Automotive Technology (47.0604) T-Chart

Compute costs for shop operations = **Summarize, represent, and interpret data on a single count or measurement variable**

Program Task: Compute costs for shop operations.

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

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

Program Associated Vocabulary:
SPECIFICATIONS, DATA COLLECTION AND INTERPRETATION, MEAN, MEDIAN, MODE, AVERAGE

Math Associated Vocabulary: STEM-AND-LEAF PLOT, BOX-AND-WHISKER PLOT, MEDIAN, RANGE, INTERQUARTILE RANGE (IQR)

Formulas and Procedures:
STEM-AND-LEAF PLOT: shows how data is distributed.
BOX-AND-WHISKER PLOT: divides data into four parts. The median divides that data into a lower half and an upper half.
MEDIAN**:** is a set of data is the middle value when the values are written in increasing order.
RANGE: from the set of data, is the difference between the greatest and the least value.
The INTERQUARTILE RANGE (IQR) of a set of a data is a measure of the spread of the middle 50% of the data. The median of the lower half of the values is called the lower quartile. The median of the upper half is called the upper quartile. The IQR is the difference between the upper and lower quartiles.

Program Formulas and Procedures:
Example: To lower costs, the owner/principal of a new car dealership has instructed the service manager to track the number of flat-rate hours each service technician is producing. Any technician not making their "guarantee" (minimum of 40-hours a week) will be terminated. How many technicians are about to lose their jobs? Six months of data yields the following Flat-Rate Hours for 15 technicians:

35, 36, 38, 40, 42, 42, 44, 45, 45, 47, 48, 49, 50, 50, 50

1. Writing the data in numerical order
   35, 36, 38, 40, 42, 42, 44, 45, 45, 47, 48, 49, 50, 50, 50
2. Separate each number into a stem and a leaf. Since these are two digit numbers, the tens digit is the stem and the units digit is the leaf.

Stem	Leaf
3	8

3. Group the numbers with the same stems. List the stems in numerical order.

Flat-Rate Hours

Stem	Leaf
3	5 6 8
4	0 2 2 4 5 5 7 8 9
5	0 0 0

4. Prepare an appropriate legend (key) for the graph.

Key: 4|6 = 46
Leaf Unit: one's place
Stem Unit: ten's place

3 technicians are under the minimum flat-rate hours of 40 hours

Example:
Here is the sorted set of data values:

44 46 47 49 63 64 66 68 68 72 72 75 76 81 84 88 106

a. Identify the smallest and largest data values in the set.
   44 and 106
b. Determine the value to use for the stem. Write the stems in a column from least to greatest.
c. Draw a vertical line to the right of the stems.
d. Write the leaves in increasing order to the right of their stems.
e. Write an explanation (key) for the data.

It is important that each stem is listed only once and that no numbers are skipped, even if it means that some stems have no leaves. The leaves are listed in increasing order in a row to the right of each stem.

4	4 6 7 9
5	
6	3 4 6 8 8
7	2 2 5 6
8	1 4 8
9	
10	6

Key: 4|6 = 46
Leaf Unit: one's place
Stem Unit: ten's place

Instructor's Script – Comparing and Contrasting

Stem-and-leaf plots are not used often, but can be quite useful to organize data and quickly produce a "picture" of a set of measurements that provides a sense of the range, mode, and mean.

Stem-and-leaf plots used side-by-side can even reveal a trend in data.

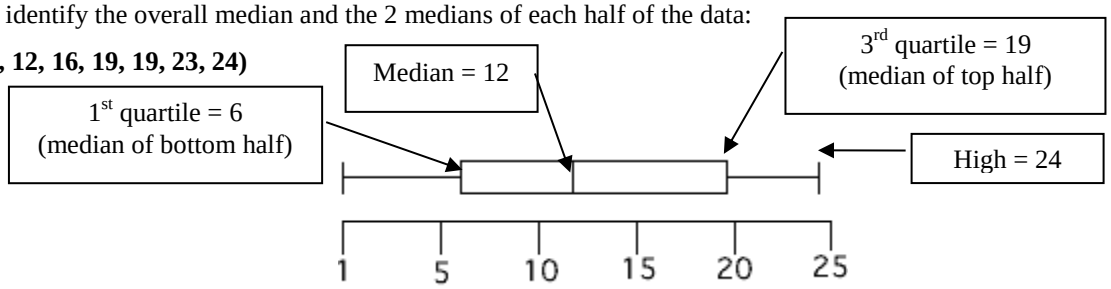
Washer Thickness (mm) **3.0 | 2 = 3.02** Weekly sampling data reveals a worsening problem

