MATHEMATICS II – Unit #4
Data Analysis and Probability/Statistics

Day 1	
E. Q. –	How do I calculate the mean and standard deviation and use these measures to compare data sets?
Standard –	MM2D1. Using sample data, students will make informal references about population means and standard deviations. b. Understand and calculate the means and standard deviations of sets of data. c. Use means and standard deviations to compare data sets.
Opening –	**<u>Warm Up:</u> Find the mean. Draw a box and whisker graph and label the lower quartile and upper quartile, and explain how to find the interquartile range** Height (in inches) of selected students in a class: 58, 61, 66, 60, 68, 65, 64, 67, 70, 60 **<u>Mini lesson</u>** • *<u>Frayer Model of Vocabulary words</u>*: Review mean and interquartile range (IQR). • Introduce the following symbols: $\sum$, $\bar{x}$, σ, σ^2 • Model, define, and explain new vocabulary: variance and standard deviation by working "Work Session Lesson 1" problems 1 & 2
Work session –	Students work in pairs on "*<u>Work Session Lesson 1</u>*" problems 3 & 4
Closing –	Student pairs are selected to share how they found their answers with the whole class. *<u>Ticket out the door</u>* – match formulas with statistical terms

Frayer Model for MEAN

Definition	Formula
MEAN	
Example	Your Example

Frayer Model for INTERQUARTILE RANGE (IQR)

Definition	Formula
INTERQUARTILE RANGE	
Example	Your Example

Frayer Model for VARIANCE

Definition

Formula

VARIANCE

Example

Your Example

Frayer Model for STANDARD DEVIATION

Definition

Formula

STANDARD DEVIATION

Example

Your Example

Math 2 Unit 4
Lesson 1

Name ______________________
Date ________________________
Period ________

Find the mean, median, variance, standard deviation, and interquartile range of each data set. Show your work.

OPENING

1.) 6, 22, 4, 15, 14, 8, 8

Mean = ____________________

Median = ___________________

Variance (σ^2) = ______________

Standard Deviation (σ) = ____________

Interquartile Range (IQR) = __________

2.) 10, 15, 12, 20, 25, 22, 29

Mean = ____________________

Median = ___________________

Variance (σ^2) = ______________

Standard Deviation (σ) = ____________

Interquartile Range (IQR) = __________

3.) 100, 150, 100, 130, 125, 135

Mean = ____________________

Median = ___________________

Variance (σ^2) = ______________

Standard Deviation (σ) = ____________

Interquartile Range (IQR) = __________

4.) 15, 11, 18, 14, 14, 13, 17, 18

Mean = ____________________

Median = ___________________

Variance (σ^2) = ______________

Standard Deviation (σ) = ____________

Interquartile Range (IQR) = __________

Work Session Lesson 1
Teacher Notes/Answer Key

Typically, mean answers were rounded to the nearest hundredth and variance/standard deviation answers to the nearest thousandth if the answer was not a terminating decimal.

1.) 6, 22, 4, 15, 14, 8, 8 → 4, 6, 8, 8, 14, 15, 22

Mean = 77 ÷ 7 = 11

Standard Deviation = 5.831

Median = 8

IQR = 15 – 6 = 9

Variance = 34

2.) 10, 15, 12, 20, 25, 22, 28 → 10, 12, 15, 20, 22, 25, 29

Mean = 133 ÷ 7 = 19

Standard Deviation = 6.459

Median = 20

IQR = 25 – 12 = 13

Variance = 41.714

3.) 100, 150, 100, 130, 125, 135 → 100, 100, 125, 130, 135, 150

Mean = 740 ÷ 6 = 123.33

Standard Deviation = 18.181

Median = (125 + 130)÷ 2 = 127.5

IQR = 135 – 100 = 35

Variance = 1983,3334 ÷ 6 = 330.556

4.) 15, 11, 19, 14, 14, 13, 17, 18 → 11, 13, 14, 14, 15, 17, 18, 18

Mean = 120 ÷ 8 = 15

Standard Deviation = 2.525

Median = (14 + 15) ÷ 2 = 14.5

IQR = 17.5 – 13.5 = 4

Variance = 51 ÷ 8 = 6.375

Math 2 DAY 1 Name ________________________________
Unit 4 TICKET OUT THE DOOR

Match the formula to the correct term by drawing a line.

1. Interquartile Range	A. $s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$
2. Mean	B. $\bar{x} = \frac{\sum x}{n}$
3. Standard Deviation	C. $\sigma^2 = \frac{\Sigma (X - \mu)^2}{N}$
4. Variance	D. $Q_3 - Q_1$

Math 2 DAY 1 Name ________________________________
Unit 4 TICKET OUT THE DOOR

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Day 2	
E. Q. –	How do I calculate the mean and standard deviation and use these measures to compare data sets?
Standard –	MM2D1. Using sample data, students will make informal references about population means and standard deviations. b. Understand and calculate the means and standard deviations of sets of data. c. Use means and standard deviations to compare data sets.
Opening –	**<u>Warm-up:</u>** Write the formulas using new symbols for mean, interquartile range, variance, and standard deviation. **<u>Mini Lesson:</u>** • Have students reference their Frayer Model sheets for vocabulary from Lesson 1. • Using "*Statistical Practice*" Worksheet, model problem 1.
Work session –	Students work in pairs on "Statistical Practice" Worksheet problems 2,3,4
Closing –	Students explain their work to the whole class. Homework: *Outliers and Central Tendency*

DAY 2
STATISTICAL PRACTICE

NAME ______________________
DATE ______________________
PERIOD ______

OPENING

Definitions Review
Write the formula or explain how to find each of the following statistical measures:

MEAN	MEDIAN	MODE	RANGE
VARIANCE	STANDARD DEVIATION	INTERQUARTILE RANGE	

The following problems are adapted from Basic Statistical Analysis, 7th Edition, by Richard C. Sprinthall. Compute each of the seven statistical measures for each set of data.

1.) A group of seven university students was randomly selected and asked to indicate the number of study hours each put in before taking a major exam. The data are as follows:

Student	Hours of Study
1	40
2	30
3	35
4	5
5	10
6	15
7	25

WORK SESSION

2.) The grade-point averages for the seven university students selected above were computed. The data are as follows:

Student	GPA
1	3.75
2	3.00
3	3.25
4	1.75
5	2.00
6	2.25
7	3.00

3.) A researcher investigating a new product for clearing up acne selects a random sample of 10 teenagers, gives them the facial product to use and asks them to report back how many days it took for the facial condition to clear up.
The results (in days) were as follows: 20, 8, 10, 14, 15, 14, 12, 11, 14, 13.

4.) A clinical psychologist is interested in assessing the prevalence of MDD (Major Depressive Disorders) among a group of fourth-grade students. A random sample of 13 students was selected and given the Children's Depression Inventory (CDI), a self-report instrument that measures levels of depression. Scores above 13 are said to indicate a major depressive disorder.
The scores were as follows: 8, 10, 11, 7, 13, 4, 8, 7, 9, 3, 15, 10, 10.

STATISTICAL PRACTICE
TEACHER NOTES/ANSWER KEY

Note: The emphasis of Math 2 is on using means and standard deviations, but the students were exposed to median, quartiles, and interquartile range in Math 1 (MM1D3a). They had previously also dealt with mean, median and mode in 7th grade (M7D1c) as well as range, quartiles, and interquartile range (M7D1d). It is the teacher's discretion whether to compute every statistical measure or whether to focus only on those emphasized in Math 2.

1.) Data were: 40, 30, 35, 5, 10, 15, 25 → 5, 10, 15, 25, 30, 35, 40

Mean = 160 ÷ 7 = 22.86

Median = 25

Mode = no mode

Range = 40 – 5 = 35

Variance = 1042.8572 ÷ 7 = 148.9796

Std. Dev. = 12.206

IQR = 35 – 10 = 25

2.) Data were: 3.75, 3.00, 3.25, 1.75, 2.00, 2.25, 3.00
→ 1.75, 2.00, 2.25, 3.00, 3.00, 3.25, 3.75

Mean = 19 ÷ 7 = 2.71

Median = 3.00

Mode = 3.00

Range = 3.75 – 1.75 = 2.00

Variance = 3.1787 ÷ 7 = 0.4541

Std. Dev. = 0.6739

IQR = 3.25 – 2.00 = 1.25

3.) Data were: 20, 8, 10, 14, 15, 14, 12, 11, 14, 13.
→ 8, 10, 11, 12, 13, 14, 14, 14, 15, 20

Mean = 131 ÷ 10 = 13.1

Median = (13 + 14) ÷ 2 = 13.5

Mode = 14

Range = 20 – 8 = 12

Variance = 94.9 ÷ 10 = 9.49

Std. Dev. = 3.081

IQR = 14 – 11 = 3

4.) Data were: 8, 10, 11, 7, 13, 4, 8, 7, 9, 3, 15, 10, 10.
→ 3, 4, 7, 7, 8, 8, 9, 10, 10, 10, 11, 13, 15

Mean = 115 ÷ 13 = 8.85

Median = 9

Mode = 10

Range = 15 – 3 = 12

Variance = 129.6925 ÷ 13 = 9.9763

Std. Dev. = 3.159

IQR = 10.5 – 7 = 3.5

DAY 2 HOMEWORK

Outliers and Central Tendency

Connect to Prior Learning The puzzle below can be used as a way to review finding measures of central tendency and the effect of an outlier on the measures of central tendency.

A 6	E 15	I 9	L 5.5	M 2.5
N 7	R 17	S 5.75	T 4.3	Y 7

__ __'__ __ __ __ __ __ __ __ __ __ __.
3 4 7 5 8 5 10 5 9 4 2 6 1

Questions to Start the Lesson
In Questions 1–10, use the data set to answer the questions. Then find the corresponding letter in the table to the left to answer the riddle.

What did Watson say to Holmes?

2, 3, 4, 5, 6, 8, 9, 9, 17

1. Find the mean.
2. Find the median.
3. Find the mode.
4. Find the standard deviation.
5. Find the range.
6. Which value is an outlier?

In Questions 7–11, find the measures of central tendency after removing the outlier.

7. Find the mean.
8. Find the median.
9. Find the range.
10. Find the standard deviation.

Day 3	
E. Q. –	How do I calculate the mean and standard deviation and use these measures to compare data sets?
Standard –	MM2D1. Using sample data, students will make informal references about population means and standard deviations. b. Understand and calculate the means and standard deviations of sets of data. c. Use means and standard deviations to compare data sets.
Opening –	Warm Up: Write two sentences using the word "deviation". How would you define "deviation"? Mini lesson: Work and explain the OPENING on ***Performance Task 1***
Work session –	Students work in groups of 3 on the WORK SESSION on ***Performance Task 1***
Closing –	Students share out and explain their answers to ***Performance Task 1.*** Students review the vocabulary: Mean deviation, Variance, and Standard Deviation.

Day 3

Mathematics II Unit 4 **Performance Task 1**

Name____ **Date**________________

OPENING

Your teacher has a problem and needs your input. She has to give one math award this year to a deserving student, but she can't make a decision. Here are the test grades for her two best students:

Bryce: 90, 90, 80, 100, 99, 81 98, 82

Brianna: 90, 90, 91, 89, 91, 89, 90, 90

Write down which of the two students should get the math award and discuss why they should be the one to receive it.

Calculate the **mean** ($\overline{X}$) of Bryce's distribution.

Calculate the mean deviation, variance, and standard deviation of Bryce's distribution.
Fill out the table to help you calculate them by hand.

X_i for Bryce	$X_i - \overline{X}$	$\lvert X_i - \overline{X} \rvert$	$(X_i - \overline{X})^2$
90			
90			
80			
100			
99			
81			
98			
82			
Σ			

Mean deviation for Bryce:

$$\text{mean deviation}: \frac{\sum_{i=1}^{n} \left| X_i - \overline{X} \right|}{n}$$

Variance for Bryce:

$$\text{variance}: \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n}$$

Standard deviation for Bryce:

$$\text{standard deviation}: \sqrt{\frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n}}$$

What do these measures of spread tell you?

WORK SESSION

Calculate the **mean** (X) of Brianna's distribution.

Calculate the mean deviation, variance, and standard deviation of Brianna's distribution.
Fill out the table to help you calculate them by hand.

X_i for Brianna	$X_i - \bar{X}$	$\lvert X_i - \bar{X} \rvert$	$(X_i - \bar{X})^2$
90			
90			
91			
89			
91			
89			
90			
90			
Σ			

Mean deviation for Brianna:

$$\text{mean deviation}: \frac{\sum_{i=1}^{n} \lvert X_i - \bar{X} \rvert}{n}$$

Variance for Brianna:

$$\text{variance}: \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n}$$

Standard deviation for Brianna:

$$\text{standard deviation}: \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n}}$$

What do these measures of spread tell you?

CLOSING

Students share their answers with whole class.

Day 4	
E. Q. –	How do I calculate the mean and standard deviation and use these measures to compare data sets?
Standard –	MM2D1. Using sample data, students will make informal references about population means and standard deviations. b. Understand and calculate the means and standard deviations of sets of data. c. Use means and standard deviations to compare data sets.
Opening –	**Warm Up:** What positions are on a baseball team? **Mini lesson:** • Review Mean, Variance, Mean Deviation and Standard Deviation using a matching game at the board. Place the vocabulary on one set of colored paper, formulas on another color of paper and definitions on another color of paper. You could place symbols for mean, standard deviation, and variance on another colored paper. Place magnetic tape on the back of each. Place vocabulary words on one side of white board and place definitions and formulas randomly on the other side of the white board. Choose students to come up and select either a definition or formula and place it by the correct word. • Explain the instructions to the *Supplemental Activity: Baseball Teams 1994 Salaries*
Work session –	Students work in groups of 2 or 3 on the "*Supplemental Activity: Baseball Team 1994 Salaries*"
Closing –	Students share and explain their solutions to whole class. Do you think athletes should make this much money? Why or why not?

Math 2 Unit 4
Day 4 Supplemental Activity: Baseball Team 1994 Salaries

Teacher Instructions

1. Have students work in groups. Provide students with calculators.

2. Each group should pick two baseball teams.

3. Each group fills out an activity sheet on each team filling in the data and finding the mean, variance, and standard deviation for each team's salaries. After analyzing the data, each group should write a brief paragraph comparing and contrasting the statistical data and the real world conclusions that can be drawn from the data.

