Announcements

- Quiz 1 available at 1pm. If you *do not* receive an email telling you it is available, you need to contact me so I can add you to the list.
- Office hours on web were wrong. They were corrected on Mon evening.
- If you plan to use R Commander in the ICS labs, you need to get an account. See course webpage for information. In the meantime, you can use a temporary account:

  Username: ics-temp , Password: Anteat3r

Homework (due Friday, Oct 1):

Chapter 2: #81, 84, 99

Today:

- Finish material from last time (some of which I rushed through at end)
- Do Section 2.7
- Go over how to install and use R Commander. (See handouts on course webpage.)

Describing Spread (Variability):

- **Range** = high value – low value
- **Interquartile Range (IQR)** = upper quartile – lower quartile = Q_3 - Q_1 (to be defined)
- **Standard Deviation**

Example 2.13 *Fastest Speeds Ever Driven*

Five-Number Summary for 87 males

		Males (87 Students)	
Median		110	
Quartiles	95		120
Extremes	55		150

- Two ***extremes*** describe spread over 100% of data
  Range = 150 – 55 = **95 mph**
- Two ***quartiles*** describe spread over middle 50% of data
  Interquartile Range = 120 – 95 = **25 mph**

Notation and Finding the Quartiles

Split the ordered values into the half that is (at or) below the median and the half that is (at or) above the median.

Q_1 = **lower quartile**
= median of data values
that are (at or) *below* the median

Q_3 = **upper quartile**
= median of data values
that are (at or) *above* the median

Example 2.13 *Fastest Speeds (cont)*

Ordered Data (in rows of 10 values) for the 87 males:

55	60	80	80	80	80	85	85	85	85
90	90	90	90	90	92	94	95	95	95
95	***95***	95	100	100	100	100	100	100	100
100	100	101	102	105	105	105	105	105	105
105	105	109	**110**	110	110	110	110	110	110
110	110	110	110	110	112	115	115	115	115
115	115	120	120	120	***120***	120	120	120	120
120	120	124	125	125	125	125	125	125	130
130	140	140	140	140	145	150			

- ***Median*** = (87+1)/2 = 44th value in the list = 110 mph
- Q_1 = median of the 43 values below the median = (43+1)/2 = 22nd value from the start of the list = 95 mph
- Q_3 = median of the 43 values above the median = (43+1)/2 = 22nd value from the end of the list = 120 mph

Percentiles

The k^{th} **percentile** is a number that has k% of the data values at or below it and $(100 - k)$% of the data values at or above it.

- Lower quartile: 25th percentile
- Median: 50th percentile
- Upper quartile: 75th percentile

Describing Spread with Standard Deviation

Standard deviation measures variability by summarizing how far individual data values are from the mean.

Think of the standard deviation as ***roughly the average distance values fall from the mean***.

Describing Spread with Standard Deviation: A very simple example

Numbers	Mean	Standard Deviation
100, 100, 100, 100, 100	100	0
90, 90, 100, 110, 110	100	10

Both sets have same mean of 100.

Set 1: all values are equal to the mean so there is *no variability* at all.

Set 2: one value equals the mean and other four values are 10 points away from the mean, so the *average distance away from the mean is about* 10.

Calculating the Standard Deviation

Formula for the (***sample***) **standard deviation**:

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

The value of s^2 is called the (*sample*) **variance.** An equivalent formula, easier to compute, is:

$$s = \sqrt{\frac{\sum x_i^2 - n\bar{x}^2}{n-1}}$$

Calculating the Standard Deviation

Example: 90, 90, 100, 110, 110

Step 1: Calculate $\bar{x}$, the sample mean. *Ex*: $\bar{x} = 100$

Step 2: For each observation, calculate the difference between the data value and the mean.

Ex: -10, -10, 0, 10, 10

Step 3: Square each difference in step 2.

Ex: 100, 100, 0, 100, 100

Step 4: Sum the squared differences in step 3, and then divide this sum by $n - 1$. Result = *variance* s^2

Ex: 400/(5 – 1) = 400/4 = 100

Step 5: Take the square root of the value in step 4.

Ex: s = standard deviation = $\sqrt{100} = 10$

Population Standard Deviation

Data sets usually represent a sample from a larger population. If the data set includes measurements for an ***entire population***, the notations for the mean and standard deviation are different, and the formula for the standard deviation is also slightly different.