Week 1 Samples		Week 2 Samples		Week 3 Samples	
2.8	8	2.8	6 8 9	2.8	4 5 8 8 9
2.9	3 4 7 7 9	**(mode)** 2.9	1 3 3 5 6 8 9	**(mode)** 2.9	1 1 2 3 5 5 6 8 8
(mode) 3.0	1 1 2 4 6 7	3.0	1 2 2 6 7 7	3.0	2 3 3 7
3.1	2 2 4 5	3.1	3 2	3.1	
3.2	3 4	3.2		3.2	

When setting up stem-and-leaf plots, think of the stem side as the portion of the data that does not change very often, while the leaf side contains the portion of each measurement that does change often.

Box-and-Whisker Plots are another way to effectively show measurement data in a way that contains a lot of information about underlying data (range, median, highest, lowest, quartiles). The key to building box-and-whisker plots is to sort the data, identify the highest and lowest, and then identify the overall median and the 2 medians of each half of the data:

Data: (1, 4, 6, 6, 9, 12, 16, 19, 19, 23, 24)



Visually, a box-and-whisker plot can provide clues about the range of all the data (lowest to highest), the median, and the range of the middle 50% of the data (boxed area between 1st and 3rd quartiles).

Common Mistakes Made By Students

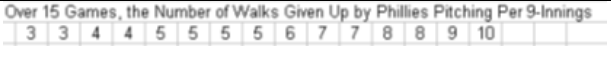
- Rounding data for stem and leaf plots so you work with only a few significant digits (32,761 and 33,124 should be shown on a stem-and-leaf as 32,700 and 33,100).
- Not using the provided key to interpret stem-and-leaf plots
- Using mean instead of median in box-and-whisker plots

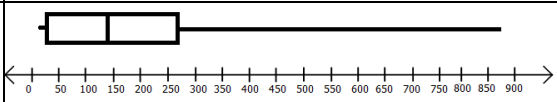
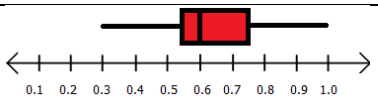
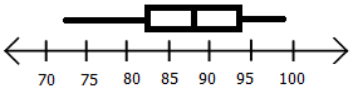
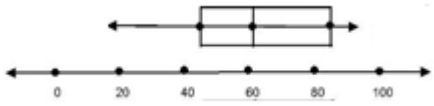
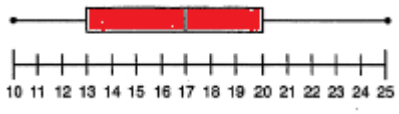
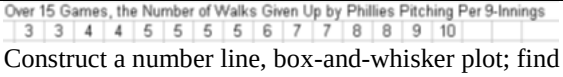
Not "splitting the difference" when finding the median between two measurements (the median of { 1, 2, 3, 4 } is halfway between 2 and 3, or 2.5.

CTE Instructor's Extended Discussion

Technical tasks are usually not presented using this model. Therefore, it is important that technical instructors demonstrate to students how these math concepts link to and are relevant in their technical training and that the math is presented in a way which shows a relationship to the math CTE students use in their academic school settings.

The interquartile range (IQR) is the difference between the upper quartile and the lower quartile. In our example the IQR = 19 - 6 = 13. The IQR is a very useful measurement. It is useful because it is less influenced by extreme values; it limits the range to the middle 50% of the values.