4. Groups share their findings with the class as a conclusion.

1994 Atlanta Braves

Tom Glavine	4,750,000
Greg Maddux	4,000,000
Jeff Blauser	3,750,000
Fred McGriff	3,750,000
John Smoltz	3,250,000
Terry Pendleton	3,200,000
David Justice	3,200,000
Deion Sanders	2,916,667
Steve Avery	2,800,000
Mike Stanton	1,400,000
Kent Mercker	1,225,000
Mark Lemke	1,100,000
Rafael Belliard	800,000
Steve Bedrosian	750,000
Dave Gallagher	700,000
Bill Pecota	575,000
Charlie O'Brien	550,000
Gregg Olson	500,000
Greg McMichael	245,000
Mark Wohlers	180,000
Milt Hill	158,000
Mike Bielecki	150,000
Ryan Klesko	111,500
Tony Tarasco	111,500
Javier Lopez	111,500
Chipper Jones	109,000
Mike Kelly	109,000

1994 New York Yankees

Jimmy Key	5,250,000
Danny Tartabull	4,550,000
Don Mattingly	4,020,000
Paul O'Neill	3,833,334
Melido Perez	3,450,000
Terry Mulholland	3,350,000
Wade Boggs	3,100,000
Jim Abbott	2,775,000
Matt Nokes	2,500,000
Steve Howe	1,900,000
Mike Gallego	1,575,000
Xavier Hernandez	1,525,000
Luis Polonia	1,500,000
Randy Velarde	1,125,000
Pat Kelly	810,000
Jim Leyritz	742,500
Mike Stanley	512,500
Donn Pall	500,000
Daryl Boston	400,000
Paul Gibson	250,000
Jeff Reardon	250,000
Scott Kamieniecki	235,000
Bemie Williams	225,000
Rob Wickman	180,000
Gerald Williams	115,000
Sterling Hitchcock	112,000

1994 Oakland Athletics

Rickey Henderson	4,800,000
Ruben Sierra	4,700,000
Bob Welch	3,450,000
Bobby Witt	3,250,000
Mark McGwire	3,000,000
Terry Steinbach	2,800,000
Ron Darling	2,250,000
Mike Bordick	1,050,000
Stan Javier	600,000
Lance Blankenship	550,000
Edwin Nunez	430,000
Mike Aldrete	430,000
Todd Van Poppel	397,000
Troy Neel	225,000
Scott Hemond	210,000
Brent Gates	190,000
Scott Brosius	155,000
Billy Taylor	132,500
Steve Ontiveros	120,000
Junior Noboa	120,000
Steve Karsay	119,000
John Briscoe	114,000
Geronimo Berroa	109,000
Carios Reyes	109,000
Dave Righetti	109,000

1994 Chicago Cubs

Ryan Sandberg	5,975,000
Mark Grace	4,400,000
Randy Myers	3,583,333
Jose Guzman	3,500,000
Mike Morgan	3,375,000
Sammy Sosa	2,950,000
Steve Buechele	2,550,000
Shawon Dunston	2,375,000
Dan Plesac	1,700,000
Glenallen Hill	1,000,000
Willie Wilson	700,000
Jose Bautista	695,000
Rick Wilkins	350,000
Shawn Boskie	300,000
Derrick May	300,000
Mark Parent	250,000
Anthony Young	230,000
Rey Sanchez	225,000
Frank Castillo	225,000
Willie Banks	190,000
Karl Rhodes	145,000
Jim Bullinger	145,000
Steve Trachsel	112,000
Eddie Zambrano	112,000
Jose Hernandez	112,000
Jessie Hollins	109,000
Blalse Ilsley	109,000

1994 Houston Astros

Doug Drabek	4,250,000
Greg Swindell	3,750,000
Craig Bigglo	3,350,000
Pete Harnisch	3,205,000
Ken Caminiti	3,200,000
Steve Finley	3,050,000
Mitch Williams	2,500,000
Jeff Bagwell	2,400,000
Luis Gonzalez	1,630,000
Mike Felder	850,000
Darryl Kile	477,500
Tom Edens	475,000
Kevin Bass	400,000
Andujar Cedeno	340,000
Sid Bream	300,000
Eddie Taubensee	275,000
Scott Servais	272,500
Brian Williams	190,000
Chris Donnels	170,000
Andy Stankiewicz	138,000
Todd Jones	135,000
Braulio Castillo	120,000
Shane Reynolds	117,500
Mike Hampton	114,000
Tony Eusebio	114,000
James Mouton	109,000
Roberto Petagine	109,000

1994 Montreal Expos

Larry Walker	4,025,000
Marquis Grissom	3,560,000
Ken Hill	2,550,000
John Wetteland	2,225,000
Moises Alou	1,400,000
Mel Rojas	850,000
Randy Milligan	600,000
Darrin Fletcher	600,000
Jeff Fassero	315,000
Mike Lansing	200,000
Sean Berry	200,000
Wilfredo Cordero	200,000
Pedro Martinez	200,000
Freddie Benavides	195,000
Lenny Webster	180,000
Jeff Shaw	172,500
Tim Scott	165,000
Lou Frazier	140,000
Gil Heredia	135,000
Denis Boucher	135,000
Tim Spehr	132,000
Kirk Rueter	130,000
Rondell White	112,000
Cliff Floyd	109,500
Jeff Gardner	109,000

1994 St. Louis Cardinals

Gregg Jefferies	4,600,000
Bob Tewksbury	3,500,000
Ozzie Smith	3,000,000
Todd Zeile	2,700,000
Tom Pagnozzi	2,575,000
Jose Oquendo	2,150,000
Ray Lankford	1,650,000
Bernard Gilkey	1,635,000
Mark Whiten	1,008,334
Brian Jordan	846,667
Rich Rodriguez	700,000
Gerald Perry	650,000
Luis Alicea	650,000
Rob Murphy	600,000
Geronimo Pena	575,000
John Habyan	250,000
Rick Sutcliffe	250,000
Paul Kilgus	225,000
Mike Perez	200,000
Rheal Cormier	160,000
Rene Arocha	140,000
Vicente Palacios	140,000
Erik Pappas	140,000
Allen Watson	130,000
Stan Royer	130,000
Tom Urbani	130,000
Donovan Osbome	112,000
Terry McGriff	109,000

1994 Detroit Tigers

Cecil Fielder	4,237,500
Belcher	3,400,000
Mike Moore	3,333,334
Alan Trammell	3,000,000
Eric Davis	3,000,000
Lou Whitaker	2,783,333
David Wells	2,500,000
Bill Gullickson	2,400,000
Travis Fryman	2,400,000
Tony Phillips	2,366,667
Mickey Tettleton	1,833,334
Kirk Gibson	1,500,000
Mike Henneman	1,333,333
Bill Krueger	1,300,000
Chad Kreuter	1,000,000
Storm Davis	800,000
Joe Boever	800,000
Scott Livingstone	365,000
John Doherty	350,000
Junior Felix	350,000
Juan Samuel	300,000
Milt Cuyler	275,000
Mike Gardiner.	150,000
Chris Gomez	140,000
Danny Bautista	125,000

Activity Sheet- Analysis of Baseball Player's salaries

Please fill out one sheet per group for each team you select.

Group Members:

Baseball team:____

1. How many players are on the team?

2. What is the mean salary for players on this team?

3. Use the chart below to help you calculate the mean deviation, variance, and standard deviation of this team's salary distribution.

X_i (player salary)	$X_i - \bar{X}$	$\lvert X_i - \bar{X} \rvert$	$(X_i - \bar{X})^2$

Sum (Σ)			

The mean deviation:

$$\frac{\sum |X_i - \bar{X}|}{n}$$

Variance:

$$\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n}$$

Standard Deviation:

$$\sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n}}$$

4. Write a paragraph telling what you learned from the data and stating any conclusions you could draw from the data.

Day 5	
E. Q. –	How do I calculate the mean and standard deviation and use these measures to compare data sets?
Standard –	MM2D1. Using sample data, students will make informal references about population means and standard deviations. b. Understand and calculate the means and standard deviations of sets of data. c. Use means and standard deviations to compare data sets.
Opening –	**Warm Up:** Data: 4,2,8,4,6,1,3,7 Find mean and standard deviation. Show your work. **Mini lesson:** • Review definitions and symbols for variance and standard deviation. Use the *Graphic Organizer* for relationship between variance and standard deviation (*Brainstorming activity).* • Model ***Performance Task 2*** Problems 1 and 2 •
Work session –	Students work in pairs on ***Performance Task 2*** questions #3, 4, 5
Closing –	• Students share out answers from Work Session • Quiz: ***Performance Task 2*** (problems # 6, 7, 8) Students share their answers with whole class.

Day 5

Brainstorm on the similarities and differences between Variance and Standard Deviation

Similarities	Differences

Day 5
Mathematics II Unit 4 Performance Task 2
Name____________________________ Date__________________

OPENING

Review the definition of variance and standard deviation. Discuss the relationship between variance and standards deviation. Guide students through problem 1. (Teachers may use PowerPoint written for Day 1 as review.)

1. Create a set of 6 data points such that the variance and standard deviation is zero. Make a dotplot of the distribution.
Data points ____ , ____ , ____ , ____ , ____ , ____

2. Create a set of 6 data points such that the variance is four and the standard deviation is two and the mean is seven. Make a dotplot of the distribution.
Data Points ____ , ____ , ____ , ____ , ____ , ____

WORK SESSION

3. Create a set of 6 data points such that the variance and standard deviation is one. Make a dotplot of the distribution.
Data Points ____ , ____ , ____ , ____ , ____ , ____

4. Create a set of 6 data points such that the variance is four and the standard deviation is two. Make a dotplot of the distribution. (Accelerated Math II - - Create numbers that are not the same +/- every time.)
Data Points ____ , ____ , ____ , ____ , ____ , ____

5. Create a set of 6 data points such that the variance is sixteen and the standard deviation is four and the mean is ten. Make a dotplot of the distribution.
Data Points ____ , ____ , ____ , ____ , ____ , ____

CLOSING
Students share answers with the class.

Quiz: Students answer questions 6-8

Day 5 Quiz

Name____________________________________ Date___________________

6. Describe the process you used to come up with your answers.

7. What is the relationship between the standard deviation and variance?

8. What does the standard deviation measure?

Day 5 – Acceleration
Math 2 Unit 4
Lesson 3 Worksheet

NAME ___________________________
DATE ___________________________

1. A company that manufactures plastic tubes takes ten samples from one machine and ten samples from another machine. The outside diameter of each sample is measured with a digital caliper. The company's goal is to produce tubes that have an outside diameter of exactly 1 inch. The results of the measurements are shown below.

Machine 1: 1.000, 0.998, 1.001, 1.000, 0.997, 1.001, 1.002, 0.996, 0.998, 1.000

Machine 2: 0.997, 1.000, 0.998, 0.996, 1.000, 0.998, 1.000, 0.998, 1.001, 0.999

A. Find the mean diameter of the samples for each machine.
B. Find the standard deviation of the samples for each machine.
C. Which machine produces an average closest to the company's goal?
D. Which machine produces the more consistent diameter?
E. Suppose that the last measurement for Machine 2 above was 0.989 instead of 0.999. What affect does this new measurement have on the mean and standard deviation?

2. The average number of textbooks in professors' offices at the University of Georgia is 16, and the standard deviation is 5. Assume that the person who compiled this data surveyed ten professors. Give an example of the data that the person could have collected.

3. Your math teacher asks you to collect data to support your hypothesis that every ice cream store in South Georgia serves an average of 20 flavors. Give an example of data you may collect that would support an average of 20 flavors with a standard deviation of 2.

4. The following data set gives the prices (in dollars) of cordless phones at an electronics store. Find the variance and standard deviation.

35, 50, 60, 60, 75, 65, 80

5. If the standard deviation of a set of data is 3, what is the variance?

6. If the variance of a set of data is 16, what is the standard deviation?

7. The following data set gives the calories in a 1-ounce serving of several breakfast cereals. Find the variance and standard deviation.

135, 115, 120, 110, 110, 100, 105, 110, 125

Day 6	
E. Q. –	How do I calculate the mean and standard deviation and use these measures to compare data sets?
Standard –	MM2D1. Using sample data, students will make informal references about population means and standard deviations. b. Understand and calculate the means and standard deviations of sets of data. c. Use means and standard deviations to compare data sets.
Opening –	**<u>Warm Up</u>**: Look at *Performance Task 3* Problem 1 **<u>Mini Lesson</u>**: *Performance Task 3* Problem 2
Work session –	*Performance Task 3* Problems 2a,2b,2c, 3
Closing –	Students share out answers. Summarize lesson by guiding students to discover the formulas for finding mean and standard deviation from a frequency chart.

Day 6

Mathematics II Unit 4 Performance Task 3

Name____**Date**____________________

OPENING
Warm Up:
Problem 1
2,2,2,2,2,3,3,3,3,3,3,3,3,3,4,4,4,4,4,5,5,5,5,5,5,5,5,5,5,5

Given the data, calculate the mean by hand:

Cody and Bernice both got the correct answer, but it took Bernice a lot longer. Bernice added all of the values and divided the sum by 30. Cody told her that there was a quicker way to do it. Can you figure out how Cody did it? Show how Cody calculated the mean below.

Mini Lesson
Problem 2
The teacher then asked the students to calculate the standard deviation of the data by hand.

2,2,2,2,2,3,3,3,3,3,3,3,3,3,4,4,4,4,4,5,5,5,5,5,5,5,5,5,5,5

Carl made a table, listed every data point, and used the formula that he learned two days ago, standard deviation : $\sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n}}$, to calculate the standard deviation.

Jessica finished the problem in half of the time that it took Carl because she listed her data in a frequency distribution and calculated the standard deviation in a slightly different manner. Show how Jessica calculated the standard deviation below.

X_i	F_i = frequency	$X_i - \overline{X}$	$(X_i - \overline{X})^2$	$F_i\ (X_i - \overline{X})^2$
2	5			
3	9			
4	5			
5	11			
$\sum$				

WORK SESSION

2a. Jessica then taught Gabe her method to calculate the standard deviation. Gabe did not get the correct answer. He did the following: $\frac{5(2-3.5)^2+9(3-3.5)^2+5(4-3.5)^2+11(5-3.5)^2}{30}$

What mistake(s) did Gabe make?

2b. Jessica also taught Melody the method to calculate the standard deviation. Melody also did not get the correct answer. She did the following:

$$\frac{5(2-3.733)^2+9(3-3.733)^2+5(4-3.733)^2+11(5-3.733)^2}{4}$$

What mistake(s) did Melody make?

2c. Jessica also taught Maria the method to calculate the standard deviation. Maria also did not get the correct answer. She did the following:

$$\frac{5(2-3.733)^2+9(3-3.733)^2+5(4-3.733)^2+11(5-3.733)^2}{30}$$

What mistake(s) did Maria make?

Problem 3

Use Cody's and Jessica's method to calculate the mean and the standard deviation of the frequency distribution below.

X_i	F_i	$X_i - \bar{X}$	$(X_i - \bar{X})^2$	$F_i\ (X_i - \bar{X})^2$
3	12			
5	15			
6	8			
7	4			
$\sum$				

CLOSING

Students share out answers with class.

Guide the class in the discovery of the following formulas.

1. Make a formula for finding the mean of any frequency distribution. Let F_i stand for the frequency.

2. Make a formula for finding the standard deviation of a frequency distribution.

Day 7	
E. Q. –	1. How do you make informal references about means and standard deviations? 2. How do you use a calculator to find the means and standard deviations of a set of data? 3. How does the Empirical Rule apply to a distribution of a data set?
Standard –	MM2D1: Using sample data, students will make informal inferences about population means and standard deviations b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviation to compare data sets.
Opening –	**Warm Up**: Make a dot plot for the following data: 5,5,5,6,6,7,7,7,7,7,8,9,9,9,10,10,10,10 **Mini Lesson:** Review *Vocabulary Sheet*. Point out **measures of center** and **measures of variability**. Look at *Performance Task 4* Model Problem 1&2 Pass out graphing calculators
Work session –	*Performance Task 4* Problem 3& 4
Closing –	Share out Problems 3 and 4 for class group discussion.

Vocabulary Sheet for Math II – Unit 4

Vocabulary- (to be used throughout lesson)

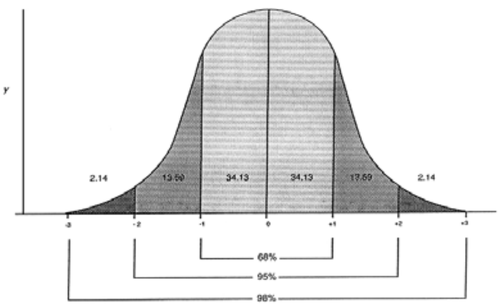
Empirical Rule is as follows:

If a distribution is normal, then approximately

68% of the data will be located within one standard deviation symmetric to the mean

95% of the data will be located within two standard deviations symmetric to the mean

99.7% of the data will be located within three standard deviations symmetric to the mean



Golden Ratio: $\varphi = \dfrac{1+\sqrt{5}}{2}$ which is approximately = 1.6180339887

Measures of Center

- Mean: The average = $\dfrac{\sum_{i=1}^{n} X_i}{N}$. The symbol for the sample mean is $\bar{X}$. The symbol for the population mean is μ_X.
- Median: When the data points are organized from least to greatest, the median is the middle number. If there is an even number of data points, the median is the average of the two middle numbers.
- Mode: The most frequent value in the data set.

Measures of Spread (or variability)

- Interquartile Range: $Q_3 - Q_1$ where Q_3 is the 75th percentile (or the median of the second half of the data set) and Q_1 is the 25th percentile (or the median of the first half of the data set).
- Mean Deviation: $\dfrac{\sum \left| X_i - \bar{X} \right|}{N}$ where X_i is each individual data point, $\bar{X}$ is the sample mean, and N is the sample size
- Variance: In this unit, I decided to use the population variance throughout. The students have an intuitive understanding of the population variance as opposed to the sample variance. The sample variance should be explored in the future. The formula for the population variance is as follows:

	variance : $\dfrac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n}$ ➢ <u>Standard Deviation:</u> The standard deviation is the square root of the variance. The formula for the population standard deviation is as follows: ➢ standard deviation : $\sqrt{\dfrac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n}}$ **<u>Normal Distribution</u>**: The standard deviation is a good measure of spread when describing a normal distribution. Many things in life vary normally. Many measurements vary normally such as heights of men. Most men are around the average height, but some are shorter and some are taller. The shape of the distribution of men's heights will be a bell shape curve. All normal distributions are bell shaped; however, all bell shaped curves are not normal. If a distribution is a normal distribution, then the Empirical Rule should apply (see Empirical Rule above). **<u>Dotplot:</u>** A statistical chart consisting of a group of data points plotted on a simple scale. **<u>Outliers:</u>** An observation or point that is numerically distance from the rest of the data.