A **population mean** is represented by the Greek μ ("mu"), and the **population standard deviation** is represented by the Greek "sigma" (lower case)

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{n}}$$

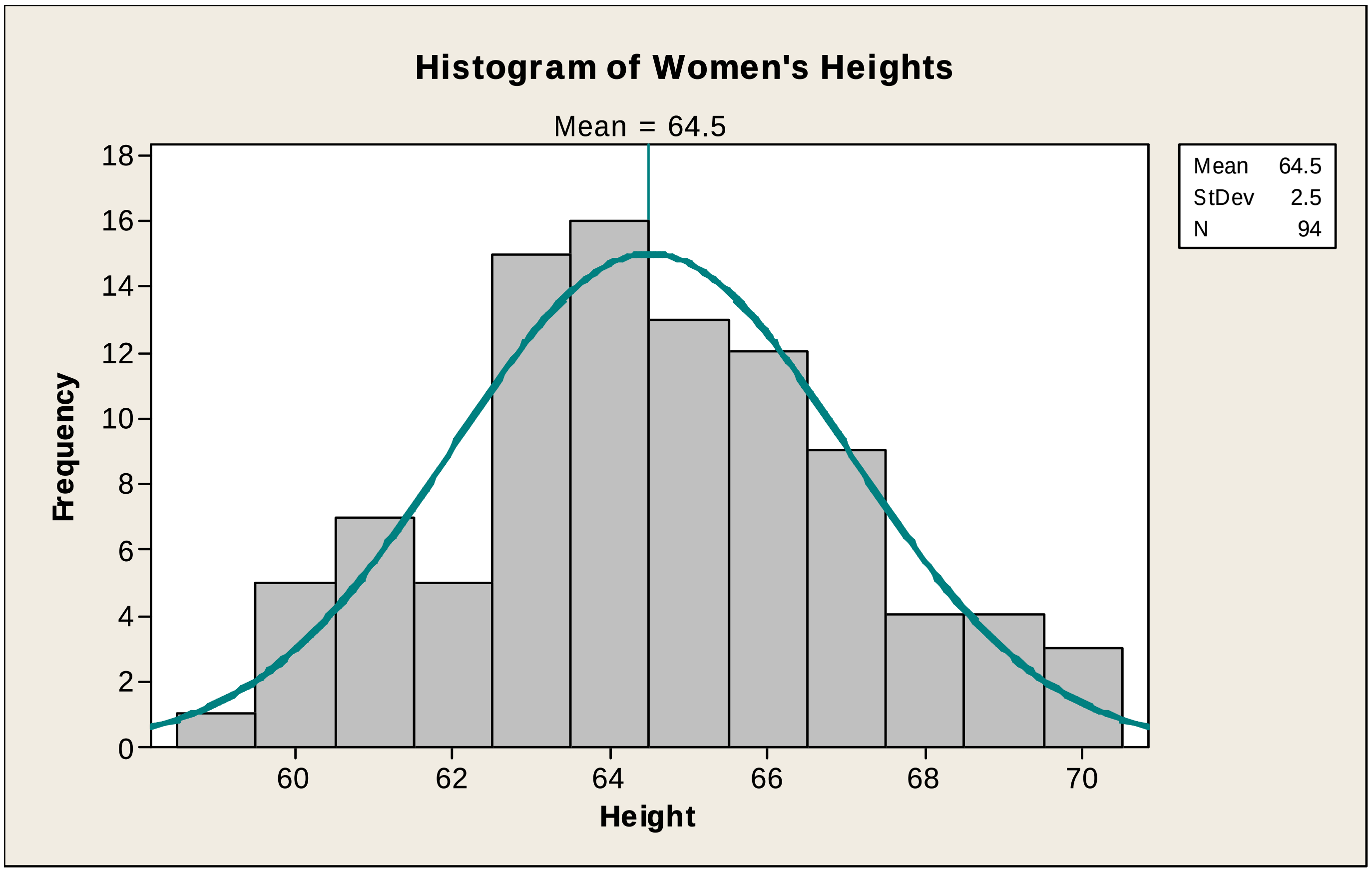
Bell-shaped distributions

- Measurements that have a bell-shape are so common in nature that they are said to have a *normal distribution*.
- Knowing the mean and standard deviation *completely determines* where all of the values fall for a normal distribution, assuming an infinite population!
- In practice we don't have an infinite population (or sample) but if we have a large sample, we can get good approximations of where values fall.

