Errors in Measurements

Errors in Measurement

- **No Measurement is Exact**
- **Every Measurement Contains Errors**
- **The “True” Value of a Measurement is Never Known**
- **The “Exact” Error Present is Always Unknown**

Mistakes or Blunders

- **Caused by:**
  - **Carelessness**
  - **Poor Judgement**
  - **Incompetence**

Sources of Errors

- **Natural**
  - **Environmental conditions: wind, temperature, humidity etc.**
  - **Tape contracts and expands due to temperature changes**
  - **Difficult to read Philadelphia Rod with heat waves coming up from the pavement**

Sources of Errors

- **Instrumental**
  - **Due to Limitation of Equipment**
    - **Warped Philadelphia Rod**
    - **Theodolite out of adjustment**
    - **Kinked or damaged Tape**

Sources of Errors

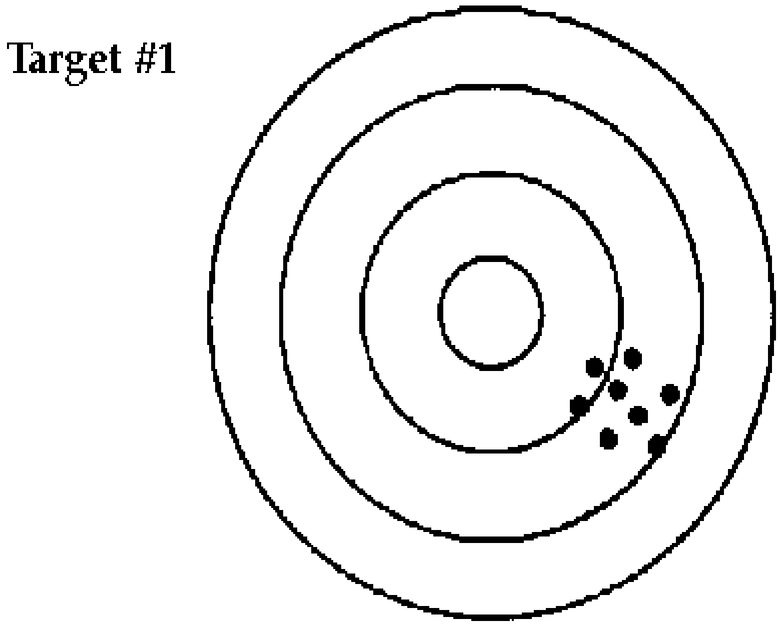
- **Personal**
  - **Limits of Human Performance Factors**
    - **Sight**
    - **Strength**
    - **Judgement**
    - **Communication**

Types of Errors

- **Systematic/Cumulative**
  - **Errors that occur each time a measurement is made**
  - **These Errors can be eliminated by making corrections to your measurements**
    - **Tape is too long or to short**
    - **Theodolite is out of adjustment**
    - **Warped Philadelphia Rod**