Day 7
Math II Unit 4

Performance Task 4

Name____Date_____________________

<u>Mini Lesson</u>
<u>Problem 1</u>
Under certain conditions, you will discover during this activity, the **<u>Empirical Rule</u> (Normal Distribution)** can be used to help you make a good guess of the standard deviation of a distribution.

The Empirical Rule is as follows:

For certain conditions (which you will discover in this activity),

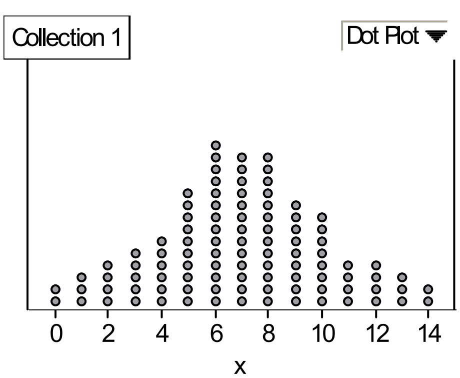
- 68% of the data will be located within <u>one standard deviation</u> symmetric to the mean
- 95% of the data will be located within <u>two standard deviations</u> symmetric to the mean
- 99.7% of the data will be located within <u>three standard deviations</u> symmetric to the mean

For example, suppose the data meets the conditions for which the empirical rule applies. If the mean ($\overline{X}$) of the distribution is 10, and the standard deviation of the distribution is 2, then about 68% of the data will be between the numbers 8 and 12 since 10-2 =8 and 10+2 = 12. We would expect approximately 95% of the data to be located between the numbers 6 and 14 since 10-2(2) = 6 and 10 + 2(2) = 14. Finally, almost all of the data will be between the numbers 4 and 16 since 10 – 3(2) = 4 and 10 + 3(2) = 16.

For each of the dotplots below, use the Empirical Rule to estimate the mean and the standard deviation of each of the following distributions. Then, use your calculator to determine the mean and standard deviation of each of the distributions. Did the empirical rule give you a good estimate of the standard deviation?

<u>For your convenience, there are 100 data points for each dotplot.***</u>***

<u>Problem 1</u>



Data	Frequency
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

Estimated mean:______________ Estimated standard deviation:___________

Problem 2
Using your calculators, calculate the actual mean ($\overline{X}$ or μ_X) and standard deviation (σ_X)

CALCULATOR STEPS (TI-83) **Can be modified for TI-30XS Multiveiw

Step 1 Press **STAT – Edit – Enter**

Step 2 If data is entered in the lists, use the arrow keys to move the cursor over the L_1.
Press **CLEAR – Enter.**
Move the cursor over the L_2. Press **CLEAR – Enter**
(Clear all lists)

Step 3 Place the cursor under the L_1 and enter the **Data** column from the table. Each data entry should be followed by the down arrow.

Step 4 Place the cursor under the L_2 and enter the **Frequency** column from the table. Each data entry should be followed by the down arrow.

Step 5 Press **STAT – CALC – 1-Var Stats – ENTER**

Step 6 A window with 1-Var Stats will come up. Press **2nd – L_1** (over the 1). Press **,**
Press **L_2** (over the 2) and Press **Enter**

This will give you the statistics for this data.

Actual mean:___________ Actual standard deviation:_________

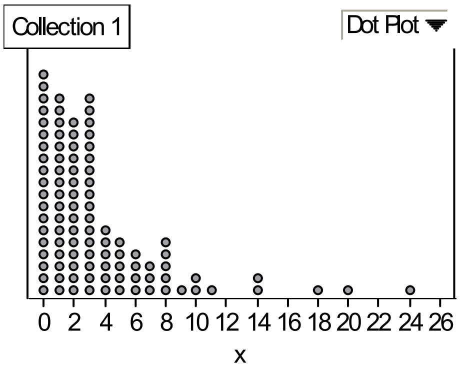
Did the empirical rule help give you a good estimate of the standard deviation?

Now that you know what the actual mean and standard deviation, calculate the following $\mu - \sigma =$ ____ and $\mu + \sigma =$ ___ .

Locate these numbers on the dotplot above.
How many dots are between these numbers?_______
Is this close to 68%?______

Do you think that the empirical rule should apply to this distribution?______

<u>WORK SESSION</u>
<u>Problem 3</u>



Estimated mean:_____________

Estimated standard deviation:__________

Using your calculators, calculate the actual mean ($\overline{X}$ or μ_X) and standard deviation (σ_X)
Use the CALCULATOR STEPS on previous page to calculate.

Actual mean:____________ Actual standard deviation:_________

Did the empirical rule help give you a good estimate of the standard deviation?

Problem 4
Now that you know what the actual mean and standard deviation, calculate the following $\mu - \sigma =$ ___ and $\mu + \sigma =$ ___ .

Locate these numbers on the dotplot above.
How many dots are between these numbers?_______
Is this close to 68%?______

Do you think that the empirical rule should apply to this distribution? Why?

<u>CLOSING</u>
Students share out answers to 3 & 4 with whole class and explain how they found their answers.

Day 8	
E. Q. –	1. How do you make informal references about means and standard deviations? 2. How do you use a calculator to find the means and standard deviations of a set of data? 3. How does the Empirical Rule apply to a distribution of a data set?
Standard –	MM2D1: Using sample data, students will make informal inferences about population means and standard deviations b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviation to compare data sets.
Opening –	**<u>Warm Up</u>**: Name the measures of center and the measures of variability. **<u>Mini Lesson:</u>** Review vocabulary and symbols from Day 7.
Work session –	*Performance Task 4* Problem 5& 6
Closing –	Share out Problems 5 & 6 for class group discussion. Day 8 Ticket Out the Door (attached below)

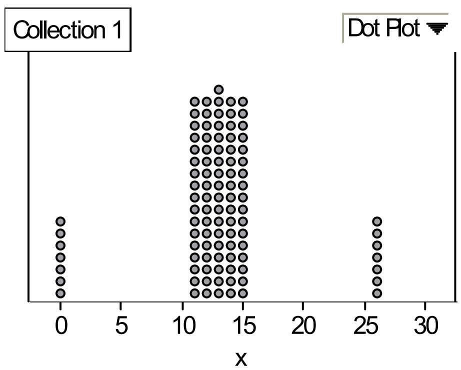
There are extra problems that can be used in a Math II Support class.

DAY 8
Math II Unit 4 **PERFORMANCE TASK 4**

Name____ Date__________________

OPENING
Review vocabulary and symbols from Day 7

WORK SESSION
Problem 5 ****** Remember there are a total of 100 dots on each dotplot*******



Estimated mean:_____________

Estimated standard deviation:__________

Using your calculators, calculate the actual mean ($\overline{X}$ or μ_X) and standard deviation (σ_X)
Use the CALCULATOR STEPS above to calculate.

Actual mean:____________ Actual standard deviation:_________

Did the empirical rule help give you a good estimate of the standard deviation?

Why or why not?

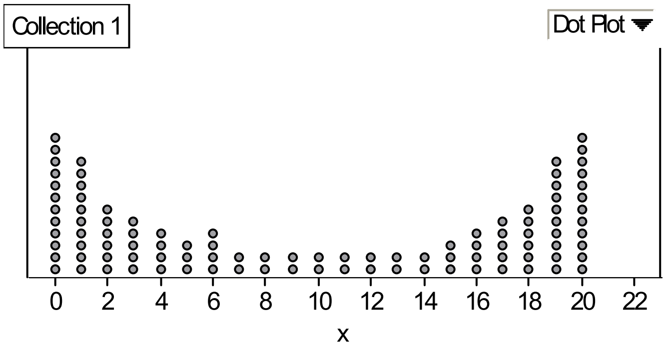
Now that you know what the actual mean and standard deviation, calculate the following $\mu - \sigma =$ ___ and $\mu + \sigma =$ ___ .

Locate these numbers on the dotplot above.
How many dots are between these numbers?_______
Is this close to 68%?______

Do you think that the empirical rule should apply to this distribution?

Why or why not?

Problem 6



Estimated mean:_____________

Estimated standard deviation:__________

Using your calculators, calculate the actual mean ($\overline{X}$ or μ_X) and standard deviation (σ_X)
Use the CALCULATOR STEPS above to calculate.

Actual mean:____________ Actual standard deviation:_________
Did the empirical rule help give you a good estimate of the standard deviation?

Now that you know what the actual mean and standard deviation, calculate the following $\mu - \sigma =$ ___ and $\mu + \sigma =$ ___ .

Locate these numbers on the dotplot above.
How many dots are between these numbers?_______
Is this close to 68%?______

Do you think that the empirical rule should apply to this distribution?

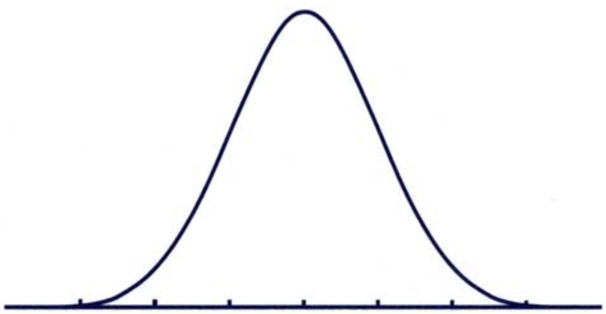
Why or why not?

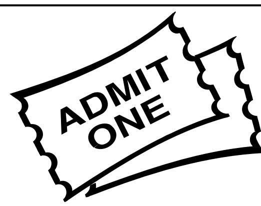
CLOSING

Share out Problem 5 and 6 for class group discussion.

Ticket Out the Door

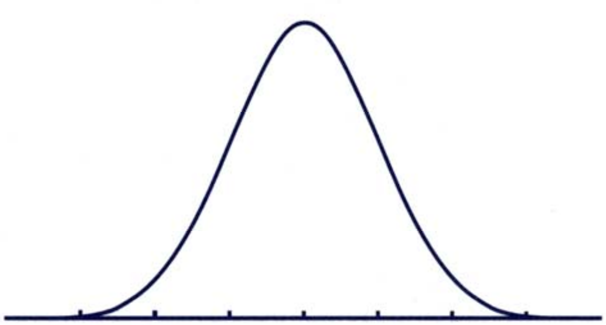
Show what you know:





Ticket Out the Door

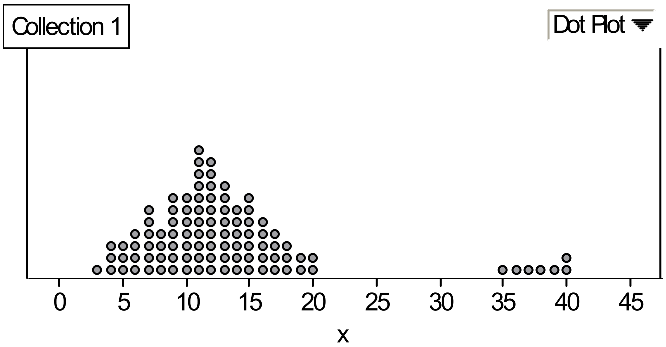
Show what you know:



Math II Unit 4
Day 8 **Math II Support Class**
Performance Task 4

Name____ Date_________________

Problem 7 ****Remember there are 100 dots on each dotplot*****



Estimated mean:_____________

Estimated standard deviation:__________

Using your calculators, calculate the actual mean ($\overline{X}$ or μ_X) and standard deviation (σ_X)
Use the CALCULATOR STEPS above to calculate.

Actual mean:____________ Actual standard deviation:_________

Did the empirical rule help give you a good estimate of the standard deviation?

Why or why not?

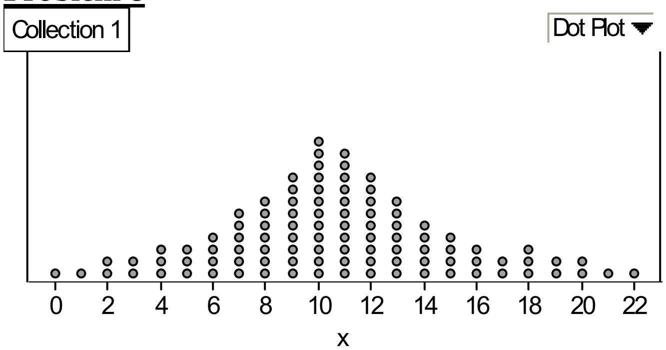
Now that you know what the actual mean and standard deviation, calculate the following $\mu - \sigma =$ ___ and $\mu + \sigma =$ ___ .

Locate these numbers on the dotplot above.
How many dots are between these numbers?_______
Is this close to 68%?______

Do you think that the empirical rule should apply to this distribution?

Why or why not?

Problem 8



Estimated mean:_____________

Estimated standard deviation:________

Using your calculators, calculate the actual mean ($\overline{X}$ or μ_X) and standard deviation (σ_X)
Use the CALCULATOR STEPS above to calculate.

Actual mean:____________ Actual standard deviation:_________

Did the empirical rule help give you a good estimate of the standard deviation?

Why or why not?

Now that you know what the actual mean and standard deviation, calculate the following $\mu - \sigma =$ ___ and $\mu + \sigma =$ ___ .

Locate these numbers on the dotplot above.
How many dots are between these numbers?_______
Is this close to 68%?______

Do you think that the empirical rule should apply to this distribution?

Why or why not?

<table>
<tr><td>Day 9</td><td></td></tr>
<tr><td>E. Q. –</td><td>Why is it important to understand the characteristics of a bell shaped dotplot?</td></tr>
<tr><td>Standard –</td><td>MM2D1: Using sample data, students will make informal inferences about population means and standard deviations
b. Understand and calculate the means and standard deviations of sets of data
c. Use means and standard deviation to compare data sets.</td></tr>
<tr><td>Opening –</td><td><u>Warm Up:</u>
Fill in the Graphic Organizer for the Empirical Rule. Pass out for students to fill out.

<u>Mini Lesson:</u>
REFER TO PERFORMANCE TASK 4 AND ANSWER THE FOLLOWING:

A. For which distributions did you give a good estimate of the standard deviation based on the empirical rule?

B. Which distributions did not give a good estimate of the standard deviation based on the empirical rule?

C. Which distributions had close to 68% of the data within one standard deviation of the mean? What do they have in common?

D. For which type of distributions do you think the Empirical rule applies?

Refer to Performance Task 4 Day 9</td></tr>
<tr><td>Work session –</td><td>Mathematics II Unit 4 – Performance Task 4 Day 9 Work problems 1& 2</td></tr>
<tr><td>Closing –</td><td>Students share answers with class.

Take photos of all students for the next day’s task.</td></tr>
</table>

Day 9
Math II Unit 4 **Performance Task 4**

Name____ **Date______________________**

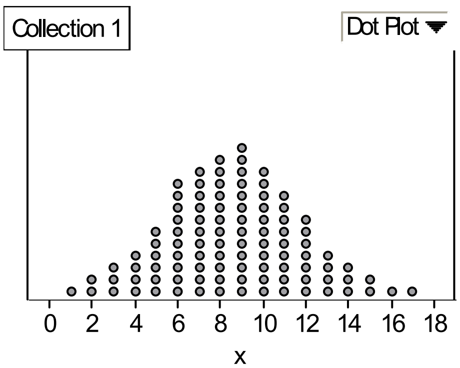
OPENING

As you discovered, the empirical rule does not work unless your data is **bell-shaped**. Not all bell-shaped graphs are normal. Review conclusions from previous lesson.
The next two dotplots are bell-shaped graphs. You will apply the empirical rule to determine if the bell-shaped graph is normal or not.

WORK SESSION

Problem 1

Make a frequency distribution for the dotplot below. Calculate the mean and the standard deviation of the distribution.