Examples of bell-shaped data

- Women's heights
  - mean = 64.5 inches, s = 2.5 inches
- Men's heights
  - mean = 70 inches, s = 3 inches
- IQ scores
  - mean = 100, s = 15
- High school GPA for intro stat students
  - mean = 3.1, s = 0.5
- Verbal SAT scores for UCI incoming students
  - mean = 569, s = 75

Women's heights from UCDavis data, n = 94
Note approximate bell-shape of histogram
"Normal curve" with mean = 64.5, s = 2.5
superimposed over histogram



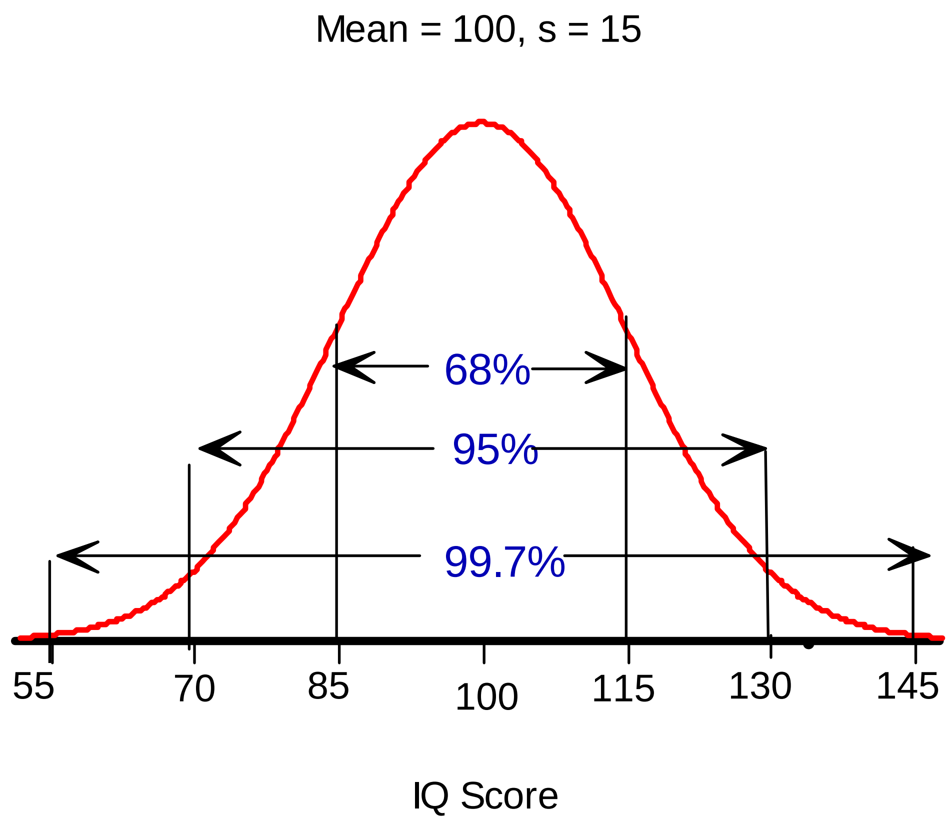
Interpreting the Standard Deviation for Bell-Shaped Curves: The Empirical Rule

For any bell-shaped curve, approximately

- **68%** of the values fall within **1 standard deviation** of the mean in either direction
- **95%** of the values fall within **2 standard deviations** of the mean in either direction
- **99.7%** (almost all) of the values fall within **3 standard deviations** of the mean in either direction

Ex: Hypothetical population of IQ scores

- 68% of IQ scores are between 85 and 115
- 95% of IQ scores are between 70 and 130
- 99.7% of IQ scores are between 55 and 145



Try Empirical Rule for these:

- Women's heights
  - mean = 64.5 inches, s = 2.5 inches
- Men's heights
  - mean = 70 inches, s = 3 inches
- High school GPA for intro stat students
  - mean = 3.1, s = 0.5
- Verbal SAT scores for UCI students
  - mean = 569, s = 75

Example: ***Women's Heights***

Mean height for the 94 UC Davis women was 64.5, and the standard deviation was 2.5 inches. Let's compare actual with ranges from Empirical Rule:

Range of Values:	Empirical Rule	Actual number	Actual percent
Mean ± 1 s.d.	68% in 62 to 67	70	70/94 = 74.5%
Mean ± 2 s.d.	95% in 59.5 to 69.5	89	89/94 = 94.7%
Mean ± 3 s.d.	99.7% in 57 to 72	94	94/94 = 100%

The Empirical Rule, the Standard Deviation, and the Range

- Empirical Rule tells us that the range from the minimum to the maximum data values equals about 4 to 6 standard deviations for data sets with an approximate bell shape.
- *For a large data set, you can get a rough idea of the value of the standard deviation by dividing the range by 6.*

$$s \approx \frac{Range}{6}$$

Standardized *z*-Scores

Standardized score or ***z*-score**:

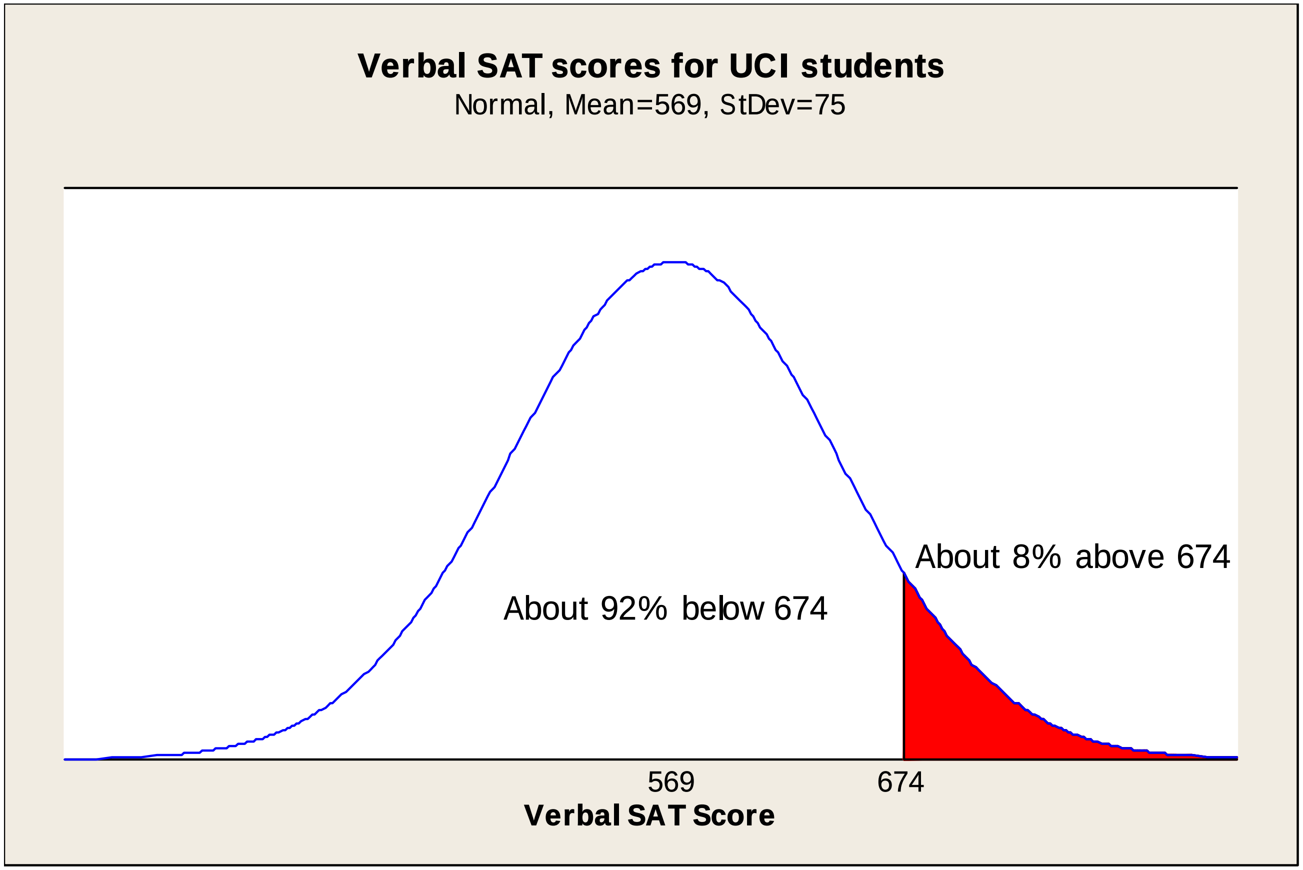
$$z = \frac{\text{Observed value} - \text{Mean}}{\text{Standard deviation}}$$

Example: UCI Verbal SAT scores had mean = 569 and s = 75. Suppose someone had SAT = 674:

$$z = \frac{674 - 569}{75} = +1.40$$

Verbal SAT of 674 for UCI student is 1.40 standard deviations ***above*** the mean for UCI students.

Verbal SAT of 674 is 1.40 standard deviations above mean.
To find proportion above or below, use Excel or R Commander
For Excel, see page 55. For R Commander, see webpage.



The Empirical Rule Restated for Standardize Scores (z-scores):

For bell-shaped data,

- About **68%** of the values have *z*-scores between –1 and +1.
- About **95%** of the values have *z*-scores between –2 and +2.
- About **99.7%** of the values have *z*-scores between –3 and +3.

Installing and Using R Commander

- "R" is a sophisticated and free statistical programming language.
- *R Commander* is an add-on, also free, that is menu-driven. It doesn't do everything R does.
- You can use R Commander in the ICS Computer labs, or install it on your computer.
- See handouts on course web page for installing R and R Commander, and for using R Commander for Chapters 2 and 5.
- Switch to laptop for R Commander demo.