrange(population)%>%
  head()
```

```
##                  state abb        region population total       rate
## 1              Wyoming  WY          West     563626     5  0.8871131
## 2 District of Columbia  DC         South     601723    99 16.4527532
## 3              Vermont  VT     Northeast     625741     2  0.3196211
## 4         North Dakota  ND North Central     672591     4  0.5947151
## 5               Alaska  AK          West     710231    19  2.6751860
## 6         South Dakota  SD North Central     814180     8  0.9825837
```

With arrange we get to decide which column to sort by. To see the states by murder rate, from lowest to highest, we arrange by rate instead:

```
murders%>%
  arrange(rate)%>%
  head()
```

```
##           state abb        region population total      rate
## 1       Vermont  VT     Northeast     625741     2 0.3196211
## 2 New Hampshire  NH     Northeast    1316470     5 0.3798036
## 3        Hawaii  HI          West    1360301     7 0.5145920
## 4  North Dakota  ND North Central     672591     4 0.5947151
## 5          Iowa  IA North Central    3046355    21 0.6893484
## 6         Idaho  ID          West    1567582    12 0.7655102
```

Note that the default behavior is to order in ascending order. In dplyr, the function desc transforms a vector so that it is in descending order. To sort the table in descending order, we can type:

```
murders%>%
  arrange(desc(rate))
```

```
##                   state abb        region population total       rate
## 1  District of Columbia  DC         South     601723    99 16.4527532
## 2             Louisiana  LA         South    4533372   351  7.7425810
```

```
## 3          Missouri  MO North Central    5988927   321 5.3598917
## 4          Maryland  MD         South    5773552   293 5.0748655
## 5    South Carolina  SC         South    4625364   207 4.4753235
## 6          Delaware  DE         South     897934    38 4.2319369
## 7          Michigan  MI North Central    9883640   413 4.1786225
## 8       Mississippi  MS         South    2967297   120 4.0440846
## 9           Georgia  GA         South    9920000   376 3.7903226
## 10          Arizona  AZ          West    6392017   232 3.6295273
## 11     Pennsylvania  PA     Northeast   12702379   457 3.5977513
## 12        Tennessee  TN         South    6346105   219 3.4509357
## 13          Florida  FL         South   19687653   669 3.3980688
## 14       California  CA          West   37253956  1257 3.3741383
## 15       New Mexico  NM          West    2059179    67 3.2537239
## 16            Texas  TX         South   25145561   805 3.2013603
## 17         Arkansas  AR         South    2915918    93 3.1893901
## 18         Virginia  VA         South    8001024   250 3.1246001
## 19           Nevada  NV          West    2700551    84 3.1104763
## 20   North Carolina  NC         South    9535483   286 2.9993237
## 21         Oklahoma  OK         South    3751351   111 2.9589340
## 22         Illinois  IL North Central   12830632   364 2.8369608
## 23          Alabama  AL         South    4779736   135 2.8244238
## 24       New Jersey  NJ     Northeast    8791894   246 2.7980319
## 25      Connecticut  CT     Northeast    3574097    97 2.7139722
## 26             Ohio  OH North Central   11536504   310 2.6871225
## 27           Alaska  AK          West     710231    19 2.6751860
## 28         Kentucky  KY         South    4339367   116 2.6732010
## 29         New York  NY     Northeast   19378102   517 2.6679599
## 30           Kansas  KS North Central    2853118    63 2.2081106
## 31          Indiana  IN North Central    6483802   142 2.1900730
## 32    Massachusetts  MA     Northeast    6547629   118 1.8021791
## 33         Nebraska  NE North Central    1826341    32 1.7521372
## 34        Wisconsin  WI North Central    5686986    97 1.7056487
## 35     Rhode Island  RI     Northeast    1052567    16 1.5200933
## 36    West Virginia  WV         South    1852994    27 1.4571013
## 37       Washington  WA          West    6724540    93 1.3829942
## 38         Colorado  CO          West    5029196    65 1.2924531
## 39          Montana  MT          West     989415    12 1.2128379
## 40        Minnesota  MN North Central    5303925    53 0.9992600
## 41     South Dakota  SD North Central     814180     8 0.9825837
## 42           Oregon  OR          West    3831074    36 0.9396843
## 43          Wyoming  WY          West     563626     5 0.8871131
## 44            Maine  ME     Northeast    1328361    11 0.8280881
## 45             Utah  UT          West    2763885    22 0.7959810
## 46            Idaho  ID          West    1567582    12 0.7655102
## 47             Iowa  IA North Central    3046355    21 0.6893484
## 48     North Dakota  ND North Central     672591     4 0.5947151
## 49           Hawaii  HI          West    1360301     7 0.5145920
## 50    New Hampshire  NH     Northeast    1316470     5 0.3798036
## 51          Vermont  VT     Northeast     625741     2 0.3196211
```

4.9.1 Nested sorting

If we are ordering by a column with ties, we can use a second column to break the tie. Similarly, a third column can be used to break ties between first and second and so on. Here we order by region, then within region we order by murder rate:

```
murders%>%
  arrange(region,rate)%>%
  head()
```

```
##           state abb    region population total      rate
## 1       Vermont  VT Northeast     625741     2 0.3196211
## 2 New Hampshire  NH Northeast    1316470     5 0.3798036
## 3         Maine  ME Northeast    1328361    11 0.8280881
## 4  Rhode Island  RI Northeast    1052567    16 1.5200933
## 5 Massachusetts  MA Northeast    6547629   118 1.8021791
## 6      New York  NY Northeast   19378102   517 2.6679599
```

4.9.2 The top n

In the code above, we have used the function head to avoid having the page fill up with the entire dataset. If we want to see a larger proportion, we can use the top_n function. This function takes a data frame as it's first argument, the number of rows to show in the second, and the variable to filter by in the third. Here is an example of how to see the top 5 rows:

```
murders%>% top_n(5,rate)
```

```
##                  state abb        region population total      rate
## 1 District of Columbia  DC         South     601723    99 16.452753
## 2            Louisiana  LA         South    4533372   351  7.742581
## 3             Maryland  MD         South    5773552   293  5.074866
## 4             Missouri  MO North Central    5988927   321  5.359892
## 5       South Carolina  SC         South    4625364   207  4.475323
```

Note that rows are not sorted by rate, only filtered. If we want to sort, we need to use arrange. Note that if the third argument is left blank, top_n filters by the last column.

4.10 Exercises

For these exercises, we will be using the data from the survey collected by the United States National Center for Health Statistics (NCHS). This center has conducted a series of health and nutrition surveys since the 1960's. Starting in 1999, about 5,000 individuals of all ages have been interviewed every year and they complete the health examination component of the survey. Part of the data is made available via the NHANES package. Once you install the NHANES package, you can load the data like this:

```
library(NHANES)
data("NHANES")
```

The NHANES data has many missing values. The mean and sd functions in R will return NA if any of the entries of the input vector is an NA. Here is an example:

```
library(dslabs)
data("na_example")
mean(na_example)
```

```
## [1] NA
```

```
sd(na_example)
```

```
## [1] NA
```

To ignore the NAs we can use the na.rm argument:

```
mean(na_example,na.rm=TRUE)
```

```
## [1] 2.301754
```

```
sd(na_example,na.rm = TRUE)
```

```
## [1] 1.22338
```

Let's now explore the NHANES data.

1. We will provide some basic facts about blood pressure. First let's select a group to set the standard. We will use 20-to-29-year-old females. AgeDecade is a categorical variable with these ages. Note that the category is coded like " 20-29", with a space in front! What is the average and standard deviation of systolic blood pressure as saved in the BPSysAve variable? Save it to a variable called ref.

Hint: Use filter and summarize and use the na.rm = TRUE argument when computing the average and standard deviation. You can also filter the NA values using filter.