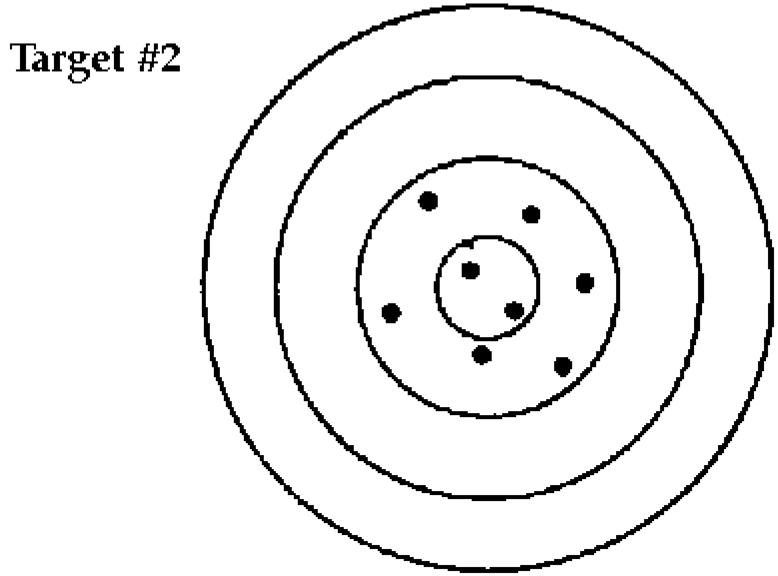
Precision vs. Accuracy

- **Precision**
  - **The "Closeness" of one measurement to another**



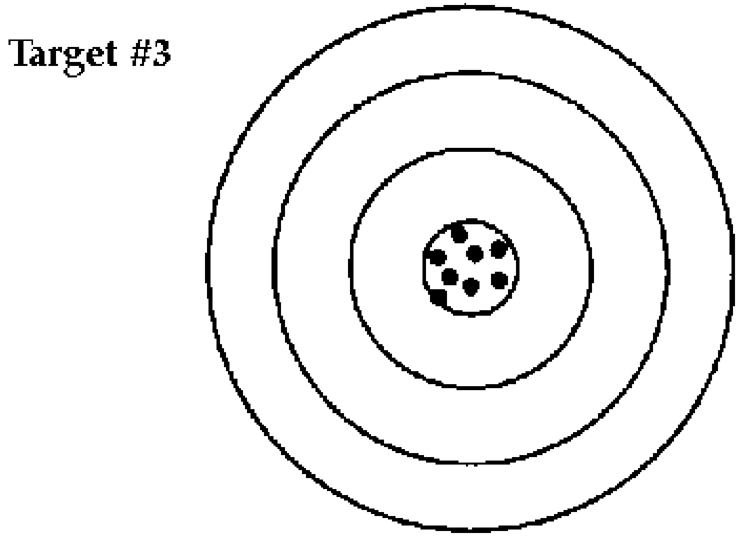
Precision vs. Accuracy

- **Accuracy**
  - **The degree of perfection obtained in a measurement.**



Precision and Accuracy

- **Ultimate Goal of the Surveyor**
  - **Rarely Obtainable**
  - **Surveyor is happy with Precise Measurements**



Computing Precision

- Precision:

$$\text{precision} = \frac{\textit{error of measurement}}{\textit{distanced measured}}$$

- For example, if a distance of 4200 feet is measured and the error is estimated as 0.7 feet, then the precision is:

$$\frac{0.7}{4200} = \frac{1}{6000}$$

Probability

- **Surveying measurements tend to follow a normal distribution or “bell” curve**
  - **Observations**
    - ***Small errors occur more frequently than larger ones***
    - ***Positive and negative errors of the same magnitude occur with equal frequency***
    - ***Large errors are probably mistakes***

Most Probable Value (MPV)

Also known as the arithmetic mean or average value

$$\mathbf{MPV = \frac{\sum M}{n}}$$

The MPV is the sum of all of the measurements divided by the total number of measurements

Standard Deviation (σ)

Also known as the Standard Error or Variance

$$\sigma^2 = \frac{\sum(M-MPV)}{n-1}$$

M-MPV is referred to as the Residual

σ is computed by taking the square root of the above equation

Example:

A distance is measured repeatedly in the field and the following measurements are recorded: 31.459 m, 31.458 m, 31.460 m, 31.854 m and 31.457 m. Compute the most probable value (MPV), standard error and standard error of the mean for the data. Explain the significance of each computed value as it relates to statistical theory.

Solution:

Measurement	$M - M_{bar}$	$(M-M_{bar})^2$
31.459	0	0
31.458	-0.0010	0.0000010
31.460	0.0010	0.0000010
31.457	-0.0020	0.0000040
Sum = 125.834		0.0000060

MPV or M_{bar} = 125.834 / 4 = 31.459 m

Solution (continued):

S.E. = $\pm$ $((0.0000060)/(4-1))^{1/2}$ = +/- 0.0014 m

Say +/- 0.001 m

$E_m = 0.001/(4)^{1/2}$ = +/- 0.0005 m

Say +/- 0.001 m

Explanation:

The MPV is 31.459 m. The value that is most likely to occur. This value represents the peak value on the normal distribution curve.

The standard error is +/- 0.001 m . 68.27% of the values would be expected to lie between the values of 31.458 m and 31.460 m. These values were computed using the MPV +/- the standard error.

Explanation (continued):

The standard error of the mean is +/- 0.001 m . The "true" length has a 68.27% chance of being within the values of 31.458m and 31.460 m. These values were computed using the MPV +/- E_m.