Data	Frequency
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

Mean (X or μ_X) = _______________________

Standard Deviation (σ_X) = ____________

1. Mark the mean on your dotplot above.

2. Calculate the following $\mu_X - \sigma_X$ = ____ and $\mu_X + \sigma_X$ = _____.
Mark these points on the x-axis of the dotplot.
How many data points are between these values?____

3. Calculate the following $\mu_X + 2\sigma_X$ =_____ and $\mu_X - 2\sigma_X$ = _____.
Mark these points on the x-axis of the dotplot.
How many data points are between these values?_____

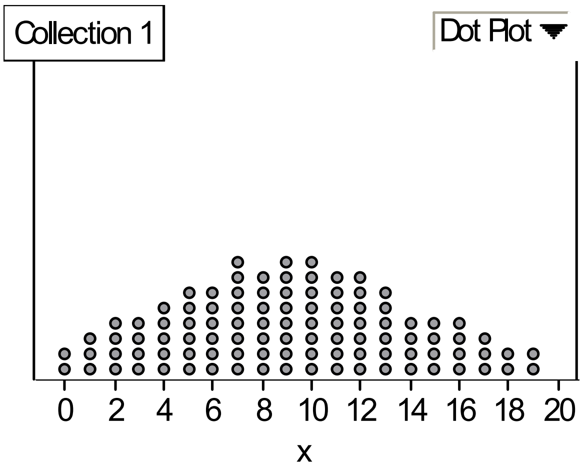
4. Calculate the following $\mu_X - 3\sigma_X$ = _____ and $\mu_X + 3\sigma_X$ = _____.
Mark these points on the x-axis of the dotplot.
How many data points are between these values?_____

5. Is it likely that this sample is from a normal population? Explain.

6. Outliers are values that are beyond two standard deviations from the mean in either direction. Which values from the data would be considered to be outliers?___________

Problem 2

Make a frequency distribution for the dotplot below. Calculate the mean and the standard deviation of the distribution.



Data	Frequency
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Mark the mean on your dotplot above.

Calculate the following $\mu_X - \sigma_X$ = ____ and $\mu_X + \sigma_X$ = _____.
Mark these points on the x-axis of the dotplot.
How many data points are between these values?____

Calculate the following $\mu_X + 2\sigma_X$ =_____ and $\mu_X - 2\sigma_X$ = _____.
Mark these points on the x-axis of the dotplot.
How many data points are between these values?_____

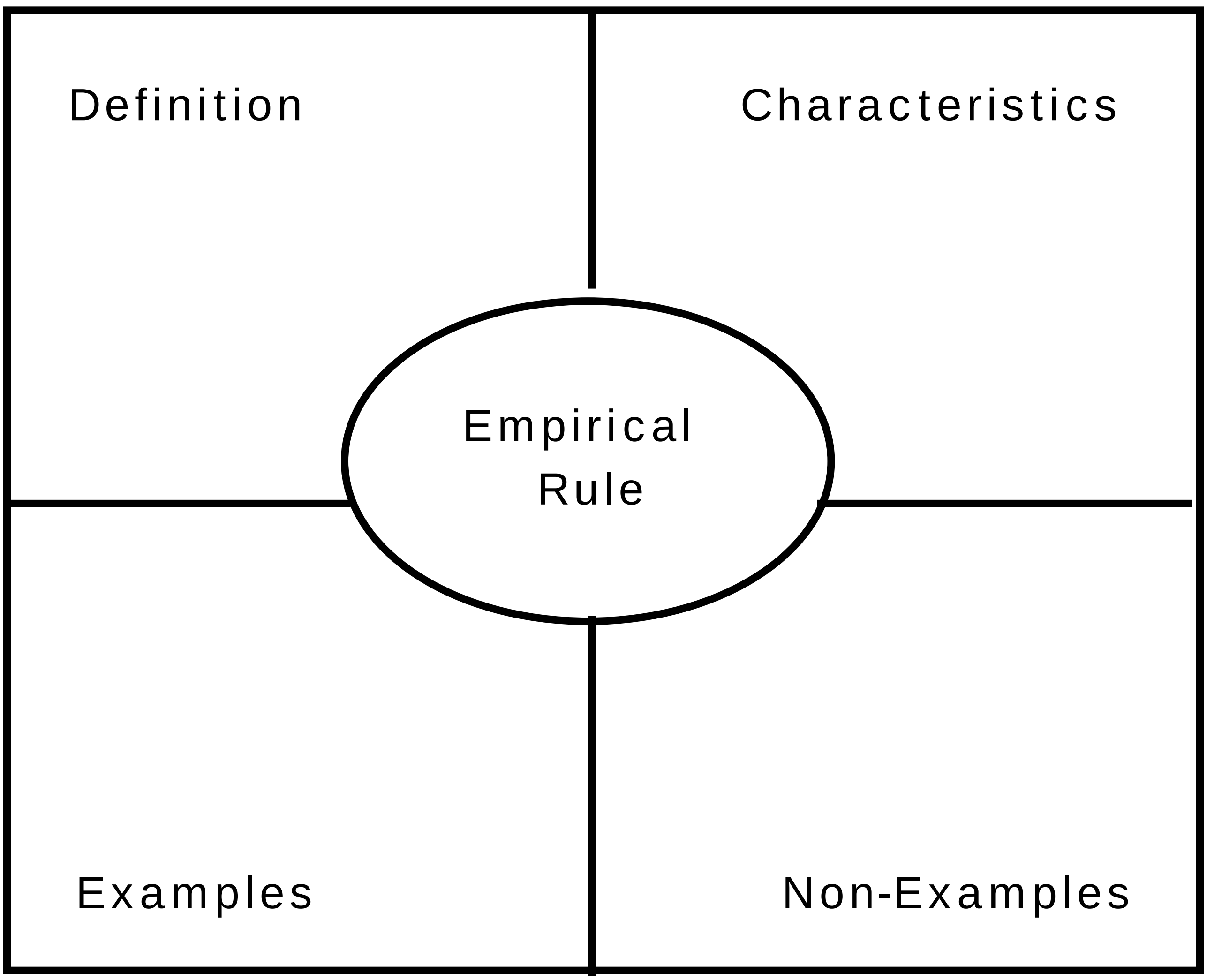
Calculate the following $\mu_X - 3\sigma_X$ = _____ and $\mu_X + 3\sigma_X$ = _____.
Mark these points on the x-axis of the dotplot.
How many data points are between these values?_____

Is it likely that this sample is from a normal population? ______ Explain.

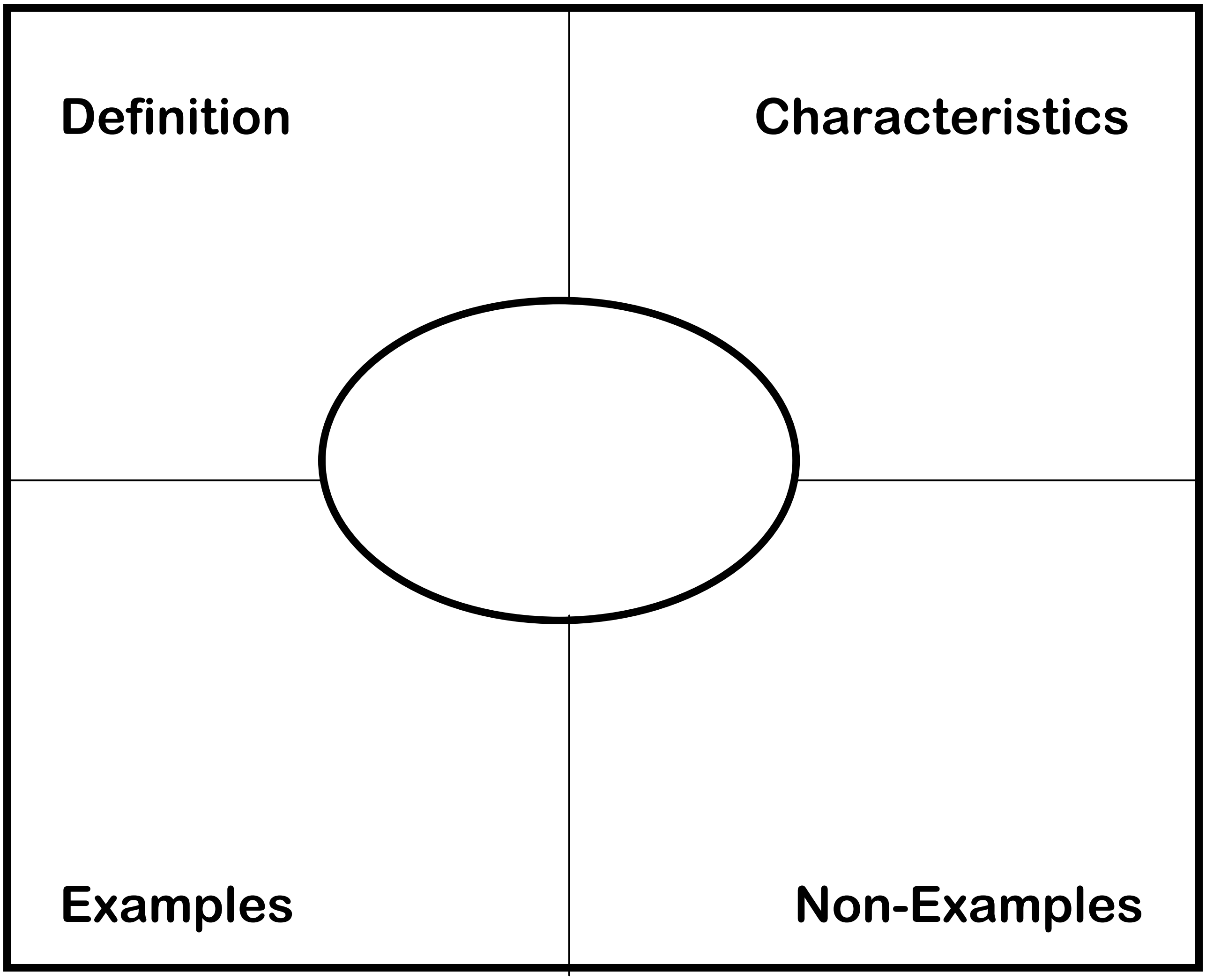
Outliers are values that are beyond two standard deviations from the mean in either direction. Which values from the data would be considered to be outliers?___________

CLOSING
Students share answers with class.

Frayer Diagram For Empirical Rule



Frayer Diagram Template



Day 10	
E. Q. –	How is the golden ratio related to our study of standard deviation and mean?
Standard –	MM2D1: Using sample data, students will make informal inferences about population means and standard deviations b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviation to compare data sets.
Opening –	**Warm Up:** Describe what a ratio is and give examples. **Mini Lesson**: Discuss Golden Ratio (Found on *Performance Task 5a Day 10* handout)
Work session –	**Students work in pairs on** *Performance Task 5a Day 10* handout
Closing –	**Discuss results of the activity whole group (Questions found on** *Performance Task 5a Day 10* handout)

Day 10

Math II – Unit 4 # Performance Task 5a

Name____Date______________

Mini Lesson

Background information for the unit:
Euclid of Alexandria (300 B.C.) defined the golden ratio in his book, "Elements." Since then, artists and architects who deem this ratio as being the most aesthetically pleasing ratio have used it as a basis for their art and buildings. It is thought that Leonardo da Vinci may have used the golden rectangle (having sides that are in the golden ratio) when painting the face of the Mona Lisa. The dimensions of Salvador Dali's painting, "Sacrament of the Last Supper," are also equal to the **Golden Ratio**. The Greeks used the golden ratio in building the Parthenon in Athens.

Throughout time, psychologists have tried to determine what humans consider to be beautiful. Gustav Theodor Fechner conducted an experiment during the 1860s and found that students preferred rectangular shapes that had the golden ratio (approximately 1.62). Since then, similar experiments have had conflicting results.

Some psychologists think that humans who have facial feature ratios closest to the golden ratio are deemed as the most beautiful. Other psychologists think that the people with the most average measurements in their facial features are considered to be the most beautiful. Still others believe that people who are not average (have higher cheek bones, thinner jaw, and larger eyes than normal) are deemed as the most beautiful.

Through the use of statistics, and using our class as a sample, we will investigate the average dimensions of the face and calculate their ratios.

What question are we trying to answer with our investigation?

Work Session

Make the following measurements for yourself and each student in your group.
You should use centimeters to be a little more accurate for the small areas of your face.

Student name and gender

Top of head to chin

Width of nose

Width of head

Nosetip to chin

Lips to chin

Length of lips

Nosetip to lips

Ratios to the nearest hundredth

$$\frac{\text{Top of head to chin}}{\text{Width of head}}$$

$$\frac{\text{Nose tip to chin}}{\text{Lips to chin}}$$

$$\frac{\text{Width of nose}}{\text{Nosetip to lips}}$$

$$\frac{\text{Length of lips}}{\text{Width of nose}}$$

Closing

Were any of your ratios close to being golden?

Did anyone in your group have ratios close to the golden ratio?

Day 11	
E. Q. –	How is the golden ratio related to our study of standard deviation and mean?
Standard –	MM2D1: Using sample data, students will make informal inferences about population means and standard deviations b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviation to compare data sets.
Opening –	**Warm Up**: Explain what the Golden Ratio is? **Mini Lesson:** Pool the class data. You should round your ratios to the nearest hundredth. Enter data in charts below
Work session –	**Students work in pairs on *Performance Task 5b* – Day 11** Make a dotplot of each class distribution below. Find the mean and standard deviation of each dotplot. Describe the shape of the distribution for each ratio.
Closing –	1. Did any student in your class have facial ratios that were close to being golden? 2. Which ratios had an average close to being golden?

Day 11
Math II – Unit 4

Performance Task 5b

Name____**Date**____________________

Mini Lesson
Pool the class data. You should round your ratios to the nearest hundredth.
Enter data in charts below

Work Session
Make a dotplot of each class distribution below.
Find the mean and standard deviation of each dotplot.
Describe the shape of the distribution for each ratio.

CLASS DATA

Ratios to the nearest hundredth															
$\frac{\text{Top of head to chin}}{\text{Width of head}}$															

Mean (X or μ_X) = ________________________
Standard deviation (σ_X) = ________________________

(dotplot) ____

CLASS DATA

$\frac{\text{Nose tip to chin}}{\text{Lips to chin}}$															

Mean (X or μ_X) = ________________________
Standard deviation (σ_X) = ________________________

$\frac{\text{Width of nose}}{\text{Nosetip to lips}}$															

(dotplot) ____

CLASS DATA

Mean (X or μ_X) = ________________________

Standard deviation (σ_X) = ________________________

____

(dotplot)

CLASS DATA

$\frac{\text{Length of lips}}{\text{Width of nose}}$															

Mean (X or μ_X) = ________________________

Standard deviation (σ_X) = ________________________

____

(dotplot)

<u>CLOSING</u>

Did any student in your class have facial ratios that were close to being golden?

Which ratios had an average close to being golden?

Day 12	
E. Q. –	How is the golden ratio related to our study of standard deviation and mean?
Standard –	MM2D1: Using sample data, students will make informal inferences about population means and standard deviations b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviation to compare data sets.
Opening –	**Warm Up**: Explain what the Golden Ratio is? **Mini Lesson:** Review what you did in the Activity from yesterday on *Performance Task 5b* – Day 11 Lesson. Explain how they are to repeat the activity today using two movie stars pictures (You will need to provide facial pictures of movie stars for them to choose from or you can give them the pictures of Barbie and Shrek)
Work session –	**Students work in pairs on *Performance Task 5c* – Day 12**
Closing –	**Writing assignment is described on the *Performance Task 5c* Day 12 Handout**

Day 12 **Performance Task 5c**

Math II Unit 4

Name____Date____________________

<u>WORK SESSION:</u>

Based on our answers to task 5, which ratios of our class are close to being golden?

Do you think that beautiful movie stars or models would have facial ratios that are closer to the golden ratio?

<u>What question are we trying to answer with our investigation?</u>

Make the following measurements for at least two movie stars or models, one male and one female, who are beautiful in your opinion. You should use **centimeters** to be a little more accurate for the small areas of their face.

Movie star/model name and gender

Top of head to chin

Width of nose

Width of head

Nosetip to chin

Lips to chin

Length of lips

Nosetip to lips

$\frac{\text{Top of head to chin}}{\text{Width of head}}$

$\frac{\text{nose tip to chin}}{\text{lips to chin}}$

$\frac{\text{width of nose}}{\text{nosetip to lips}}$

$\frac{\text{length of lips}}{\text{width of nose}}$

Were any of their ratios close to being golden?