```
ref<-NHANES%>%
  filter(AgeDecade==" 20-29" &Gender=="female")%>%
  summarise(average=mean(BPSysAve,na.rm=TRUE),
            standard_deviation=sd(BPSysAve,na.rm=TRUE))
ref
```

```
## # A tibble: 1 x 2
##   average standard_deviation
##     <dbl>              <dbl>
## 1    108.               10.1
```

2. Using a pipe, assign the average to a numeric variable ref_avg. Hint: Use the code similar to above and then pull.

```
ref_avg<-ref%>%
  pull(average)
ref_avg
```

```
## [1] 108.4224
```

3. Now report the min and max values for the same group.

```r
qs<-quantile(NHANES$BPSysAve,c(0,1),na.rm = TRUE)

NHANES%>%
  filter(AgeDecade==" 20-29" &Gender=="female")%>%
  summarise(data.frame(min=qs[1],max=qs[2]))
```

```
## # A tibble: 1 x 2
##     min   max
##   <dbl> <dbl>
## 1    76   226
```

4. Compute the average and standard deviation for females, but for each age group separately rather than a selected decade as in question 1. Note that the age groups are defined by AgeDecade. Hint: rather than filtering by age and gender, filter by Gender and then use group_by.

```r
NHANES%>%
  filter(Gender=="female")%>%
  group_by(AgeDecade)%>%
  summarise(average=mean(BPSysAve,na.rm=TRUE),
            standard_deviation=sd(BPSysAve,na.rm=TRUE))
```

```
## # A tibble: 9 x 3
##   AgeDecade average standard_deviation
##   <fct>       <dbl>              <dbl>
## 1 " 0-9"       100.               9.07
## 2 " 10-19"     104.               9.46
## 3 " 20-29"     108.              10.1
## 4 " 30-39"     111.              12.3
## 5 " 40-49"     115.              14.5
## 6 " 50-59"     122.              16.2
## 7 " 60-69"     127.              17.1
## 8 " 70+"       134.              19.8
## 9  <NA>        142.              22.9
```

5. Repeat exercise 4 for males.

```r
NHANES%>%
  filter(Gender=="male")%>%
  group_by(AgeDecade)%>%
  summarise(average=mean(BPSysAve,na.rm=TRUE),
            standard_deviation=sd(BPSysAve,na.rm=TRUE))
```

```
## # A tibble: 9 x 3
##   AgeDecade average standard_deviation
##   <fct>       <dbl>              <dbl>
## 1 " 0-9"       97.4               8.32
## 2 " 10-19"    110.               11.2
## 3 " 20-29"    118.               11.3
## 4 " 30-39"    119.               12.3
## 5 " 40-49"    121.               14.0
## 6 " 50-59"    126.               17.8
```

```
## 7 " 60-69"    127.               17.5
## 8 " 70+"      130.               18.7
## 9  <NA>       136.               23.5
```

6. We can actually combine both summaries for exercises 4 and 5 into one line of code. This is because group_by permits us to group by more than one variable. Obtain one big summary table using group_by(AgeDecade, Gender).

```
NHANES%>%
  group_by(AgeDecade,Gender)%>%
  summarise(average=mean(BPSysAve,na.rm=TRUE),
            standard_deviation=sd(BPSysAve,na.rm=TRUE))
```

```
## `summarise()` has grouped output by 'AgeDecade'. You can override using the `.groups` argument.
```

```
## # A tibble: 18 x 4
## # Groups:   AgeDecade [9]
##    AgeDecade Gender average standard_deviation
##    <fct>     <fct>    <dbl>              <dbl>
##  1 " 0-9"    female   100.                9.07
##  2 " 0-9"    male      97.4               8.32
##  3 " 10-19"  female   104.                9.46
##  4 " 10-19"  male     110.               11.2
##  5 " 20-29"  female   108.               10.1
##  6 " 20-29"  male     118.               11.3
##  7 " 30-39"  female   111.               12.3
##  8 " 30-39"  male     119.               12.3
##  9 " 40-49"  female   115.               14.5
## 10 " 40-49"  male     121.               14.0
## 11 " 50-59"  female   122.               16.2
## 12 " 50-59"  male     126.               17.8
## 13 " 60-69"  female   127.               17.1
## 14 " 60-69"  male     127.               17.5
## 15 " 70+"    female   134.               19.8
## 16 " 70+"    male     130.               18.7
## 17  <NA>     female   142.               22.9
## 18  <NA>     male     136.               23.5
```

7. For males between the ages of 40-49, compare systolic blood pressure across race as reported in the Race1 variable. Order the resulting table from lowest to highest average systolic blood pressure.

