Short Summary:
Lists estimates of the percentage of body fat determined by underwater weighing and various body circumference measurements for 252 men.

Classroom use of this data set:
This data set can be used to illustrate multiple regression techniques. Accurate measurement of body fat is inconvenient/costly and it is desirable to have easy methods of estimating body fat that are not inconvenient/costly.

More Details:
A variety of popular health books suggest that the readers assess their health, at least in part, by estimating their percentage of body fat. In Bailey (1994), for instance, the reader can estimate body fat from tables
using their age and various skin-fold measurements obtained by using a caliper. Other texts give predictive equations for body fat using body circumference measurements (e.g. abdominal circumference) and/or skin-fold
measurements. See, for instance, Behnke and Wilmore (1974), pp. 66-67; Wilmore (1976), p. 247; or Katch and McArdle (1977), pp. 120-132).

Percentage of body fat for an individual can be estimated once body density
has been determined. Folks (e.g. Siri (1956)) assume that the body consists
of two components - lean body tissue and fat tissue. Letting

D = Body Density (gm/cm^3)
A = proportion of lean body tissue
B = proportion of fat tissue (A+B=1)
a = density of lean body tissue (gm/cm^3)
b = density of fat tissue (gm/cm^3)

we have

$$D = 1/[(A/a) + (B/b)]$$

solving for B we find

$$B = (1/D)*[ab/(a-b)] - [b/(a-b)].$$

Using the estimates a=1.10 gm/cm^3 and b=0.90 gm/cm^3 (see Katch and McArdle
(1977), p. 111 or Wilmore (1976), p. 123) we come up with "Siri's equation":

Percentage of Body Fat (i.e. 100*B) = 495/D - 450.

Volume, and hence body density, can be accurately measured a variety of

ways.
The technique of underwater weighing "computes body volume as the difference
between body weight measured in air and weight measured during water submersion. In other words, body volume is equal to the loss of weight in
water with the appropriate temperature correction for the water's density"
(Katch and McArdle (1977), p. 113). Using this technique,

Body Density = WA/[(WA-WW)/c.f. - LV]

where

WA = Weight in air (kg)
WW = Weight in water (kg)
c.f. = Water correction factor (=1 at 39.2 deg F as one-gram of water
occupies exactly one cm^3 at this temperature, =.997 at 76-78 deg F)
LV = Residual Lung Volume (liters)

(Katch and McArdle (1977), p. 115). Other methods of determining body volume
are given in Behnke and Wilmore (1974), p. 22 ff.

The variables listed below, from left to right, are:

Density determined from underwater weighing
Percent body fat from Siri's (1956) equation
Age (years)
Weight (lbs)
Height (inches)
Neck circumference (cm)
Chest circumference (cm)
Abdomen 2 circumference (cm)
Hip circumference (cm)
Thigh circumference (cm)
Knee circumference (cm)
Ankle circumference (cm)
Biceps (extended) circumference (cm)
Forearm circumference (cm)
Wrist circumference (cm)

(Measurement standards are apparently those listed in Benhke and Wilmore (1974), pp. 45-48 where, for instance, the abdomen 2 circumference is measured "laterally, at the level of the iliac crests, and anteriorly, at
the umbilicus".)

These data are used to produce the predictive equations for lean

body weight given in the abstract "Generalized body composition prediction
equation for men using simple measurement techniques", K.W. Penrose, A.G.
Nelson, A.G. Fisher, FACSM, Human Performance Research Center, Brigham Young
University, Provo, Utah 84602 as listed in _Medicine and Science in Sports
and Exercise_, vol. 17, no. 2, April 1985, p. 189. (The predictive equations
were obtained from the first 143 of the 252 cases that are listed below).
The data were generously supplied by Dr. A. Garth Fisher who gave permission to
freely distribute the data and use for non-commercial purposes.