Problems	Career and Technical Math Concepts	Solutions
1. A V-8 engine is running rough (missing). The service manual recommends a cylinder compression balance test. These are the compression readings: 110, 120, 122, 115, 90, 113, 112, & 122. Organize the data and create a stem plot. Be sure to include a Key, Leaf Unit & Stem Unit.		
2. The amounts (rounded) of the daily Repair Orders are $180, $220, $875, $25, $280, $255, $290, $410, $25, $25, $25, $80, $25, $65, $175, $100, $110, $15, $625 & $240. Write the data in increasing order then construct a number line, box-and-whisker plot and find the median, the lower quartile, the upper quartile & the IQR of the provided data.		
3. The voltage drop for the fuel injectors on a V-8 engine are: .0.3, 0.5, 0.6, 0.6, 0.6, 0.7, 0.8 & 1.0 Volts. What range of values contains the middle 50% of the data?		
Problems	**Related, Generic Math Concepts**	**Solutions**
4. The travel times (in minutes) for 11 students on a school bus are 15, 12, 8, 22, 17, 6, 13, 24, 11, 27 & 7. Display the data using a stem-and-leaf plot.		
5. The scores on a test in your science class are 85, 90, 72, 95, 93, 87, 88, 80, 78, 99, 96, 92, 86. Write the data in increasing order then construct a number line, box-and-whisker plot and find the median, the lower quartile, the upper quartile & the IQR of the provided data.		
6. The following set of numbers are the amount of marbles 13-different boys own (they are arranged from least to greatest). 18, 27, 34, 52, 54, 59, 61, 68, 78, 82, 85, 87, 91. Construct a number line, box-and-whisker plot and find the median, the lower quartile, the upper quartile & the IQR of the provided data.		
Problems	**PA Core Math Look**	**Solutions**
7. This data shows the average wind speeds (in miles per hour) in California during a 15 day period January: 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 7.3, 5.0, 5.3, 6.5, 6.8, 7.9, 7.1, 5.4 & 6.6. Organize the data and create a stem plot.		
8. Look at the box-and-whisker plot below. What range of contains the middle 50% of the data?		
9.  Construct a number line, box-and-whisker plot; find the median, the LQ, UQ & IQR of the provided data.		

Problems	Career and Technical Math Concepts	Solutions
1. A V-8 engine is running rough (missing). The service manual recommends a cylinder compression balance test. These are the compression readings: 110, 120, 122, 115, 90, 113, 112, & 122. Organize the data and create a stem plot. Be sure to include a Key, Leaf Unit & Stem Unit.	**Compression Readings** Stem | Leaf 9 | 0 10 | 11 | 0 2 3 5 12 | 0 2 2	Key 10|5 = 105 Leaf Unit = 1.0 Stem Unit – 10.0
2. The amounts (rounded) of the daily Repair Orders are $180, $220, $875, $25, $280, $255, $290, $410, $25, $25, $25, $80, $25, $65, $175, $100, $110, $15, $625 & $240. Write the data in increasing order then construct a number line, box-and-whisker plot and find the median, the lower quartile, the upper quartile & the IQR of the provided data.		Median: 142.5 Lower Quartile: 25 Upper Quartile: 267.5 Range: 860 Mode: 25 IQR: 242.5
3. The voltage drop for the fuel injectors on a V-8 engine are: .0.3, 0.5, 0.6, 0.6, 0.6, 0.7, 0.8 & 1.0 Volts. What range of values contains the middle 50% of the data?		Median: 0.6 Lower Quartile: 0.55 Upper Quartile: 0.75 Range: 0.70 IQR: 0.20
Problems	**Related, Generic Math Concepts**	**Solutions**
4. The travel times (in minutes) for 11 students on a school bus are 15, 12, 8, 22, 17, 6, 13, 24, 11, 27 & 7. Display the data using a stem-and-leaf plot.	**Travel Time** Stem | Leaf 0 | 6 7 8 1 | 1 2 3 5 7 2 | 2 4 7	Key 2|5 = 25 Leaf Unit = 1.0 Stem Unit – 10.0
5. The scores on a test in your science class are 85, 90, 72, 95, 93, 87, 88, 80, 78, 99, 96, 92, 86. Write the data in increasing order then construct a number line, box-and-whisker plot and find the median, the lower quartile, the upper quartile & the IQR of the provided data.		Median: 88 Lower Quartile: 82.5 Upper Quartile: 94 Range: 27 Mode: none IQR: 11.5
6. The following set of numbers are the amount of marbles 13-different boys own (they are arranged from least to greatest). 18, 27, 34, 52, 54, 59, 61, 68, 78, 82, 85, 87, 91. Construct a number line, box-and-whisker plot and find the median, the lower quartile, the upper quartile & the IQR of the provided data.		Median: 61 Lower Quartile: 43 Upper Quartile: 83.5 Range: 73 IQR: 40.5
Problems	**PA Core Math Look**	**Solutions**
7. This data shows the average wind speeds (in miles per hour) in California during a 15 day period January: 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 7.3, 5.0, 5.3, 6.5, 6.8, 7.9, 7.1, 5.4 & 6.6. Organize the data and create a stem plot.	**Wind Speed** Stem | Leaf 5 | 0 0 3 4 5 6 | 0 5 5 6 8 7 | 0 1 3 5 9	Key 2|5 = 2.5 Leaf Unit = 0.1 Stem Unit – 1.0
8. Look at the box-and-whisker plot below. What range of contains the middle 50% of the data?		
9.  Construct a number line, box-and-whisker plot; find the median, the LQ, UQ & IQR of the provided data.