```
NHANES%>%
  filter(Gender=="male"&AgeDecade==" 40-49")%>%
  group_by(Race1)%>%
  summarise(average=mean(BPSysAve,na.rm=TRUE))
```

```
## # A tibble: 5 x 2
##   Race1    average
##   <fct>      <dbl>
## 1 Black       126.
## 2 Hispanic    122.
## 3 Mexican     122.
## 4 White       120.
## 5 Other       120.
```

4.11 Tibbles

Tidy data must be stored in data frames. We introduced the data frame in Section 2.4.1 and have been using the murders data frame throughout the book. In Section 4.7.3 we introduced the group_by function, which permits stratifying data before computing summary statistics. But where is the group information stored in the data frame?

```
murders%>%group_by(region)
```

```
## # A tibble: 51 x 6
## # Groups:   region [4]
##    state                abb   region    population total  rate
##    <chr>                <chr> <fct>          <dbl> <dbl> <dbl>
##  1 Alabama              AL    South        4779736   135  2.82
##  2 Alaska               AK    West          710231    19  2.68
##  3 Arizona              AZ    West         6392017   232  3.63
##  4 Arkansas             AR    South        2915918    93  3.19
##  5 California           CA    West        37253956  1257  3.37
##  6 Colorado             CO    West         5029196    65  1.29
##  7 Connecticut          CT    Northeast    3574097    97  2.71
##  8 Delaware             DE    South         897934    38  4.23
##  9 District of Columbia DC    South         601723    99 16.5 
## 10 Florida              FL    South       19687653   669  3.40
## # ... with 41 more rows
```

Notice that there are no columns with this information. But, if you look closely at the output above, you see the line A tibble followd by dimensions. We can learn the class of the returned object using:

```
murders%>%group_by(region)%>%class()
```

```
## [1] "grouped_df" "tbl_df"     "tbl"        "data.frame"
```

The tbl, pronounced tibble, is a special kind of data frame. The functions group_by and summarize always return this type of data frame. The group_by function returns a special kind of tbl, the grouped_df. We will say more about these later. For consistency, the dplyr manipulation verbs (select, filter, mutate, and arrange) preserve the class of the input: if they receive a regular data frame they return a regular data frame, while if they receive a tibble they return a tibble. But tibbles are the preferred format in the tidyverse and as a result tidyverse functions that produce a data frame from scratch return a tibble. For example, in Chapter 5 we will see that tidyverse functions used to import data create tibbles.

Tibbles are very similar to data frames. In fact, you can think of them as a modern version of data frames. Nonetheless there are three important differences which we describe next.

4.11.1 Tibbles display better

The print method for tibbles is more readable than that of a data frame. To see this, compare the outputs of typing murders and the output of murders if we convert it to a tibble. We can do this using as_tibble(murders). If using RStudio, output for a tibble adjusts to your window size. To see this, change the width of your R console and notice how more/less columns are shown.