References:

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37.3	21.9	32.0	27.4	17.1					
1.0853	6.1	22	173.25	72.25	38.5	93.6	83.0	98.7	58.7
37.3	23.4	30.5	28.9	18.2					
1.0414	25.3	22	154.00	66.25	34.0	95.8	87.9	99.2	59.6
38.9	24.0	28.8	25.2	16.6					
1.0751	10.4	26	184.75	72.25	37.4	101.8	86.4	101.2	60.1
37.3	22.8	32.4	29.4	18.2					
1.0340	28.7	24	184.25	71.25	34.4	97.3	100.0	101.9	63.2
42.2	24.0	32.2	27.7	17.7					
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56.0    36.9    23.0    34.0    29.8    18.1
  1.0374    27.1      44  186.00   69.75    37.8   104.6   101.1   102.1
58.9    37.9    22.7    30.9    28.8    17.6
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  1.0325    29.4      43  187.75   74.00    37.7    97.8    98.6   100.6
63.6    39.2    23.8    34.3    28.4    17.7
  1.0481    22.4      40  168.25   71.25    34.3    98.3    88.5    98.3
58.1    38.4    22.5    31.7    27.4    17.6
  1.0522    20.4      49  212.75   75.00    40.8   104.7   106.6   107.7
66.5    42.5    24.5    35.5    29.8    18.7
  1.0422    24.9      40  176.75   71.00    37.4    98.6    93.1   101.6
59.1    39.6    21.6    30.8    27.9    16.6
  1.0571    18.3      40  173.25   69.50    36.5    99.5    93.0    99.3
60.4    38.2    22.0    32.0    28.5    17.8
  1.0459    23.3      52  167.00   67.75    37.5   102.7    91.0    98.9
57.1    36.7    22.3    31.6    27.5    17.9
  1.0775     9.4      23  159.75   72.25    35.5    92.1    77.1    93.9
56.1    36.1    22.7    30.5    27.2    18.2
  1.0754    10.3      23  188.15   77.50    38.0    96.6    85.3   102.5
59.1    37.6    23.2    31.8    29.7    18.3
  1.0664    14.2      24  156.00   70.75    35.7    92.7    81.9    95.3
56.4    36.5    22.0    33.5    28.3    17.3
  1.0550    19.2      24  208.50   72.75    39.2   102.0    99.1   110.1
71.2    43.5    25.2    36.1    30.3    18.7
  1.0322    29.6      25  206.50   69.75    40.9   110.9   100.5   106.2
68.4    40.8    24.6    33.3    29.7    18.4
  1.0873     5.3      25  143.75   72.50    35.2    92.3    76.5    92.1
51.9    35.7    22.0    25.8    25.2    16.9
  1.0416    25.2      26  223.00   70.25    40.6   114.1   106.8   113.9
67.6    42.7    24.7    36.0    30.4    18.4
  1.0776     9.4      26  152.25   69.00    35.4    92.9    77.6    93.5
56.9    35.9    20.4    31.6    29.0    17.8
  1.0542    19.6      26  241.75   74.50    41.8   108.3   102.9   114.4
72.9    43.5    25.1    38.5    33.8    19.6
  1.0758    10.1      27  146.00   72.25    34.1    88.5    72.8    91.1
53.6    36.8    23.8    27.8    26.3    17.4
  1.0610    16.5      27  156.75   67.25    37.9    94.0    88.2    95.2
56.8    37.4    22.8    30.6    28.3    17.9
  1.0510    21.0      27  200.25   73.50    38.2   101.1   100.1   105.0
62.1    40.0    24.9    33.7    29.2    19.4
  1.0594    17.3      28  171.50   75.25    35.6    92.1    83.5    98.3
57.3    37.8    21.7    32.2    27.7    17.7
  1.0287    31.2      28  205.75   69.00    38.5   105.6   105.0   106.4
68.6    40.0    25.2    35.2    30.7    19.1
  1.0761    10.0      28  182.50   72.25    37.0    98.5    90.8   102.5
60.8    38.5    25.0    31.6    28.0    18.6
  1.0704    12.5      30  136.50   68.75    35.9    88.7    76.6    89.8
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  1.0477    22.5      31  177.25   71.50    36.2   101.1    92.4    99.3
59.4    39.0    24.6    30.1    28.2    18.2
  1.0775     9.4      31  151.25   72.25    35.0    94.0    81.2    91.5