Did anyone in your group have ratios close to the golden ratio?

Pool the class data. You should round your ratios to the nearest hundredth. Make 7 dotplots of the class distribution below. Find the mean and standard deviation of each dotplot. Describe the shape of the distribution for each ratio.

Copy the dotplots of the movie stars/models next to the dotplots of the students from task #5.

Fill in the table below to compare the movie star/model distributions to the class distributions.

Ratio	**Shape of the Distribution**		**Mean of the Distribution**		**Standard Deviation of the Distribution**		**Percent of individuals who had the Golden Ratio in the Distribution**	
	Class	**Movie Star**	**Class**	**Movie Star**	**Class**	**Movie Star**	**Class**	**Movie Star**
Top of head to chin / Width of head								
Nose tip to chin / Lips to chin								
Width of nose / Nosetip to lips								
Length of lips / Width of nose								

CLOSING:

In a paragraph, compare the movie star/model distributions to the class distributions. Make sure that you discuss center, shape and spread. If there are any discrepancies, discuss possible reasons why they exist. What is the answer to the question that was posed at the beginning of this task?

Performance Task 5 Teacher Notes:

What question are we trying to answer with our investigation?
Are the facial ratios of beautiful people the same as the population (class average)?

In a paragraph, compare the movie star/model distributions to the class distributions. Make sure that you discuss center, shape and spread. If there are any discrepancies, discuss possible reasons why they exist. What is the answer to the question that was posed at the beginning of this task? One discrepancy that should be discussed is that the class data was based on 3-dimensional models, whereas, the movie star data was based on 2-dimensional pictures. Another point that may be brought up is that photos can be altered. When I did this with my class, the first ratio, "top of head to chin/width of head," centered closely to the golden ratio for movie stars. This is the rectangle of their entire face. It would be very easy for someone to stretch a picture to fit the golden ratio. Although it may have been a coincidence, it is a valid point that could be brought up in a discussion.

Further exploration if time permits:
You may want to use a man-made creation such as "Barbie" or "Shrek" to see if their facial proportions are outliers or very close to the golden ratio.

Additional Measurements to look for Golden Ratios:

Movie star/model name and gender

Top of head to chin

Top of head to pupil

Pupil to nosetip

Pupil to Lip

Width of nose

Outside distance between eyes

Width of head

Hairline to pupil

Nosetip to chin

Lips to chin

Length of lips

Nosetip to lips

Top of head to chin
Width of head

Top of head to pupil
Pupil to Lip

Nose tip to chin
Lips to chin

Nose tip to chin
Pupil to nosetip

Width of nose
Nosetip to lips

Outside dist. Bet. Eyes
Hairline to pupil

Length of lips
Width of nose

Day 13	
E.Q.	How do the sample means vary from one sample to the next? What happens to the statistics of the data as the sample size approaches the population size when the population distribution is normal?
Standard	MM2D1d Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening	Warm Up: Hours worked per week for one month: 8, 9, 15, 6, 10 Find the Mean and Standard Deviation. Mini Lesson: Teacher led Given the dot-plot from the list of ratios: (top of head to chin/width of head) (Teacher collected from task 5 for all students from all classes) Model how to calculate the mean and the standard deviation from your dot plot using a graphing calculator. Investigate the distribution of the mean for a random sample of 5 people from the population distribution working in pairs. **Teacher: Demonstrate the process for using a calculator to choose a sample size of 5.** **Process for using calculator to randomly generate a sample size of 5 using the TI-83 and TI-84.** **1. Press the Math key.** **2. Right Arrow over to highlight PRB on the screen** **3. Arrow down to number 5: randInt(** **4. press Enter** **5. press the number 1** **6. press the comma** **7. enter the population size (the total number of data values collected from your classes from task 5-- (i.e. If you teach 100 students Math II, the population size would be 100.)** **8. press the comma** **9. press the number 5 (the sample size)** **10. press the left parenthesis** **Your screen should have the following on the top randInt(1, 100, 5). This is telling your calculator to choose 5 numbers between 1 and 100.** **10. Press enter. Your calculator should display five numbers inside parenthesis.** **11. To randomly generate another sample sizer of 5, do not clear your calculator and press enter.** A random set of numbers like (5, 8, 22, 54, 72) would tell you to count your dots in your dotplot from left to right and choose the 5^{th} data value, the 8^{th} data value, the 22^{nd} data value, the 54^{th} data value, and the 72^{nd} data value from the dot plot. These data values would be your random sample of 5 data values. Compare the distribution to your class distribution from task 5.

Work Session	Complete *Performance Task 6* Exercise 1 (see attached)
Closing	1. Students share out their work with whole class. 2. If you were a researcher, you would most likely obtain a sample one time. If you were to randomly choose a sample of 5 people, what is the probability that the sample mean of those 5 people is the same as the population mean? (Hint, count the dots on your dotplot) (Teacher: To find the probability that the sample mean is same as the population mean, count the number of means in the sample that are the equal to the population mean and write that as a ratio of favorable outcomes over total number of means from the sample)

Day 13
Performance Task 6 Exercise 1
Math II Unit 4
Name ____Date_________________

Investigate the distribution of the mean for a random sample of 5 people from the population distribution.

1. Step 1 Using TI-83 or TI -84 randomly generate a sample size of 5. (See handout for randomly generating a sample size of 5)
2. Go to your dotplot and count the dots from left to right to locate the number your calculator chose. (A random set of numbers like (5, 8, 22, 54, 72) would tell you to count your dots in your dot plot from left to right and choose the 5th data value, the 8th data value, the 22nd data value, the 54th data value, and the 72nd data value from the dotplot. These data values would be your random sample of 5 data values.)
3. Record the ratios for these five points in the table below.
4. Calculate the mean of these five ratios and record in the table. Round your means to the nearest hundredth.
5. Repeat this process three more times and record data in the table.

	1	2	3	4	5	Mean
Trial 1 Random Numbers						
Corresponding Ratios						
Trial 2 Random Numbers						
Corresponding Ratios						
Trial 3 Random Numbers						
Corresponding Ratios						
Trial 4 Random Numbers						
Corresponding Ratios						

Draw the dot plot below for the means of the samples.

Distribution of the Mean for the Ratio (Top of head to chin/Width of head) for n = 5 (sample size 5)

Task 6 Exercise 1 continued

1. Calculate the mean of the sample means. ____________________
2. How does mean of the sample means compare to the population mean?
3. Calculate the standard deviation of the sample means.
4. How does the standard deviation of the samples compare to the standard deviation of the population?

Day 14

E.Q.	How do the sample means vary from one sample to the next? What happens to the statistics of the data as the sample size approaches the population size when the population distribution is normal?
Standard	MM2D1d Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening	Warm Up: How is a sample different from a population? Mini Lesson: Investigate the distribution of the mean for a random sample of 15 people from the population distribution working in pairs. Teacher: Recall the process for randomly selecting 5 numbers. Repeat that process using a sample size of 15 instead of 5.
Work Session	Complete *Performance Task 6* Exercise 2 (see attached)
Closing (10 minutes)	Based on the values in the distribution table completed in Exercise 2, what can you conclude? What happens to your statistics as your sample size increases? Teacher randomly selects pairs to report their findings. Journal Entry: If you were a researcher, you would most likely obtain a sample one time. If you were to randomly choose a sample of 15 people, what is the probability that the sample mean of those 15 people is the same as the population mean? (Hint, count the dots on your dotplot) (Teacher: To find the probability that the sample mean is same as the population mean count the number of means in the sample that are the equal to the population mean and write that as a ratio of favorable outcomes over total number of means from the sample)

Day 14
Math II Unit 4

Performance Task 6 Exercise 2

Name ____ Date _________________________

Investigate the distribution of the mean for a random sample of 5 people from the population distribution.

1. Step 1 Using TI-83 or TI -84 randomly generate a sample size of 15. (See handount for randomly generating a sample size of 15)
2. Go to your dot-plot and count the dots from left to right to locate the number your calculator chose.
3. Record the ratios for these fifteen points in the table below.
4. Calculate the mean of these five ratios and record in the table. Round your means to the nearest hundredth.
5. Repeat this process three more time and record data in the table.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean
Trial 1 Random Numbers																
Corresponding Ratios																
Trial 2 Random Numbers																
Corresponding Ratios																
Trial 3 Random Numbers																
Corresponding Ratios																
Trial 4 Random Numbers																
Corresponding Ratios																

Draw the dot plot below for the means of the samples.

Distribution of the Mean for the Ratio (Top of head to chin/Width of head) for n = 15 (sample size 15)

Task 6 Exercise 2 continued

1. Calculate the mean of the sample means. ____________________

2. How does mean of the sample means compare to the population mean?

3. Calculate the standard deviation of the sample means. __________________

4. How does the standard deviation of the samples compare to the standard deviation of the population?

Distribution	**Draw the shape of the distribution**	**Mean of the Distribution**	**Standard Deviation of the Distribution**	**Probability that the mean of one sample is the same as the mean of the distribution**
Of individual data points in the population				
Of the mean for sample size = 5				
Of the mean for sample size = 15				

Process for using calculators to randomly generate a sample size of 5 using the TI-83 and TI-84.

1. **Press the Math key.**
2. **Right Arrow over to highlight PRB on the screen**
3. **Arrow down to number 5: randInt(**
4. **press Enter**
5. **press the number 1**
6. **press the comma**
7. **enter the population size (the total number of data values collected from your classes from task 5-- (i.e. If you teach 100 students Math II, the population size would be 100.)**
8. **press the comma**
9. **press the number 5 (the sample size)**
10. **press the left parenthesis**
    Your screen should have the following on the top
    randInt(1, 100, 5). This is telling your calculator to choose 5 numbers between 1 and 100.
11. **Press enter. Your calculator should display five numbers inside parenthesis.**
12. **To randomly generate another sample size of 5, do not clear your calculator and press enter.**

A random set of numbers like (5, 8, 22, 54, 72) would tell you to count your dots in your dot plot from left to right and choose the 5^{th} data value, the 8^{th} data value, the 22^{nd} data value, the 54^{th} data value, and the 72^{nd} data value from the dot plot. These data values would be your random sample of 5 data values.

Unit 4 Name of Unit Data Analysis and Probability Mathematics II

Day 15	
E.Q.	How do the statistics of various random samples compare?
Standard	MM2D1d Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening (5 min)	Introduction of assessment and guidelines.
Work Session (30 – 40 minutes)	Assessment for Task 5 and 6. Work Individually to complete assessment.
Closing (10 minutes)	Discuss the results of the assessment. Note: It may not take the full day for this assessment. You may want to begin next task.

Day 15

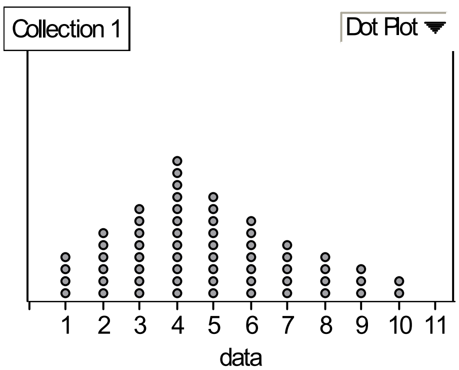
Math II Unit 4 Assessment for MM2D1d

Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.

Name ____Date__________________

On your calculator, type randint(1,60,2) to select 2 points. Locate the associated 2 points on the dotplot below. What are they?____________________

Calculate the average of these 2 points. ______________



Repeat this process four more times and record the results below:

Randint(1,60,2)=________________ mean of the 2 associate values on the dotplot :______

Randint(1,60,2)=________________ mean of the 2 associate values on the dotplot :______

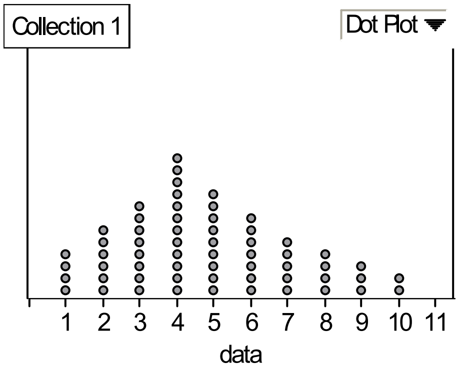
Randint(1,60,2)=________________ mean of the 2 associate values on the dotplot :______

Randint(1,60,2)=________________ mean of the 2 associate values on the dotplot :______

What is the mean of these 5 sample means of size 2?________ What is the standard deviation of these 5 sample means?_______

On your calculator, type randint(1,60,5) to select five points. Locate the associated five points on the dotplot below. What are they?____________________

Calculate the average of these 5 points. ______________



Repeat this process four more times and record the results below:

Randint(1,60,5)=________________ mean of the 5 associate values on the dotplot :______

Randint(1,60,5)=________________ mean of the 5 associate values on the dotplot :______

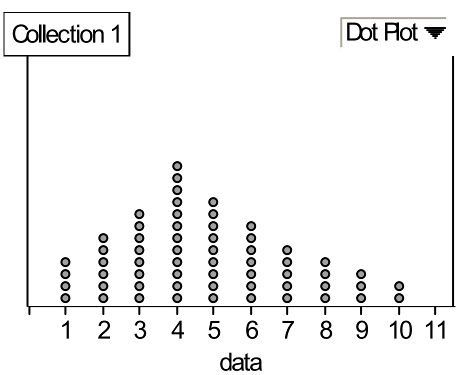
Randint(1,60,5)=________________ mean of the 5 associate values on the dotplot :______

Randint(1,60,5)=________________ mean of the 5 associate values on the dotplot :______

What is the mean of these 5 sample means?________ What is the standard deviation of these 5 sample means?_______

On your calculator, type randint(1,60,30) to select 30 points. Locate the associated 30 points on the dotplot below. What are they?____________________

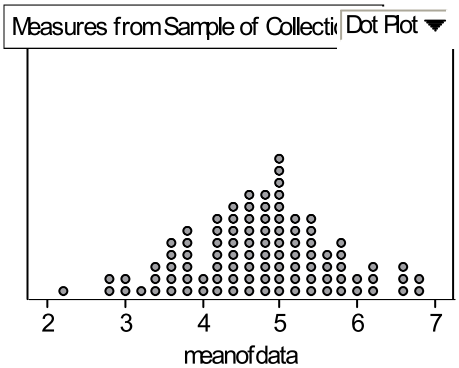
Calculate the average of these 30 points. ______________

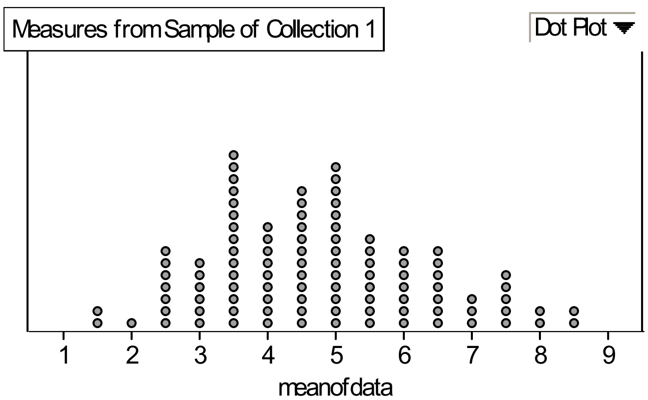


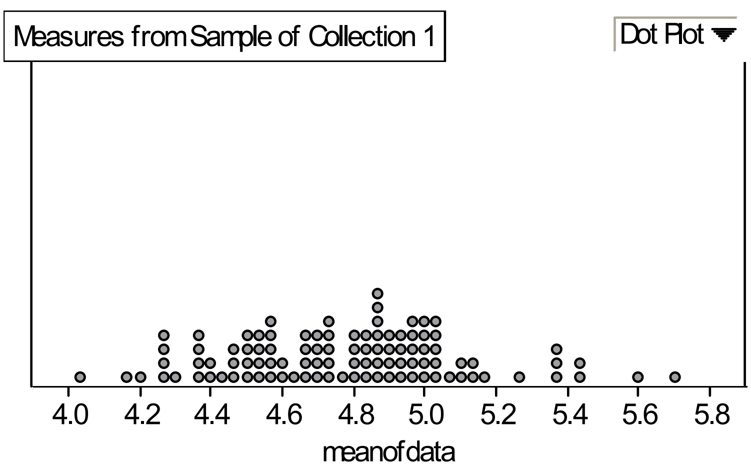
Repeat this process one more time and record the results below:

Randint(1,60,30)=________________ mean of the 30 associate values on the dotplot :______

Below are three dotplots. Which dotplot could represent the distribution of the mean for samples of size 2, 5, and 30? Why?