```r
murders
```

```
##                   state abb        region population total       rate
## 1               Alabama  AL         South    4779736   135  2.8244238
## 2                Alaska  AK          West     710231    19  2.6751860
## 3               Arizona  AZ          West    6392017   232  3.6295273
## 4              Arkansas  AR         South    2915918    93  3.1893901
## 5            California  CA          West   37253956  1257  3.3741383
## 6              Colorado  CO          West    5029196    65  1.2924531
## 7           Connecticut  CT     Northeast    3574097    97  2.7139722
## 8              Delaware  DE         South     897934    38  4.2319369
## 9  District of Columbia  DC         South     601723    99 16.4527532
## 10              Florida  FL         South   19687653   669  3.3980688
## 11              Georgia  GA         South    9920000   376  3.7903226
## 12               Hawaii  HI          West    1360301     7  0.5145920
## 13                Idaho  ID          West    1567582    12  0.7655102
## 14             Illinois  IL North Central   12830632   364  2.8369608
## 15              Indiana  IN North Central    6483802   142  2.1900730
## 16                 Iowa  IA North Central    3046355    21  0.6893484
## 17               Kansas  KS North Central    2853118    63  2.2081106
## 18             Kentucky  KY         South    4339367   116  2.6732010
## 19            Louisiana  LA         South    4533372   351  7.7425810
## 20                Maine  ME     Northeast    1328361    11  0.8280881
## 21             Maryland  MD         South    5773552   293  5.0748655
## 22        Massachusetts  MA     Northeast    6547629   118  1.8021791
## 23             Michigan  MI North Central    9883640   413  4.1786225
## 24            Minnesota  MN North Central    5303925    53  0.9992600
## 25          Mississippi  MS         South    2967297   120  4.0440846
## 26             Missouri  MO North Central    5988927   321  5.3598917
## 27              Montana  MT          West     989415    12  1.2128379
## 28             Nebraska  NE North Central    1826341    32  1.7521372
## 29               Nevada  NV          West    2700551    84  3.1104763
## 30        New Hampshire  NH     Northeast    1316470     5  0.3798036
## 31           New Jersey  NJ     Northeast    8791894   246  2.7980319
## 32           New Mexico  NM          West    2059179    67  3.2537239
## 33             New York  NY     Northeast   19378102   517  2.6679599
## 34       North Carolina  NC         South    9535483   286  2.9993237
## 35         North Dakota  ND North Central     672591     4  0.5947151
## 36                 Ohio  OH North Central   11536504   310  2.6871225
## 37             Oklahoma  OK         South    3751351   111  2.9589340
## 38               Oregon  OR          West    3831074    36  0.9396843
## 39         Pennsylvania  PA     Northeast   12702379   457  3.5977513
## 40         Rhode Island  RI     Northeast    1052567    16  1.5200933
## 41       South Carolina  SC         South    4625364   207  4.4753235
## 42         South Dakota  SD North Central     814180     8  0.9825837
## 43            Tennessee  TN         South    6346105   219  3.4509357
## 44                Texas  TX         South   25145561   805  3.2013603
## 45                 Utah  UT          West    2763885    22  0.7959810
## 46              Vermont  VT     Northeast     625741     2  0.3196211
## 47             Virginia  VA         South    8001024   250  3.1246001
## 48           Washington  WA          West    6724540    93  1.3829942
## 49        West Virginia  WV         South    1852994    27  1.4571013
## 50            Wisconsin  WI North Central    5686986    97  1.7056487
## 51              Wyoming  WY          West     563626     5  0.8871131
```

```r
as_tibble(murders)
```

```
## # A tibble: 51 x 6
##    state                abb   region    population total  rate
##    <chr>                <chr> <fct>          <dbl> <dbl> <dbl>
##  1 Alabama              AL    South        4779736   135  2.82
##  2 Alaska               AK    West          710231    19  2.68
##  3 Arizona              AZ    West         6392017   232  3.63
##  4 Arkansas             AR    South        2915918    93  3.19
##  5 California           CA    West        37253956  1257  3.37
##  6 Colorado             CO    West         5029196    65  1.29
##  7 Connecticut          CT    Northeast    3574097    97  2.71
##  8 Delaware             DE    South         897934    38  4.23
##  9 District of Columbia DC    South         601723    99 16.5
## 10 Florida              FL    South       19687653   669  3.40
## # ... with 41 more rows
```

4.11.2 Subsets of tibbles are tibbles

If you subset the columns of a data frame, you may get back an object that is not a data frame, such as a vector or scalar. For example:

```r
class(murders[,4])
```

```
## [1] "numeric"
```

is not a data frame. With tibbles this does not happen:

```r
class(as_tibble(murders)[,4])
```

```
## [1] "tbl_df"     "tbl"        "data.frame"
```

This is useful in the tidyverse since functions require data frames as input.

With tibbles, if you want to access the vector that defines a column, and not get back a data frame, you need to use the accessor $:

```r
class(as_tibble(murders)$population)
```

```
## [1] "numeric"
```

A related feature is that tibbles will give you a warning if you try to access a column that does not exist. If we accidentally write Population instead of population this:

```r
murders$Population
```

```
## NULL
```

returns a NULL with no warning, which can make it harder to debug. In contrast, if we try this with a tibble we get an informative warning:

```
as_tibble(murders)$Population
```

```
## Warning: Unknown or uninitialised column: ‘Population‘.

## NULL
```

4.13.3 Tibbles can have complex entries

While data frame columns need to be vectors of numbers, strings, or logical values, tibbles can have more complex objects, such as lists or functions. Also, we can create tibbles with functions:

```
tibble(id=c(1,2,3),func=c(mean,median,sd))
```

```
## # A tibble: 3 x 2
##      id func
##   <dbl> <list>
## 1     1 <fn>
## 2     2 <fn>
## 3     3 <fn>
```

4.11.4 Tibbles can be grouped

The function group_by returns a special kind of tibble: a grouped tibble. This class stores information that lets you know which rows are in which groups. The tidyverse functions, in particular the summarize function, are aware of the group information.

4.11.5 Create a tibble using tibble instead of data.frame

It is sometimes useful for us to create our own data frames. To create a data frame in the tibble format, you can do this by using the tibble function.

```
grades<-tibble(names=c("John","Juan","Jean","Yao"),
               exam_1=c(95,80,90,85),
               exam_2=c(90,85,85,90))
```

Note that base R (without packages loaded) has a function with a very similar name, data.frame, that can be used to create a regular data frame rather than a tibble.

```
grades<-data.frame(names=c("John","Juan","Jean","Yao"),
               exam_1=c(95,80,90,85),
               exam_2=c(90,85,85,90))
```

To convert a regular data frame to a tibble, you can use the as_tibble function.

```
as_tibble(grades)%>% class()
```

```
## [1] "tbl_df"     "tbl"        "data.frame"
```

4.12 The dot operator

One of the advantages of using the pipe %>% is that we do not have to keep naming new objects as we manipulate the data frame. As a quick reminder, if we want to compute the median murder rate for states in the southern states, instead of typing:

```
tab_1<-filter(murders, region=="South")
tab_2<-mutate(tab_1,rate=total/population*10^5)
rates<-tab_2$rate
median(rates)
```

```
## [1] 3.398069
```

We can aboid defining any new intermediate objects by instead typing:

```
filter(murders, region=="South")%>%
  mutate(rate=total/population*10^5)%>%
  summarize(median=median(rate))%>%
  pull(median)
```

```
## [1] 3.398069
```

We can do this because each of these functions takes a data frame as the first argument. But what if we want to access a component of the data frame. For example, what if the pull function was not available and we wanted to access tab_2$rate? What data frame name would we use? The answer is the dot operator.

For example to access the rate vector without the pull function we could use

```
rates<-filter(murders, region=="South")%>%
  mutate(rate=total/population*10^5)%>%
  .$rate
median(rates)
```

```
## [1] 3.398069
```

4.13 The purrr package

In Section 3.5 we learned about the sapply function, which permitted us to apply the same function to each element of a vector. We constructed a function and used sapply to compute the sum of the first n integers for several values of n like this:

```
compute_s_n<-function(n){
  x<-1:n
  sum(x)
}
n<-1:25
s_n<-sapply(n,compute_s_n)
```

This type of operation, applying the same function or procedure to elements of an object, is quite common in data analysis. The purrr package includes functions similar to sapply but that better interact with other tidyverse functions. The main advantage is that we can better control the output type of functions. In contrast, sapply can return several different object types; for example, we might expect a numeric result from a line of code, but sapply might convert our result to character under some circumstances. purrr functions will never do this: they will return objects of a specified type or return an error if this is not possible.

The first purrr function we will learn is map, which works very similar to sapply but always, without exception, returns a list:

```
library(purrr)
s_n<-map(n,compute_s_n)
class(s_n)
```

```
## [1] "list"
```

If we want a numeric vector, we can instead use map_dbl which always returns a vector of numeric values.