52.5    36.6    21.0    27.0    26.3    16.5
  1.0653    14.6      33  196.00   73.00    38.5   103.8    95.6   105.1
61.4    40.6    25.0    31.3    29.2    19.1
  1.0690    13.0      33  184.25   68.75    40.7    98.9    92.1   103.5
64.0    37.3    23.5    33.5    30.6    19.7
  1.0644    15.1      34  140.00   70.50    36.0    89.2    83.4    89.6
52.4    35.6    20.4    28.3    26.2    16.5
  1.0370    27.3      34  218.75   72.00    39.5   111.4   106.0   108.8
63.8    42.0    23.4    34.0    31.2    18.5
  1.0549    19.2      35  217.00   73.75    40.5   107.5    95.1   104.5
64.8    41.3    25.6    36.4    33.7    19.4
  1.0492    21.8      35  166.25   68.00    38.5    99.1    90.4    95.6
55.5    34.2    21.9    30.2    28.7    17.7
  1.0525    20.3      35  224.75   72.25    43.9   108.2   100.4   106.8
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74.4    40.6    24.0    36.1    31.8    18.8
  1.0610    16.5      35  172.75   69.50    37.6    99.1    90.8    98.1
60.1    39.1    23.4    32.5    29.8    17.4
  1.0926     3.0      35  152.25   67.75    37.0    92.2    81.9    92.8
54.7    36.2    22.1    30.4    27.4    17.7
  1.0983      .7      35  125.75   65.50    34.0    90.8    75.0    89.2
50.0    34.8    22.0    24.8    25.9    16.9
  1.0521    20.5      35  177.25   71.00    38.4   100.5    90.3    98.7
57.8    37.3    22.4    31.0    28.7    17.7
  1.0603    16.9      36  176.25   71.50    38.7    98.2    90.3    99.9
59.2    37.7    21.5    32.4    28.4    17.8
  1.0414    25.3      36  226.75   71.75    41.5   115.3   108.8   114.4
69.2    42.4    24.0    35.4    21.0    20.1
  1.0763     9.9      37  145.25   69.25    36.0    96.8    79.4    89.2
50.3    34.8    22.2    31.0    26.9    16.9
  1.0689    13.1      37  151.00   67.00    35.3    92.6    83.2    96.4
60.0    38.1    22.0    31.5    26.6    16.7
  1.0316    29.9      37  241.25   71.50    42.1   119.2   110.3   113.9
69.8    42.6    24.8    34.4    29.5    18.4
  1.0477    22.5      38  187.25   69.25    38.0   102.7    92.7   101.9
64.7    39.5    24.7    34.8    30.3    18.1
  1.0603    16.9      39  234.75   74.50    42.8   109.5   104.5   109.9
69.5    43.1    25.8    39.1    32.5    19.9
  1.0387    26.6      39  219.25   74.25    40.0   108.5   104.6   109.8
68.1    42.8    24.1    35.6    29.0    19.0
  1.1089      .0      40  118.50   68.00    33.8    79.3    69.4    85.0
47.2    33.5    20.2    27.7    24.6    16.5
  1.0725    11.5      40  145.75   67.25    35.5    95.5    83.6    91.6
54.1    36.2    21.8    31.4    28.3    17.2
  1.0713    12.1      40  159.25   69.75    35.3    92.3    86.8    96.1
58.0    39.4    22.7    30.0    26.4    17.4
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1.0794 8.6 40 167.50 71.50 39.4 89.5 83.7 98.1
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63.5 39.8 23.5 36.4 30.4 19.1
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53.0 36.2 22.5 31.4 27.5 17.7
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  1.0373    27.2      49  216.25   74.50    40.2   115.6   104.0   109.0
63.7    40.3    23.2    36.8    31.0    18.9
  1.0543    19.5      49  168.25   71.75    38.3    98.3    89.7    99.1
56.3    38.8    23.0    29.5    27.9    18.6
  1.0561    18.7      50  194.75   70.75    39.0   103.7    97.6   104.2
60.0    40.9    25.5    32.7    30.0    19.0
  1.0543    19.5      50  172.75   73.00    37.4    98.7    87.6    96.1
57.1    38.1    21.8    28.6    26.7    18.0
   .9950    47.5      51  219.00   64.00    41.2   119.8   122.1   112.8