BEGIN HERE. NEED TO ADD A LESSON WHERE DATA IS COLLECTED. DAY 16

MATHEMATICS II Unit #4 Task 8

Day 16	
E. Q. –	How do you make informal inferences based on population means and standard deviation?
Standard –	MM2D1 a,b,c,d
Opening –	**Warm Up**: Read the Activity for today and pose a question to investigate: **Mini Lesson** Discuss the difference between a sample and a random sample. Revisit meaning of a population. Teacher explains the instructions for *Performance Task 8 Exercise 1* This activity could be done outside. Students will need a tape measure and something to mark the distance.
Work session –	Divide students into groups of 4 and have them collect their group's data. Students will collect data for *Performance Task 8 Exercise 1*
Closing –	Students share their data with whole class to complete their class charts.

Day 16 **Performance Task 8 – Exercise 1**
Math II Unit 4
Name ____Date_________________

Background Information: The **standing long jump** is an athletic event that was featured in the Olympics from 1900 to 1912.

In performing the standing long jump, the springer stands at a line marked on the ground with his feet slightly apart. The athlete takes off and lands using both feet, swinging his arms and bending his knees to provide forward drive. In Olympic rules, the measurement taken was the longest of three tries. The jump must be repeated if the athletes falls back or uses a step at take-off.

The men's record for the standing long jump is 3.71 meters. The women's record is 2.92 m (9 ft 7 in).

Men and women are often separated in the Olympics and also in high school sports for various reasons. In terms of the standing long jump, do you think that they are separated due to the reason that men in general jump farther than women. Or, do you think that men can jump farther because they are generally taller and have longer legs than women?

Pose a question to investigate:

Collect Data:
Jump three times according to the method described above. Record the class information in the table below.

Small group Data

Gender	**Length of leg from waist to the floor**	**Jump distance….best of 3 jumps**

Random Sample (Class Data)

Gender	**Length of leg from waist to the floor**	**Jump distance….best of 3 jumps**

Day 17	
E. Q. –	How do you make informal inferences based on population means and standard deviation?
Standard –	MM2D1 a,b,c,d
Opening –	**Warm Up:** Make a stem and leaf plot for the following data 23,23,24,25,26,28,29,29 30 **Mini Lesson** Prior to this lesson, the students must collect data . The teacher will pool the data from all Math II classes and present to the students at the beginning of the lesson. Students will use their data collected on the previous day, compare it to the pooled data, and make a conjecture. See attached *Performance Task 8 Exercise 2.* Model how to make a back to back stem and leaf plot.
Work session –	1. As a whole group, the class will complete a back to back stem and leaf plot. Discussions will take place comparing the two sets of data. The mean and standard deviation will be discussed for male and female jump distances comparing the two distributions. 2. Students will be placed in groups by height. Place your students in groups of 4 using their heights. In each group, the students will make a back to back stem and leaf plot. Using the information gathered, the students will calculate the means and standard deviations. The students will compare the two distributions verbalizing and writing these comparisons. See Exercise 2.
Closing –	1. As a whole group, the teacher will facilitate a discussion about the conjectures. 2. In 8th grade, students (M8D4) estimated and determine a line of best fit from a scatter plot. In support classes, this concept will need to reviewed extensively.

FOR YOUR INFORMATION

Lesson Page

Stem-and-Leaf Plots

Math A

Data can be displayed in many ways. One method of displaying a set of data is with a stem-and-leaf plot.

A stem-and-leaf plot is a display that organizes data to show its shape and distribution.

In a stem-and-leaf plot each data value is split into a "**stem**" and a "**leaf**". The "**leaf**" is usually the last digit of the number and the other digits to the left of the "leaf" form the "**stem**". The number 123 would be split as:

stem 12
leaf 3

Constructing a stem-and-leaf plot:

The data: Math test scores out of 50 points: 35, 36, 38, 40, 42, 42, 44, 45, 45, 47, 48, 49, 50, 50, 50.

Writing the data in numerical order may help to organize the data, but is NOT a required step. Ordering can be done	35, 36, 38, 40, 42, 42, 44, 45, 45, 47, 48, 49, 50, 50, 50

<table>
<tr><td>later.</td><td></td></tr>
<tr><td>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.</td><td>The number 38 would be represented as
<table><tr><th>Stem</th><th>Leaf</th></tr><tr><td>3</td><td>8</td></tr></table></td></tr>
<tr><td>Group the numbers with the same stems. List the stems in numerical order. (If your leaf values are not in increasing order, order them now.) Title the graph.</td><td><table><tr><th colspan="2">Math Test Scores
(out of 50 pts)</th></tr><tr><th>Stem</th><th>Leaf</th></tr><tr><td>3</td><td>5 6 8</td></tr><tr><td>4</td><td>0 2 2 4 5 5 7 8 9</td></tr><tr><td>5</td><td>0 0 0</td></tr></table></td></tr>
<tr><td>Prepare an appropriate legend (key) for the graph.</td><td>Legend: 3 | 6 means 36</td></tr>
</table>

A stem-and-leaf plot shows the shape and distribution of data. It can be clearly seen in the diagram above that the data clusters around the row with a stem of 4.

Notes:

- The leaf is the digit in the place farthest to the right in the number, and the stem is the digit, or digits, in the number that remain when the leaf is dropped.
- To show a one-digit number (such as 9) using a stem-and-leaf plot, use a stem of 0 and a leaf of 9.
- To find the median in a stem-and-leaf plot, count off half the total number of leaves.

Special Case:

If you are comparing two sets of data, you can use a back-to-back stem-and-leaf plot.

Data Set A		Data Set B
Leaf	**Stem**	**Leaf**
3 2 0	4	1 5 6 7

The numbers 40, 42, and 43 are from Data Set A.
The numbers 41, 45, 46, and 47 are from Data Set B.

Day17

Performance Task 8 Exercise 2

Math II Unit 4

Name ____Date _________________

1. Make a back to back stem and leaf plot comparing data by heights.

2. Calculate the means and standard deviations.

3. Compare the two distributions within your group. Based upon your discussions, make a conjecture. Explain why you made this conjecture.

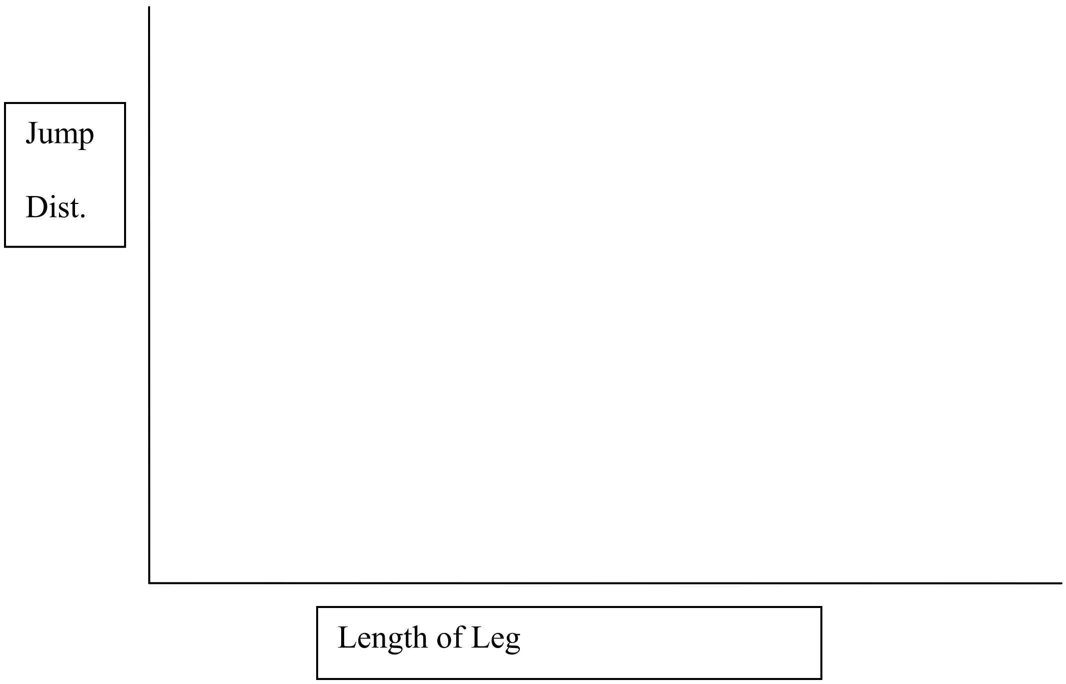
Conjecture:

Explanation:

Day 17 Ticket Out The Door

Name:_______________________________________ Date:_________

Make a scatterplot of (length of leg, length of jump).



Fit a least squares regression line to the data. What is the correlation coefficient?

Is there an association between leg length and jump distance?

Day 18	Comparing a random set of data to a set of data that is not necessarily random.
E. Q. –	How can the method of data collection affect the population mean and standard deviation of a data analysis?
Standard –	MM2D1 a,b,c,d
Opening –	**Warm Up:** Explain what a random sample is? **Mini lesson:** In this lesson, the students will compare their class data from Performance Task 8 to a completely random set of data generated by the TI-83 or TI-84. The students should discuss the reasons their class data may not be random and what constitutes a random set of data. Teacher will review how to use the Graphing Calculator to generate a random set of data. Use TI-83/84 to generate a random set of data: a. Press MATH and select PRB (Probability) on your calculator. b. Press 5 or RANDINT( ) and type in (1, 45) and press ENTER. (45 is the total number of male students and we are going to select 15 of those students).
Work session –	1. As a whole group, the class will complete a back to back stem and leaf plot using data from Performance Task 8 (your Math 2 class verses All Math 2 classes). Discussions will take place comparing the two sets of data for male and female jump distances. 2. Students will complete the table provided (Exercise 2) to compare population mean and population standard deviation verses class mean and standard deviation. 3. Make conjecture about distances jumped in relation to jumper's sex and allow students to debate on their reasoning. 4. Compare population standard deviation to the male's population mean and the female population mean. Discuss what the deviation implies and what implications a larger deviation has in relation to the mean. Discuss outlier. 5. Next we use TI-83/84 to generate a random set of data: a. Press MATH and select PRB (Probability) on your calculator. b. Press 5 or RANDINT( ) and type in (1, 45) and press ENTER. (45 is the total number of male students and we are going to select 15 of those students). c. Take the data generated and calculate the mean and the standard deviation. 6. Complete a dotplot for the random selection of male students and answer questions (Exercise 3). 7. Repeat the process for the females and generate a random sample of 15 female students and calculate the mean and standard deviation as done for the male students (Attachment 3). 8. Use the chart provided (Exercise 4), compare the population mean, class mean and the random sample mean. Determine which is the closest to the population mean, the class mean or the random sample mean. 9. Make the scatter plot of (length of leg, length of distance) for the students in all of your Math 2 classes. Fit a least squares regression line to the data. What is the correlation coefficient (slope of the line)? 10. You can use your calculator (TI-83) to do the same.

Closing –	Is there a relationship between height and jump distance? What is the correlation coefficient?

Performance Task 8 Exercise 2

Compare your class distribution from yesterday to the population distributions. Is your class representative of the population?

	Population mean	Class mean	Population standard deviation	Class standard deviation
Males				
Females				

Recall from yesterday that the men's record for the standing long jump is 3.71 meters, and the women's record is 2.92 m (9 ft 7 in).

How many population standard deviations is 3.71 meters away from the male's population mean?___________

How many population standard deviations is 2.92 meters away from the women's population mean?______

If a value is more than 2 standard deviations above or below the mean of a normal distribution, then that value is considered to be an outlier. Is 3.71 meters an outlier for men?_______ Is 2.92 meters an outlier for women? _______

Performance Task 8 Exercise 3

Random Samples: Use the "randInt" feature on your calculator to select a random sample of 15 different males from the population of all males in your teacher's math 2 classes. Calculate the mean jump distances of these 15 randomly selected males._______

Pool the class data. Each student should record their sample mean on a class dotplot. Draw the class dotplot below:

Mean jump distances of males for a random sample of size 15

What is the mean of the sample means?_________ What is the standard deviation of the sample means?_______

Now use the "randInt" feature on your calculator to select a random sample of 15 different females from the population of all females in your teacher's math 2 classes. Calculate the mean jump distances of these 15 randomly selected females._______

Pool the class data. Each student should record their sample mean on a class dotplot. Draw the class dotplot below:

Mean jump distances of females for a random sample of size 15

What is the mean of the sample means?_________ What is the standard deviation of the sample means?_______

Performance Task 8 Exercise 4

Compare the mean and standard deviation of the sample means to the population parameters. Fill in the table to help you make the comparison of the population mean, the class mean, and the mean of the random sample means.

	Population mean	Class mean	Mean of sample means	Population standard deviation	Class standard deviation	Standard deviation of sample means
Males						
Females						

Which came closer to the population mean….the class mean or the mean of the sample means?___________
Why?

Which had the smallest standard deviation…the population distribution, the class distribution, or the distribution of the sample means?__________ Why?

Is there a relationship between height and jump distance?
Make a scatterplot of (length of leg, length of jump) for the students in all of your teacher's MATH 2 classes. Fit a least squares regression line to the data. What is the correlation coefficient?__________

Day 19	Cumulative Performance Task 10 All attachments are at the end.
E. Q. –	As the sample size changes, how do the changes affect the distribution of the data and, more specifically, the mean and standard deviation?
Standard –	**MM2D1: Using sample data, students will make informal inferences about population means and standard deviations** d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening –	Review vocabulary: sampling distribution, normal distribution, golden ratio, mean, standard deviation Use box and whisker plot and part I of task 10 to review median, quartiles, interquartile range, outliers (see Exercise 1) Teacher will lead part II of *Performance Task 10.* Teacher will use overhead graphing calculator so that students can observe how the curve changes as the sample sizes increases
Work session –	.
Closing –	Ticket out the door: How did the sample size affect the distribution of data?

Day 20	Task 10 con't.
E. Q. –	As the sample size changes, how do the changes affect the distribution of the data and, more specifically, the mean and standard deviation?
Standard –	**MM2D1: Using sample data, students will make informal inferences about population means and standard deviations** d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening –	Review data from day 1. Review distribution curve and how sample size affects the curve. Show students how to use RandInt feature on graphing calculator.
Work session –	Students complete Exercise 3 of *Perfosrmance Task 10.* Discuss. Students complete Exercise 4 o *Performance Task 10.* Discuss.
Closing –	Summarize findings in a short paragraph.

Day 21	Cumulative Assignment
E. Q. –	How do you use sample data to make informal inferences about population means and standard deviations?
Standard –	**MM2D1: Using sample data, students will make informal inferences about population means and standard deviations** a. Pose a question and collect sample data from at least two different populations. b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviations to compare data sets d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening –	Introduce task and review necessary symbols and formulas.
Work session –	Complete Part 1 of Cumulative task 1 (see attachment 2)
Closing –	Have students develop an order to be placed by the teacher and explain their reasoning.

Day 22	Cumulative Assignment con't
E. Q. –	How do you use sample data to make informal inferences about population means and standard deviations?
Standard –	**MM2D1: Using sample data, students will make informal inferences about population means and standard deviations** a. Pose a question and collect sample data from at least two different populations. b. Understand and calculate the means and standard deviations of sets of data c. Use means and standard deviations to compare data sets d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.
Opening –	Return prior collected data and instruct students to use data to complete part 2 of cumulative task 1.
Work session –	Students will complete part 2 of cumulative task 1.
Closing –	Summarize data.

Attachment 1

Performance Task 10 :

Part I

We have looked at sampling distributions taken from normal distributions (golden ratio and jump distances). Today we will examine a sampling distribution from a non-normal distribution.

What was the price of your last haircut/style/color? _______

Collect class data and draw dotplot of the distribution below.

____

Hair Cut Prices

Describe the shape of the distribution.

Calculate the mean and the standard deviation:________________________, _____________________

Calculate the median and the Interquartile range:_______________________, ____________________

Are there any outliers?___________________

Which is a better measure of center for the class data?___________
Why?

