

Average part measurements = Summarize, represent, and interpret data on a single count or measurement variable

Program Task: Develop a Quality Control Plan.

PA Core Standard: CC.2.4.HS.B.1

Program Associated Vocabulary:
AVERAGE, SAMPLING, SPC

Description: Summarize, represent, and interpret data on a single count or measurement variable.

Math Associated Vocabulary
MEASURE OF CENTRAL TENDENCY, MEAN, AVERAGE, MEDIAN, MODE

Program Formulas and Procedures:
In SPC (Statistical Process Control) the average of the dimensions from a sample of a machining operation is plotted on a graph called an X-Bar chart. This is done at certain time intervals to track the consistency of part sizes.

Math Formulas and Procedures:
To calculate the **mean** or **average**, add the numbers and divide by the number of given values.

To determine an average use the following formula:

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n}$$

$$\text{Average} = \frac{(x_1 + x_2 + \dots + x_n)}{n}$$

To find the **median**, list the numbers in order from least to greatest and find the middle number. If there are two middle numbers then find the average of the two numbers.

x = size of each sample
n = number of samples

The **mode** is the number that appears most often. A set of data can have more than one mode or no mode.

Example:
A CNC milling operation machines 35 jet engine turbines each hour. The sampling plan requires inspection of a .3935 ± .001 dimension of four parts every hour.

Example:
The following are a student's quiz scores for the quarter: 0, 0, 70, 75, 77, 78, 80, 90, 100, and 100. Find the mean, median, and mode. Determine the measure of central tendency of that would best describe this student's performance in the class this quarter.

Three samplings give the following dimensions:

Calculate the mean.

$$\bar{x} = \frac{0 + 0 + 70 + 75 + 77 + 78 + 80 + 90 + 100 + 100}{10}$$

S ₁	S ₂	S ₃
.3928	.3936	.3939
.3933	.3937	.3945
.3932	.3939	.3943
.3927	.3940	.3945

$$\bar{x} = \frac{670}{10} \rightarrow \bar{x} = 67$$

Find the average of each sampling.
S₁ = (.3928 + .3933 + .3932 + .3927) ÷ 4 = .3930
S₂ = (.3936 + .3937 + .3939 + .3940) ÷ 4 = .3938
S₃ = (.3939 + .3945 + .3943 + .3945) ÷ 4 = .3943

The mean of the set of data is 67.

Maximum Limit = .3935 + .001 = .3945
Minimum Limit = .3935 - .001 = .3925

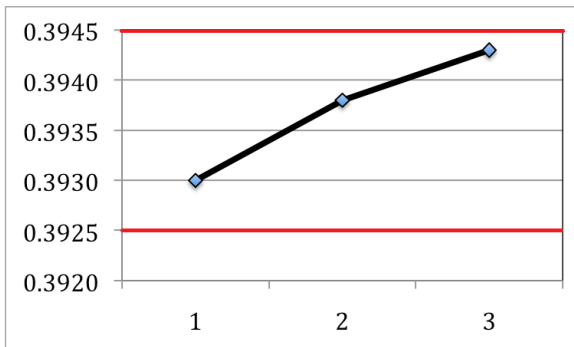
Calculate the median.
0, 0, 70, 75 77, 78, 80, 90, 100, 100
4 values 4 values

To find the median find the average of 77 and 78.

The values can be plotted on the X-Bar Chart to show trends. Note that in this machining operation the size is approaching the maximum limit.

$$\bar{x} = \frac{77 + 78}{2} = 77.5$$

The median is 77.5.



Calculate the mode.
There are 2 modes 0 and 100.

In this case, the median best represents the student's performance for the quarter.

Instructor’s Script – Comparing and Contrasting

Studying statistics is very useful in business and industry. These Machine Tool Technology examples show where the tool of mean or average is used in this industry. The mean is a very popular measure of central tendency and is often the best representation of the data. In another t-chart you will learn how outliers affect measures of central tendency and this may be one reason that the mean may be skewed, and not be the best measure of central tendency.

Common Mistakes Made By Students

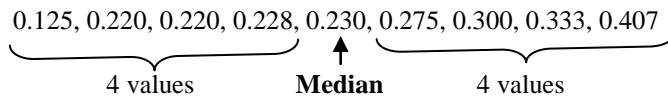
- In calculating measures of central tendency, often students make calculation errors or divide by the wrong number when calculating the mean.
- When finding the mode, students often stop after finding one mode when there may be multiple modes.