```
s_n<-map_dbl(n,compute_s_n)
class(s_n)
```

```
## [1] "numeric"
```

This produces the same results as the sapply call shown above.

A particularly useful purrr function for interacting with the rest of the tidyverse is map_df, which always returns a tibble data frame. However, the function being called needs to return a vector or a list with names. For this reason, the following code would result in a Argument 1 must have names error:

```
#s_n<-map_df(n,compute_s_n)
#Error: Argument 1 must have names. Run `rlang::last_error()` to see where the error occurred.
```

We need to change the function to make this work:

```
compute_s_n<-function(n){
  x<-1:n
  tibble(sum=sum(x))
}
s_n<-map_df(n,compute_s_n)
```

The purrr package provides much more functionality not covered here. For more details you can consult this online resource.

4.14 Tidyverse conditionals

A typical data analysis will often involve one or more conditional operations. In Section 3.1 we described the ifelse function, which we will use extensively in this book. In this section we present two dplyr functions that provide further functionality for performing conditional operations.

4.14.1 case_when

The case_when function is useful for vectorizing conditional statements. It is similar to ifelse but can output any number of values, as opposed to just TRUE or FALSE. Here is an example splitting numbers into negative, positive, and 0:

```
x<-c(-2,-1,0,1,2)
case_when(x<0~"Negative",
          x>0~"Positive",
          TRUE~"Zero")
```

```
## [1] "Negative" "Negative" "Zero"     "Positive" "Positive"
```

A common use for this function is to define categorical variables based on existing variables. For example, suppose we want to compare the murder rates in four groups of states: New England, West Coast, South, and other. For each state, we need to ask if it is in New England, if it is not we ask if it is in the West Coast, if not we ask if it is in the South, and if not we assign other. Here is how we use case_when to do this:

```
murders%>%
  mutate(group=case_when(
    abb%in%c("ME","NH","VT","MA","RI","CT")~"New England",
    abb%in%c("WA","OR","CA")~"West Coast",
    region=="South"~"South",
    TRUE~"Other"))%>%
  group_by(group)%>%
  summarise(rate=sum(total)/sum(population)*10^5)
```

```
## # A tibble: 4 x 2
##   group        rate
##   <chr>       <dbl>
## 1 New England  1.72
## 2 Other        2.71
## 3 South        3.63
## 4 West Coast   2.90
```

4.14.2 between

A common operation in data analysis is to determine if a value falls inside an interval. We can check this using conditionals. For example, to check if the elements of a vector x are between a and b we can type

```
#x>=a&x<=b
```

However, this can become cumbersome, especially within the tidyverse approach. The between function performs the same operation.

```
#between(x,a,b)
```

4.15 Exercises

1. Load the murders dataset. Which of the following is true?

Answer: b.murders is in tidy format and is stored in a data frame.

2. Use as_tibble to convert the murders data table into a tibble and save it in an object called murders_tibble.

```
murders_tibble<-as_tibble(murders)
```

3. Use the group_by function to convert murders into a tibble that is grouped by region.