Is your haircut price closer to the mean price or the median price? _____________

Part II

Perform a simulation 50 times to determine whether the mean or median is a better measure of center. Your teacher will randomly select a student with his/her calculator. If you are randomly selected, tell your teacher if your haircut is closer to the mean or median price for your class. You may be called on more than once. You may never be selected. It's random. Tally the responses below.

Class Tally: Your individual haircut price is closer to the…..

Mean:

Median:

What percent of the 50 simulations were closer to the mean?________________________

What percent of the 50 simulations were closer to the median?______________________

If you randomly pick a student in your class, is it more likely that their price was closer to the mean or median?____________ Which is a better measure of center?_______________

Part III

Distribution of the Mean:

Use the RandInt feature on your calculator to randomly select 5 haircuts. Find the average price of these 5 haircuts. _______________

Repeat the process 2 more times.
What are the average prices for your other two simulations? ____________, ______________

Pool your class data. Record the class data on the dotplot below.

____

Distribution of the average price of a haircut…sample size 5

How does the shape of this distribution compare to the dotplot of individual prices that you graphed earlier?

Are there any outliers? __________________

What is the mean of the distribution of the average cost for sample size 5?_______

How does it compare to the mean of the distribution of individual prices? ____________

Would the mean be good to use for the distribution of the average? __________ Explain.

What is the standard deviation of the average cost for sample size 5? __________

How does this compare to the standard deviation of individual prices? ______________ Explain.

Part IV

Use the RandInt feature on your calculator to randomly select 12 haircuts. Find the average price of these 12 haircuts. _______________

Repeat the process 2 more times.
What are the average prices for your other two simulations? ____________, ______________

Pool your class data. Record the class data on the dotplot below.

____

Distribution of the average price of a haircut…..sample size 12

How does the shape of this distribution compare to the dotplot of individual prices that you graphed earlier?

Are there any outliers? ___________________

What is the mean of the distribution of the average cost for sample size 12?_______

How does it compare to the mean of the distribution of individual prices? ____________

Would the mean be good to use for the distribution of the average? __________ Explain.

What is the standard deviation of the average cost for sample size 12? __________

How does this compare to the standard deviation of individual prices? ______________ Explain.

Fill in the table below with the statistics that you have obtained.

Distribution	**Shape of the distribution**	**Mean of the Distribution**	**Standard Deviation of the Distribution**
Of individual data points in the population			
Of the mean for sample size = 5			
Of the mean for sample size = 12			

Summarize your findings below in a short paragraph.

Task 10 teacher:

This activity will once again reinforce the objective:

> d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.

The main difference is that the distribution of haircut prices will most likely not be a normal distribution. From the central limit theorem, which the students will formally be introduced in Math 3 and 4, we know that the mean of the averages is the same as the mean of the population for any sample size and shape.

The shape of the distribution of the means will become more normal-like as the sample size increases even if the population distribution of individual values is strongly skewed. This is something that most students may not intuitively understand.

The standard deviation of the sample means will decrease as the sample size increases. Theoretically, the standard deviation of the mean will equal the standard deviation of the population of individual outcomes divided by the square root of the sample size or: $\sigma_{\bar{x}} = \frac{\sigma_X}{\sqrt{n}}$.

In addition to laying the foundation for the central limit theorem, students will also use simulations to determine whether the mean or median is a better measure of center. They should have learned in Math I that the median is a better measure of center when the data is not normal. However, the simulation is a fun activity and it informally proves to them that the median will be a better measure of haircut price for a randomly selected student.

Part I

We have looked at sampling distributions taken from normal distributions (golden ratio and jump distances). Today we will examine a sampling distribution from a non-normal distribution.

What was the price of your last haircut/style/color? _______ You may want to include the cost of your last haircut.

Collect class data and draw dotplot of the distribution below.

Price of your last haircut

Describe the shape of the distribution. The shape will vary from class to class, but most likely it will not be normal. I found with my classes that there are usually a few females that pay a lot more money (especially if they get color or highlights) than most males. Several students may go to "Great Clips" or another chain salon and pay around $10. Occasionally, some students cut their own hair and pay nothing.

Calculate the mean and the standard deviation:_______________________

Calculate the median and the Interquartile range:______________________ They computed these last year. The IQR is the third quartile minus the first quartile.

Are there any outliers?__________________ If a value is beyond two standard deviations from the mean, it is an outlier. If the value is below the number:
First quartile - 1.5(IQR) or above the number Third quartile + 1.5(IQR), then it is an outlier.

Which is a better measure of center for the class data? Probably the median unless the distribution is symmetric. Why? Medians, unlike means, are resistant to outliers and strong skewness. The median is the 50^{th} percentile. It will be the middle of the distribution. The mean will be pulled toward the more extreme values.

Is your haircut price closer to the mean price or the median price? _____________

Part II

Perform a simulation 50 times to determine whether the mean or median is a better measure of center. Your teacher will randomly select a student with his/her calculator. If you are randomly selected, tell your teacher if your haircut is closer to the mean or median price for your class. You may be called on more than once. You may never be selected. It's random. Tally the responses below. To randomly select a student, give each student a number. Type "Math" "PRB" "RandInt(1, class size) to randomly select a student.

Class Tally: Your individual haircut price is closer to the…..

Mean:

Median:

What percent of the 50 simulations were closer to the mean?______

What percent of the 50 simulations were closer to the median?______

If you randomly pick a student in your class, is it more likely that their price was closer to the mean or median?_______ Which is a better measure of center?_________

Part III

Distribution of the Mean:

Use the RandInt feature on your calculator to randomly select 5 haircuts. Find the average price of these 5 haircuts. _________

Repeat the process 2 more times. What are the average prices for your other two simulations? ______ __________

Pool your class data. Record the class data on the dotplot below.

Distribution of the average price of a haircut…sample size 5

How does the shape of this distribution compare to the dotplot of individual prices that you graphed earlier? If your population distribution was strongly skewed, then this distribution will probably be skewed (not quite as strong) as well. If your population was barely skewed, then this distribution may look approximately normal. As your sample size increases, the shape should look more normal-like.

Are there any outliers?

What is the mean of the distribution of the average cost for sample size 5?_______ How does it compare to the mean of the distribution of individual prices?____________

Would the mean be good to use for the distribution of the average? ______ Explain.

What is the standard deviation of the average cost for sample size 5?__________ How does this compare to the standard deviation of individual prices?_______

Part IV

Use the RandInt feature on your calculator to randomly select 12 haircuts. Find the average price of these 12 haircuts. _________

Repeat the process 2 more times. What are the average prices for your other two simulations? ______ __________

Pool your class data. Record the class data on the dotplot below.

Distribution of the average price of a haircut…sample size 12

How does the shape of this distribution compare to the dotplot of individual prices that you graphed earlier?

Are there any outliers?

What is the mean of the distribution of the average cost for sample size 12?_______ How does it compare to the mean of the distribution of individual prices?____________

Would the mean be good to use for the distribution of the average? ______ Explain.

What is the standard deviation of the average cost for sample size 12?__________ How does this compare to the standard deviation of individual prices?_______

Fill in the table below with the statistics that you have obtained.

Distribution	**Shape of the distribution**	**Mean of the Distribution**	**Standard Deviation of the Distribution**
Of individual data points in the population			
Of the mean for sample size = 5			
Of the mean for sample size = 12			

Summarize your findings below in a short paragraph.

You should expect the shape of the distribution to become more normal-like as the sample size increases. The mean should be about the same as the mean of the population regardless of sample size. The standard deviation of the mean should decrease as the sample size increases.

Attachment 2

Cumulative Task #1 student:
Part I

Mr. Jung is a statistics teacher who also volunteers to run the school store. He needed to order a new style of t-shirt, but he had no idea how many shirts he should order. There are 2000 girls in the school, but their sizes vary. He knew that there was a relationship between height and t-shirt size, so he decided if he knew the distribution of heights of high school girls at his school, he could get a rough estimate of sizes he should order.

What question does Mr. Jung need to investigate?

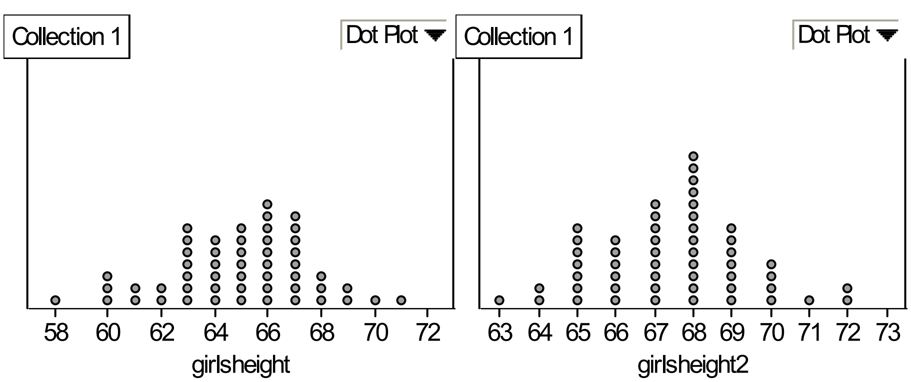
He sent two students, Bonnie and Jessica, to collect the data. Bonnie is a counselor's aide during 2nd period and was allowed to collect the data during that period. There were 172 classes in session during 2nd period. She collected her data as follows:

- She listed the names of all of those teachers in alphabetical order.
- She typed on her calculator RandInt (1, 172) to choose 2 unique numbers.
- She went to those classes and measured every girl's height

Jessica's schedule did not allow her to collect data during school hours. She had to collect data after school instead. The only girls that she could find after school were practicing for the volleyball and basketball teams. She wanted to match the sample size of Bonnie, so from the 62 girls at practice, she collected her data as follows:

- She listed the names of the 62 girls in alphabetical order.
- She typed on her calculator RandInt (1,62) to choose 52 unique numbers.
- She measured the height of each of the 52 girls she randomly selected.

The dotplots that they presented to Mr. Jung are shown below.

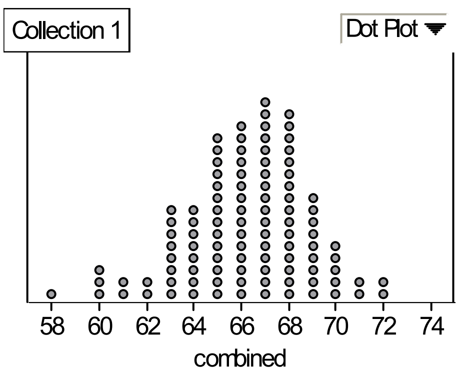


Circle the distribution of the data that Jessica collected? Why do you think that this is Jessica's data?

Mr. Jung knows that heights vary normally, so when he glanced at the two samples he did not see anything unusual. When he sat down to place the order, he noticed that there were some differences in the distributions. Compare the two distributions. Be sure to include the mean and standard deviation in your discussion.

When Mr. Jung noticed the discrepancy, he asked both girls if they used random techniques to obtain their samples. Bonnie and Jessica promised that they did, so Mr. Jung believed them without further investigation. Why would it be plausible for both girls to come up with different means if they both used random techniques to gather their samples?

He decided to combine the two samples to make one distribution of sample size 104. Below is the dotplot:



Calculate the mean and standard deviation of the combined distribution.

Mr. Jung decides to compare all three distributions to determine what percent of shirt sizes he should order. From past experience, he knows the following:

- girls who prefer x-small shirts are 1.5 standard deviations below the average height
- girls who prefer small shirts are between 1.5 and .5 standard deviations below the average height
- girls who prefer mediums are between .5 standard deviations below and above the average height
- girls who prefer large shirts are between .5 and 1.5 standard deviations above the average height.
- girls who prefer x-large shirts are above 1.5 standard deviations above the average height

He condensed this information into the following table for each distribution. Fill out the table to compare the distributions.

	μ_X	σ_X	$\mu_X - .5\sigma_X$	$\mu_X + .5\sigma_X$	$\mu_X - \sigma_X$	$\mu_X + \sigma_X$	$\mu_X - 1.5\sigma_X$	$\mu_X + 1.5\sigma_X$
Girls height								
Girls height 2								
Combined								

Based on the table above and the associated dotplots, he then tallied the number of girls from each distribution who might wear a certain shirt size based on his classification system as described above.

Record this information in the table below:

Number of girls who wear a size:	Extra small	small	medium	large	Extra large
Girls height					
Girls height 2					
Combined					

He then converted these numbers to percents to find:

Percent of girls who wear a size:	Extra small	small	medium	large	Extra large
Girls height					
Girls height 2					
Combined					

Mr. Jung was going to order 250 shirts. Based on the distributions and the answers from the table above, how many of each size would you recommend to order? Explain.

Part II

Based upon the data you collected, complete the following:

Record your individual project data on the dotplots below.

Student 1 | Student 2

Calculate the mean and standard deviation of each set of data.

Combine your data and complete the following dotplot:

Combined Data

Calculate the mean and standard deviation of the combined distribution.

Condense this information into the following table for each distribution. Fill out the table to compare the distributions.

	μ_X	σ_X	$\mu_X - .5\sigma_X$	$\mu_X + .5\sigma_X$	$\mu_X - \sigma_X$	$\mu_X + \sigma_X$	$\mu_X - 1.5\sigma_X$	$\mu_X + 1.5\sigma_X$
Student 1								
Student 2								
Combined								

Summarize your findings.

Cumulative Task #1 teacher:

*****NOTE: At any time charts can be added for differentiation.**

This task incorporates the following standards:

MM2D1: Using sample data, students will make informal inferences about population means and standard deviations

a. Pose a question and collect sample data from at least two different populations.
b. Understand and calculate the means and standard deviations of sets of data
c. Use means and standard deviations to compare data sets
d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next.

Part I

Mr. Jung is a statistics teacher who also volunteers to run the school store. He needed to order a new style of t-shirt, but he had no idea how many shirts he should order. There are 2000 girls in the school, but their sizes vary. He knew that there was a relationship between height and t-shirt size, so he decided if he knew the distribution of heights of high school girls at his school, he could get a rough estimate of sizes he should order.

What question does Mr. Jung need to investigate? What is the distribution of heights of girls at his high school?

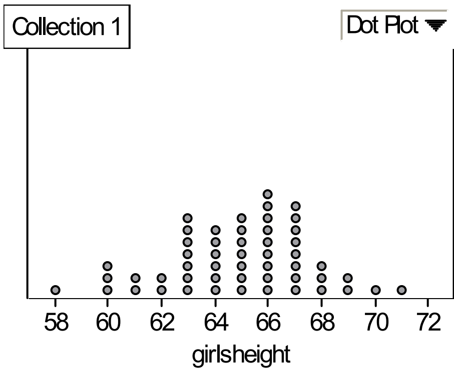
He sent two students, Bonnie and Jessica, to collect the data. Bonnie is a counselor's aide during 2nd period and was allowed to collect the data during that period. There were 172 classes in session during 2nd period. She collected her data as follows:

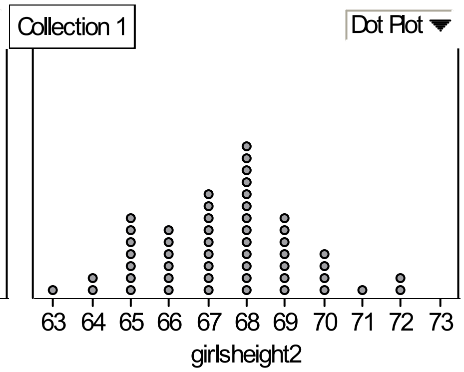
- She listed the names of all of those teachers in alphabetical order.
- She typed on her calculator RandInt(1, 172) to choose 2 unique numbers.
- She went to those classes and measured every girl's height

Jessica's schedule did not allow her to collect data during school hours. She had to collect data after school instead. The only girls that she could find after school were practicing for the volleyball and basketball teams. She wanted to match the sample size of Bonnie, so from the 62 girls at practice, she collected her data as follows:

- She listed the names of the 62 girls in alphabetical order.
- She typed on her calculator RandInt(1,62) to choose 52 unique numbers.
- She measured the height of each of the 52 girls she randomly selected.

The dotplots that they presented to Mr. Jung are shown below.





Circle the distribution of the data that Jessica collected? Why do you think that this is Jessica's data? Since Jessica only measured heights of girls involved with the school sports, her distribution is "girls height 2". You would expect those girls on the basketball and volleyball team to be taller on average.