Example:

The High School baseball teams starters batting averages are: 0.125, 0.220, 0.228, 0.300, 0.333, 0.407, 0.275, 0.230, and 0.220. Find the mean, median and mode of the set of data. Compare the three values.

$$\bar{x} = \frac{0.125 + 0.220 + 0.228 + 0.300 + 0.333 + 0.407 + 0.275 + 0.230 + 0.220}{9}$$

Rounding the mean to the thousandths place gives a batting average of 0.260.



The median of the data is 0.230.

The mode is 0.220.

In this case all three values are within 0.040 of each other. None of the three measures of central tendency are extremely different than the others. The mode of 0.220 is lower than the others and the mean is affected by the high batting average of 0.407.

CTE Instructor’s Extended Discussion

Averaging can be used in countless machining applications. If a part size needs to be determined from existing parts or features, averaging the part or feature sizes can be a good method.

Rates for production machining operations can be averaged from different workers, machines, shifts, plants, and departments to help in scheduling time.

Averaging costs is also common for planning.

Many GD&T specifications including circularity, position, concentricity, parallelism, and even diameters are inspected with a CMM using averages.

Regardless of the application of averaging, keep in mind that larger sample sizes result in more accurate representations of the whole.

Problems	Career and Technical Math Concepts	Solutions															
<p>1. Average the following samplings:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">S₁</th> <th style="text-align: center;">S₂</th> <th style="text-align: center;">S₃</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">.683</td> <td style="text-align: center;">.685</td> <td style="text-align: center;">.683</td> </tr> <tr> <td style="text-align: center;">.685</td> <td style="text-align: center;">.686</td> <td style="text-align: center;">.684</td> </tr> <tr> <td style="text-align: center;">.684</td> <td style="text-align: center;">.686</td> <td style="text-align: center;">.686</td> </tr> <tr> <td style="text-align: center;">.685</td> <td style="text-align: center;">.683</td> <td style="text-align: center;">.685</td> </tr> </tbody> </table>	S ₁	S ₂	S ₃	.683	.685	.683	.685	.686	.684	.684	.686	.686	.685	.683	.685		
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<p>2. You need to machine a replacement cover plate for a gearbox and the customer says to use the average hole size for the mounting holes. The sizes are: .783, .788, .785, .783, .786, .783, .786, and .784. What size will you make the holes?</p>																	
<p>3. You and five other students are milling 1” square aluminum blocks for a class project. You can mill 15 per session. The other students can mill 10, 12, 14, 14, and 16 per session. What is the average count per student per session? If the goal is to make 100 daily, how many students should work on the project?</p>																	
Problems	Related, Generic Math Concepts	Solutions															
<p>Use the following data for questions four through six: A company has 11 employees. The following is a list of their salaries \$30k, \$30k, \$25k, \$40k, \$48k, \$42k, \$47k, \$50k, \$750k, \$900k, \$25k.</p> <p>4. What is the mean salary to the nearest dollar?</p>																	
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<p>Use the following data for questions seven through nine: A shoe company has recorded size for the last 20 pairs of men’s shoes they have sold. The following is a list of the sizes 11, 11, 11½, 12, 11, 11, 11½, 11, 14, 10, 12½, 10, 11, 11, 11½, 9, 11 ½, 12 ½, 12, 12, and 12.</p> <p>7. What is the mean?</p>																	
<p>8. What is the median for the shoe sizes in #7?</p>																	
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<p>3. You and five other students are milling 1" square aluminum blocks for a class project. You can mill 15 per session. The other students can mill 10, 12, 14, 14, and 16 per session. What is the average count per student per session? If the goal is to make 100 daily, how many students should work on the project?</p>		$N = (15 + 10 + 12 + 14 + 14 + 16) \div 6 = 13.5$ $100 \div 13.5 = 7.4$ <p>If eight students work on the project, the goal should be met.</p>															
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<p>4. What is the mean salary to the nearest dollar?</p>																	
<p>5. What is the median salary for the employees in #4?</p>		<p><u>25k, 25k, 30k, 30k, 40k, 42k, 47k, 48k, 50k, 750k, 900k</u></p> <p>The median salary is \$42,000.</p>															
<p>6. What is the mode salary and what is the best measure of central tendency for the employees in #4?</p>		<p>There are 2 modes \$25,000 and \$30,000.</p> <p>The median is the best measure of central tendency for this data set.</p>															
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