```
murders%>%
  group_by(region)
```

```
## # A tibble: 51 x 6
## # Groups:   region [4]
##    state                abb   region    population total  rate
##    <chr>                <chr> <fct>          <dbl> <dbl> <dbl>
##  1 Alabama              AL    South        4779736   135  2.82
##  2 Alaska               AK    West          710231    19  2.68
##  3 Arizona              AZ    West         6392017   232  3.63
##  4 Arkansas             AR    South        2915918    93  3.19
##  5 California           CA    West        37253956  1257  3.37
##  6 Colorado             CO    West         5029196    65  1.29
##  7 Connecticut          CT    Northeast    3574097    97  2.71
##  8 Delaware             DE    South         897934    38  4.23
##  9 District of Columbia DC    South         601723    99 16.5
## 10 Florida              FL    South       19687653   669  3.40
## # ... with 41 more rows
```

4. Write tidyverse code that is equivalent to this code:

```
exp(mean(log(murders$population)))
```

```
## [1] 3675209
```

Write it using the pipe so that each function is called without arguments. Use the dot operator to access the population. Hint: The code should start with murders %>%.

```
murders%>%
  .$population%>%
  log()%>%
  mean()%>%
  exp()
```

```
## [1] 3675209
```

5. Use the map_df to create a data frame with three columns named n, s_n, and s_n_2. The first column should contain the numbers 1 through 100. The second and third columns should each contain the sum of 1 through n with n the row number.

```
n<-1:100
compute_s_n<-function(n){
  x<-1:n
  data.frame(n=n,
         s_n=sum(x),
         s_n_2=sum(x))
}
map_df(n,compute_s_n)
```

```
##        n  s_n s_n_2
## 1      1    1     1
## 2      2    3     3
## 3      3    6     6
## 4      4   10    10
## 5      5   15    15
## 6      6   21    21
## 7      7   28    28
## 8      8   36    36
## 9      9   45    45
## 10    10   55    55
## 11    11   66    66
## 12    12   78    78
## 13    13   91    91
## 14    14  105   105
## 15    15  120   120
## 16    16  136   136
## 17    17  153   153
## 18    18  171   171
## 19    19  190   190
## 20    20  210   210
## 21    21  231   231
## 22    22  253   253
## 23    23  276   276
## 24    24  300   300
## 25    25  325   325
## 26    26  351   351
## 27    27  378   378
## 28    28  406   406
## 29    29  435   435
## 30    30  465   465
## 31    31  496   496
## 32    32  528   528
## 33    33  561   561
## 34    34  595   595
## 35    35  630   630
## 36    36  666   666
## 37    37  703   703
## 38    38  741   741
## 39    39  780   780
## 40    40  820   820
## 41    41  861   861
## 42    42  903   903
## 43    43  946   946
## 44    44  990   990
## 45    45 1035  1035
## 46    46 1081  1081
## 47    47 1128  1128
## 48    48 1176  1176
## 49    49 1225  1225
## 50    50 1275  1275
## 51    51 1326  1326
## 52    52 1378  1378
## 53    53 1431  1431
```

```
## 54    54 1485  1485
## 55    55 1540  1540
## 56    56 1596  1596
## 57    57 1653  1653
## 58    58 1711  1711
## 59    59 1770  1770
## 60    60 1830  1830
## 61    61 1891  1891
## 62    62 1953  1953
## 63    63 2016  2016
## 64    64 2080  2080
## 65    65 2145  2145
## 66    66 2211  2211
## 67    67 2278  2278
## 68    68 2346  2346
## 69    69 2415  2415
## 70    70 2485  2485
## 71    71 2556  2556
## 72    72 2628  2628
## 73    73 2701  2701
## 74    74 2775  2775
## 75    75 2850  2850
## 76    76 2926  2926
## 77    77 3003  3003
## 78    78 3081  3081
## 79    79 3160  3160
## 80    80 3240  3240
## 81    81 3321  3321
## 82    82 3403  3403
## 83    83 3486  3486
## 84    84 3570  3570
## 85    85 3655  3655
## 86    86 3741  3741
## 87    87 3828  3828
## 88    88 3916  3916
## 89    89 4005  4005
## 90    90 4095  4095
## 91    91 4186  4186
## 92    92 4278  4278
## 93    93 4371  4371
## 94    94 4465  4465
## 95    95 4560  4560
## 96    96 4656  4656
## 97    97 4753  4753
## 98    98 4851  4851
## 99    99 4950  4950
## 100  100 5050  5050
```