62.5    36.9    23.6    34.7    29.1    18.4
  1.0678    13.6      51  149.25   69.75    34.8    92.8    81.1    96.3
53.8    36.5    21.5    31.3    26.3    17.8
  1.0819     7.5      51  154.50   70.00    36.9    93.3    81.5    94.4
54.7    39.0    22.6    27.5    25.9    18.6
  1.0433    24.5      52  199.25   71.75    39.4   106.8   100.0   105.0
63.9    39.2    22.9    35.7    30.4    19.2
  1.0646    15.0      53  154.50   69.25    37.6    93.9    88.7    94.5
53.7    36.2    22.0    28.5    25.7    17.1
  1.0706    12.4      54  153.25   70.50    38.5    99.0    91.8    96.2
57.7    38.1    23.9    31.4    29.9    18.9
  1.0399    26.0      54  230.00   72.25    42.5   119.9   110.4   105.5
64.2    42.7    27.0    38.4    32.0    19.6
  1.0726    11.5      54  161.75   67.50    37.4    94.2    87.6    95.6
59.7    40.2    23.4    27.9    27.0    17.8
  1.0874     5.2      55  142.25   67.25    35.2    92.7    82.8    91.9
54.4    35.2    22.5    29.4    26.8    17.0
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57.4    37.1    21.8    34.1    31.1    19.2
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56.6    38.5    22.6    33.4    29.3    18.8
  1.0418    25.2      55  198.50   74.25    38.3   105.3    96.7   106.6
64.0    42.6    23.4    33.2    30.0    18.4
  1.0647    14.9      56  174.50   69.50    38.1   104.0    89.4    98.4
58.4    37.4    22.5    34.6    30.1    18.8
  1.0601    17.0      56  167.75   68.50    37.4    98.6    93.0    97.0
55.4    38.8    23.2    32.4    29.7    19.0
  1.0745    10.6      57  147.75   65.75    35.2    99.6    86.4    90.1
53.0    35.0    21.3    31.7    27.3    16.9
  1.0620    16.1      57  182.25   71.75    39.4   103.4    96.7   100.7
59.3    38.6    22.8    31.8    29.1    19.0
  1.0636    15.4      58  175.50   71.50    38.0   100.2    88.1    97.8
57.1    38.9    23.6    30.9    29.6    18.0
  1.0384    26.7      58  161.75   67.25    35.1    94.9    94.9   100.2
56.8    35.9    21.0    27.8    26.1    17.6
  1.0403    25.8      60  157.75   67.50    40.4    97.2    93.3    94.0
54.3    35.7    21.0    31.3    28.7    18.3
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  1.0563    18.6      62  168.75   67.50    38.3   104.7    95.6    93.7
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59.3    40.3    23.0    32.6    28.5    19.0
  1.0372    27.3      63  219.15   69.50    40.2   117.6   113.8   111.8
63.4    41.1    22.3    35.1    29.6    18.5
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61.2    39.1    22.3    29.8    28.9    18.3
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50.7    33.4    20.1    28.5    24.8    16.5
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63.7    42.4    24.6    35.6    30.7    19.5
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  1.0334    29.0      67  199.50   68.50    40.7   118.3   106.1   101.6
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54.3    37.5    22.6    29.2    27.3    18.5
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63.3    44.0    22.6    37.5    32.6    18.8
  1.0736    11.0      70  134.25   67.00    34.9    89.2    83.6    88.8
49.6    34.8    21.5    25.6    25.7    18.5
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56.0    41.6    22.7    30.5    29.4    19.8
  1.0271    31.9      74  207.50   70.00    40.8   112.4   108.5   107.1
59.3    42.2    24.6    33.7    30.0    20.9
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