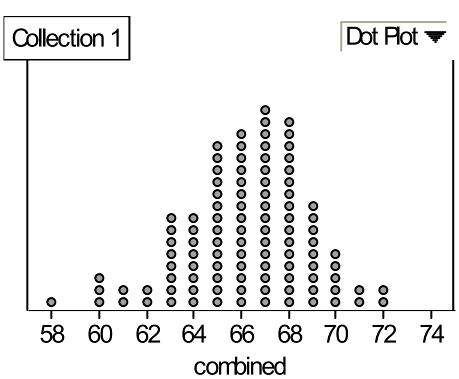
Mr. Jung knows that heights vary normally, so when he glanced at the two samples he did not see anything unusual. When he sat down to place the order, he noticed that there were some differences in the distributions. Compare the two distributions. Be sure to include the mean and standard deviation in your discussion.

The mean of girls height = 64.942 and its standard deviation is 2.689.
The mean of girls height 2 = 67.44 and its standard deviation is 1.984.

The girls height distribution has a smaller mean but more variability than girlsheight2. You should expect this because girls involved with school sports teams are generally taller than average so there is less variability than compared to the general population.

When Mr. Jung noticed the discrepancy, he asked both girls if they used random techniques to obtain their samples. Bonnie and Jessica promised that they did, so Mr. Jung believed them without further investigation. Why would it be plausible for both girls to come up with different means if they both used random techniques to gather their samples? It would be plausible because sample means vary from sampling distribution to sampling distribution.

He decided to combine the two samples to make one distribution of sample size 104. Below is the dotplot:



Calculate the mean and standard deviation of the combined distribution.
The mean is 66.192 and its standard deviation is 2.666.

Mr. Jung decides to compare all three distributions to determine what percent of shirt sizes he should order. From past experience, he knows the following:

- girls who prefer x-small shirts are 1.5 standard deviations below the average height
- girls who prefer small shirts are between 1.5 and .5 standard deviations below the average height
- girls who prefer mediums are between .5 standard deviations below and above the average height
- girls who prefer large shirts are between .5 and 1.5 standard deviations above the average height.
- girls who prefer x-large shirts are above 1.5 standard deviations above the average height

He condensed this information into the following table for each distribution. Fill out the table to compare the distributions. (note: these values have been rounded to fit in the table)

	μ_X	σ_X	$\mu_X - .5\sigma_X$	$\mu_X + .5\sigma_X$	$\mu_X - \sigma_X$	$\mu_X + \sigma_X$	$\mu_X - 1.5\sigma_X$	$\mu_X + 1.5\sigma_X$
Girls height	64.9	2.7	63.6	66.3	62.25	67.63	60.91	68.98
Girls height 2	67.4	1.98	66.5	68.4	65.46	69.43	64.46	70.42
Combined	66.2	2.7	64.9	67.5	63.5	68.9	62.19	70.19

Based on the table above and the associated dotplots, he then tallied the number of girls from each distribution who might wear a certain shirt size based on his classification system as described above.

Record this information in the table below:

Number of girls who wear a size:	Extra small	small	medium	large	Extra large
Girls height	4	11	22	11	4
Girls height 2	3	13	22	11	3
Combined	8	16	46	30	4

He then converted these numbers to percents to find:

Percent of girls who wear a size:	Extra small	small	medium	large	Extra large
Girls height	7.7%	21.1%	42.3%	21.1%	7.7%
Girls height 2	5.7%	25%	42.3%	21.1%	5.7%
Combined	7.7%	15.4%	44.2%	28.8%	3.8%

Mr. Jung was going to order 250 shirts. Based on the distributions and the answers from the table above, how many of each size would <u>you</u> recommend to order?

The amount ordered for each distribution would be as follows:

Percent of girls who wear a size:	Extra small	small	medium	large	Extra large
Girls height	19	53	106	53	19
Girls height 2	14	63	106	53	14
Combined	8	16	46	30	4

The student should use the "Girls height" distribution because it should be most representative of the population of girls at their high school. Although random techniques were used, "Girls height 2" was taken from a non-representative sample. Although the sample size was larger for the combined distribution, it did not combine two representative samples. Therefore, it would overestimate the larger sizes.

Part II

Students will have collected data during the population and sample part of the unit.

Based upon the data you collected, complete the following:

Record your individual project data on the dotplots below.

________________________________ ________________________________

Student 1 Student 2

Calculate the mean and standard deviation of each set of data.

Combine your data and complete the following dotplot:

____

Combined Data

Calculate the mean and standard deviation of the combined distribution.

Condense this information into the following table for each distribution. Fill out the table to compare the distributions.

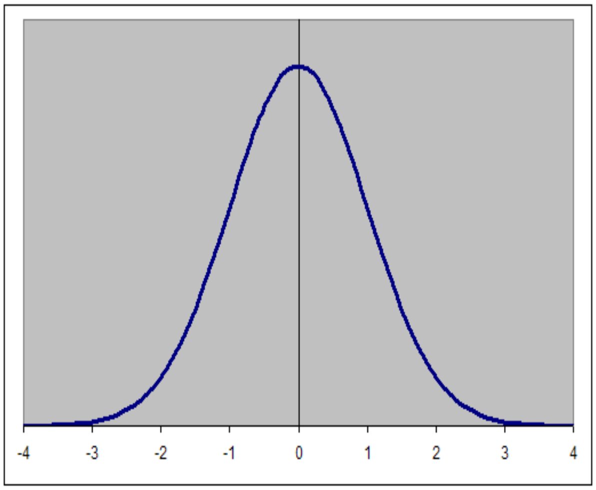
	μ_X	σ_X	$\mu_X - .5\sigma_X$	$\mu_X + .5\sigma_X$	$\mu_X - \sigma_X$	$\mu_X + \sigma_X$	$\mu_X - 1.5\sigma_X$	$\mu_X + 1.5\sigma_X$
Student 1								
Student 2								
Combined								

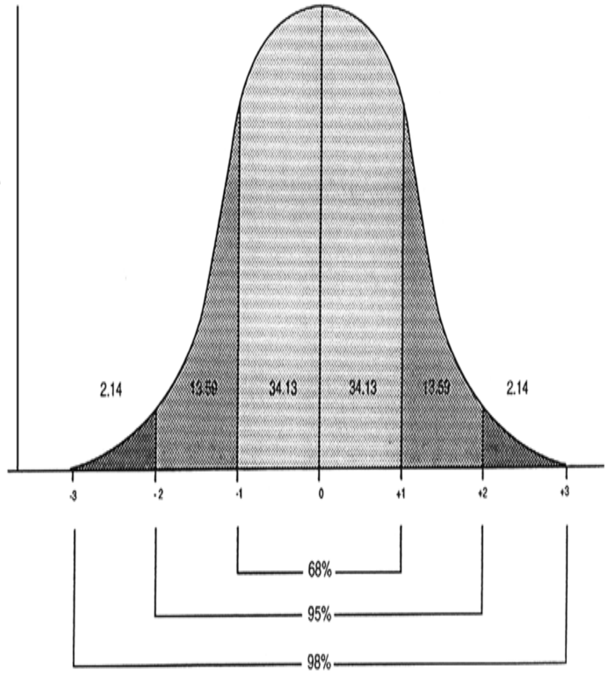
Summarize your findings.

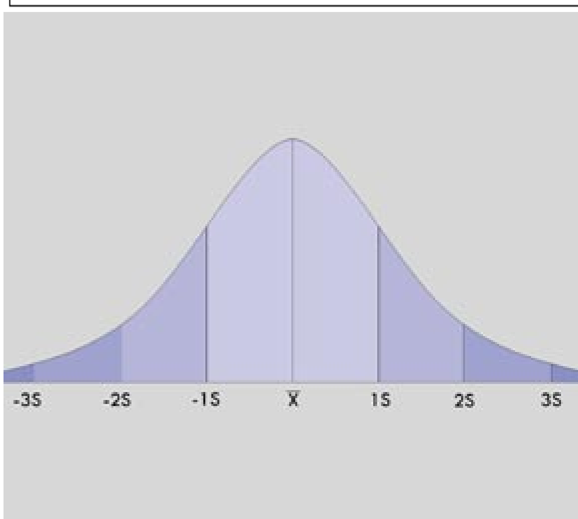
Cumulative Assignment Instructions

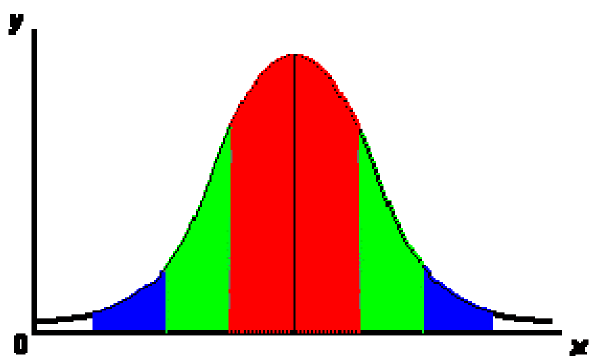
This assignment will be used throughout the data analysis section. On day 6 of this unit, students will be paired up and given the task of selecting a data analysis project. The project topic from each group will be submitted to the teacher for approval. The students will be given a deadline to submit topic and an assigned number of days to gather the data. Sample topics include the following: student smokers vs student nonsmokers, compare distance measurement of 2 brands of golf balls, soft drink preference, compare distance measurement of baseballs/softballs hit with 2 different brands of bats, fast food chain preference, etc. The data will then be used to complete part II of cumulative task 1.

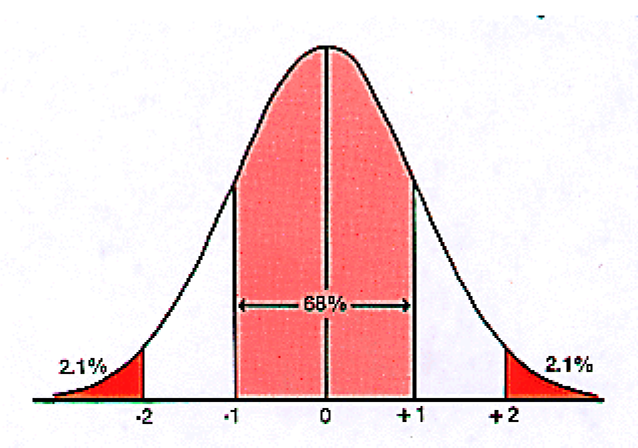
Additonal Normal Bell Curves:











ADDITIONAL PRACTICE:

Which things around you are made in the golden ratio?

Measure the following with a centimeter measuring tape or stick. (Round measurements to the nearest .5 cm.) Then rank the items from closest (1) to the golden ratio to least close (4).

Rank	Item Measured	Length(cm)	Width(cm)	Ratio(L:W)
	TV screen			
	Calculator			
	Math Textbook			
	Notebook paper			
	$1 Bill			

Find an item that has a ratio even closer to the golden ratio.

List its dimensions and ratio below.

Item Measured	Length(cm)	Width(cm)	Ratio(L:W)

A Golden Ratio Activity

A GOLDEN GREEK FACE

Toolbox: Calculator; metric ruler (measures to mm)

Statues of human bodies considered most perfect by the Greeks had many Golden Ratios. It turns out that the "perfect" (to the Greeks) human face has a whole flock of Golden Ratios as well.

You'll be measuring lengths on the face of a famous Greek statue (with a broken nose) by using the instructions on this page. Before you start, notice that near the face on the second page are names for either a location on the face or a length between two places on the face. Lines mark those lengths or locations exactly.

Using your cm/mm ruler and the face picture on the next page, find each measurement below to the nearest millimeter, that is tenth of a cm or .1cm (___._ cm). Remember, you are measuring the **distance** or **length** between the **two locations** mentioned. You can use the marking lines to place the ruler for your measurements. Fill in this table.

a	= Top-of-head to chin	=	___.__	cm
b	= Top-of-head to pupil	=	___.__	cm
c	= Pupil to nosetip	=	___.__	cm
d	= Pupil to lip	=	___.__	cm
e	= Width of nose	=	___.__	cm
f	= Outside distance between eyes	=	___.__	cm
g	= Width of head	=	___.__	cm
h	= Hairline to pupil	=	___.__	cm
i	= Nosetip to chin	=	___.__	cm
j	= Lips to chin	=	___.__	cm
k	= Length of lips	=	___.__	cm
l	= Nosetip to lips	= ___.__ cm		

Now **use these letters** and go on to the next page to compute **ratios** with them with your calculator. Remember: a/g, the first one, means find measurement **a** divided by measurement **g** as a **rounded-off 3-decimal-place** value.

Finding the Gold

Now, find these ratios to three decimal places, using your calculator:

$\frac{a}{g} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______

$\frac{b}{d} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______

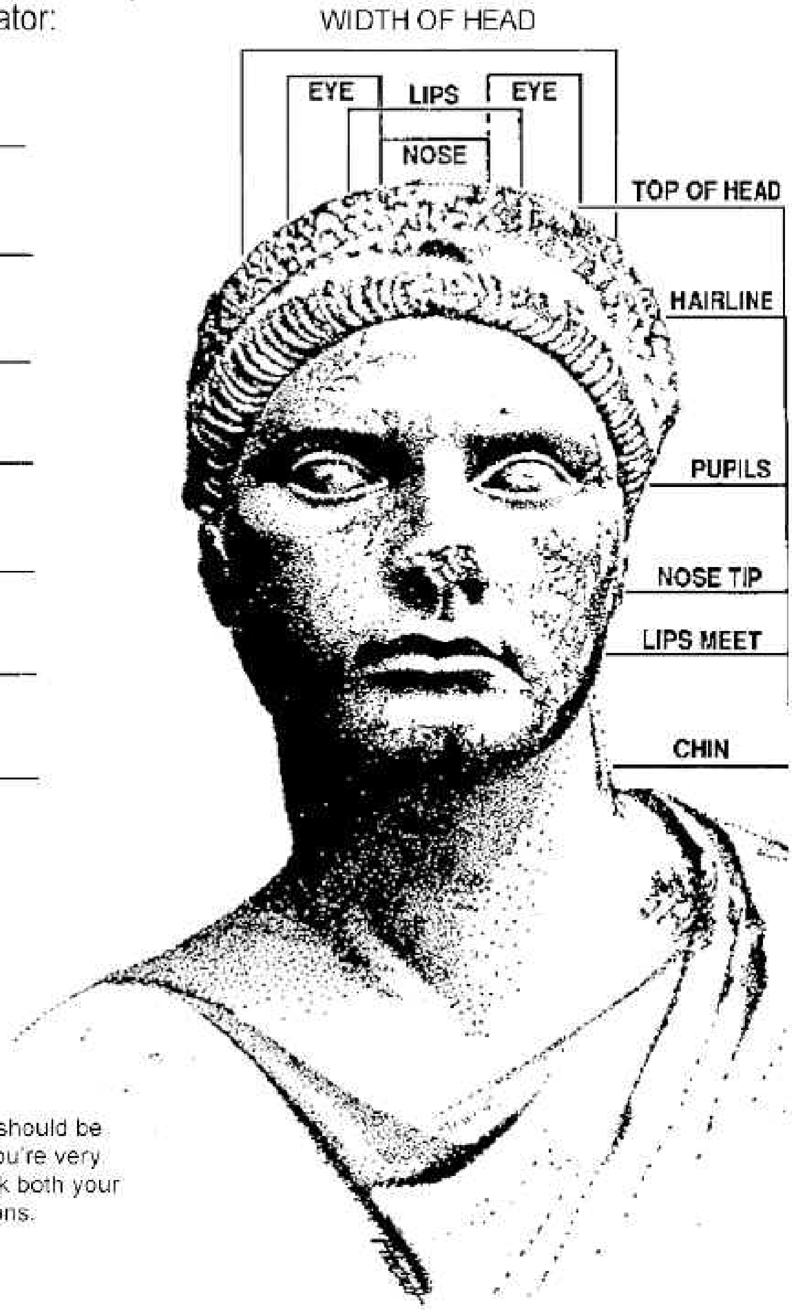
$\frac{i}{j} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______

$\frac{i}{c} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______

$\frac{e}{l} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______

$\frac{f}{h} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______

$\frac{k}{e} = \frac{\_\_\_\ cm}{\_\_\_\ cm} =$ ______



Your answers to the above ratios should be near the Golden Ratio, 1.618. If you're very far off on any one of them, recheck both your measurements and your calculations.