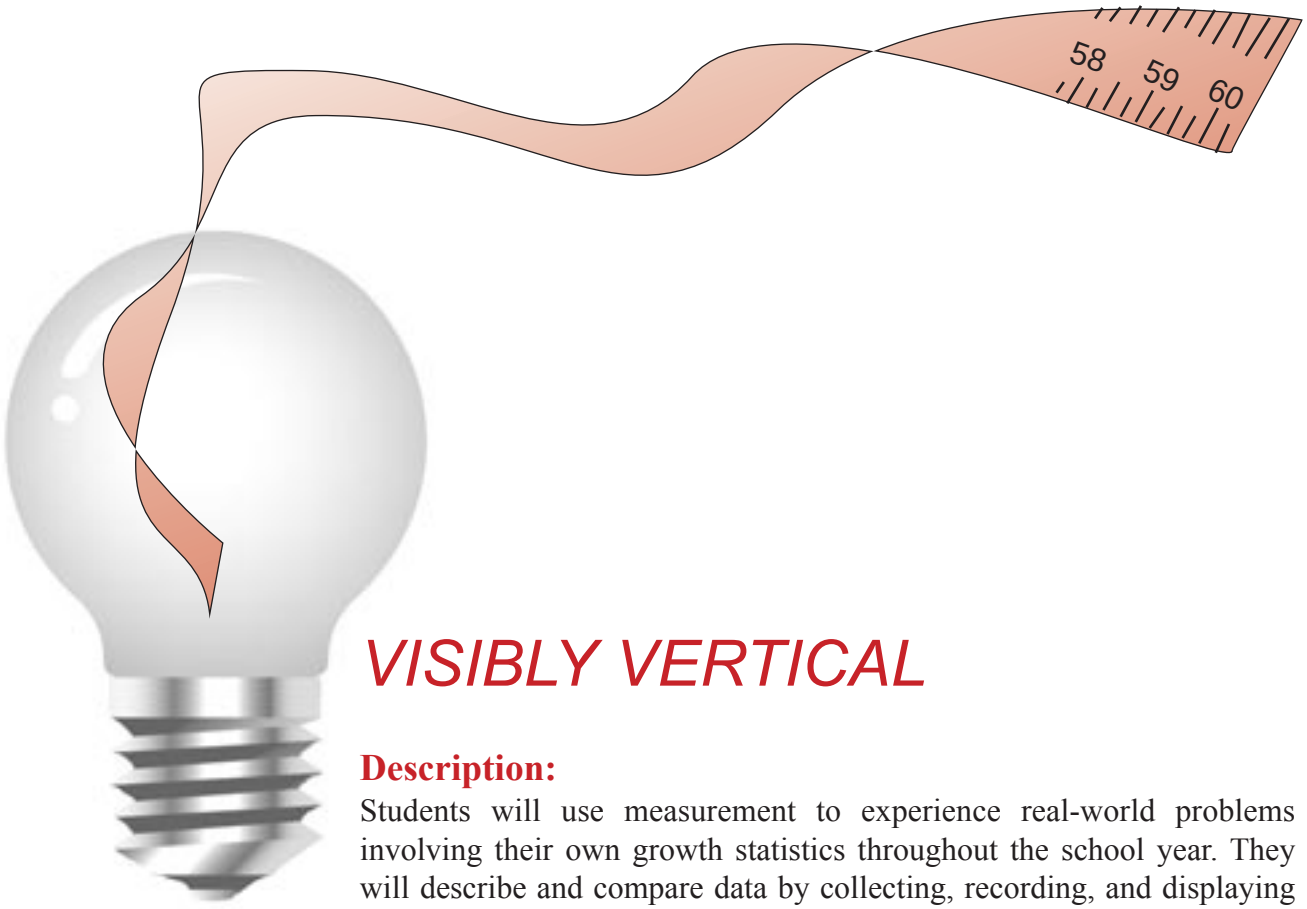
Key Idea 5—Measurement:

Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.

Overview:

Students need to be able to estimate, make, and use measurement in real-world situations. They should be aware that measurement is approximate, never exact. Elementary students learn how to use appropriate measurement tools and come to understand the various measurement attributes. The students begin to use statistical methods such as graphs, tables, and charts to display and interpret data. Intermediate students continue to develop measurement skills, explore measures of central tendency, and informally derive and apply measurement formulas. Commencement-level students build on their measurement skills, using dimensional analysis techniques and statistical methods. They need to understand error in measurement and its consequence on subsequent calculations.



VISIBLY VERTICAL

Description:

Students will use measurement to experience real-world problems involving their own growth statistics throughout the school year. They will describe and compare data by collecting, recording, and displaying data in various ways. Students will measure each other's height on the first Friday of each month. They will keep monthly records of their height. Each time the heights are recorded, the teacher will have measurement activities for the students to investigate.

Elementary Performance Indicators

Students will:

- Understand that measurement is approximate, never exact.
- Select appropriate standard and nonstandard measurement tools in measurement activities.
- Understand the attributes of length.
- Estimate and find measures such as length using both nonstandard and standard units.
- Collect and display data.
- Use statistical methods such as graphs, tables, and charts to interpret data.

PreK – K

1. Have students discuss different types of **nonstandard** tools (e.g., blocks, books, hands) to **measure length**.
2. Mark off heights of the students against the wall.
3. Ask the class to decide on a nonstandard tool to measure their heights.
4. As you compare student heights, use expressions such as **taller than**, **shorter than,** or the **same as**.
5. Ask students to find classmates who are taller, shorter, and/or the same height as they are.

Grades 1 – 2

1. Have students measure heights using nonstandard units.
2. Explain **meterstick**, **meter**, and **centimeter**.
3. Have students measure their heights in centimeters using metersticks (see Activity Sheet 1).
4. Have students investigate **similarities** and **differences** of **data**.
5. Make a **pictograph** of students' heights for one month.
6. Make a **bar graph** of students' heights for another month.
7. Compare heights over time.

Grades 3 – 4

1. Have students decide how to obtain the most accurate measurement of their height. Ask students what unit they should use. Ask students how they can make sure their measurements are accurate.
2. Measure the height of each student monthly (see Activity Sheet 2).
3. Using **tally** marks, have students organize **data** into a **frequency table**. Make a **pictograph** to display the number of students in each **interval** using fractional symbols. For example, if one smiley face represents two students, half a smiley face represents one student.
4. Discuss how to get the **average** class height. Have students make predictions.
5. Have students find the **mean** and the **range** of the data each month.
6. After collecting data for six months, have students **plot** their height for each of the previous months as a **line graph**.
7. At the end of the year, have students graph the class mean for each month. Discuss the concept of growth over time.

Intermediate Performance Indicators

Students will:

- Estimate, make, and use measurements in real-world situations.
- Select appropriate standard and nonstandard measurement units and tools to measure to a desired degree of accuracy.
- Develop measurement skills and informally derive and apply formulas in direct measurement activities.
- Use statistical methods and measures of central tendencies to display, describe, and compare data.
- Explore and produce graphic representations of data using calculators/computers.
- Develop critical judgment for the reasonableness of measurement.

Grades 5 – 6

1. Have students decide how to obtain the most **accurate** measurement of their height. Discuss the concept of accuracy. Ask students what unit they want to use. Introduce **millimeters** as a more precise unit of measure. How can they be certain they are accurate?
2. Working in pairs, students should measure each other's height monthly. This yearlong project is described in Activity Sheet 3.
3. Have students organize data into a **frequency table** and display their results as a graph. (The teacher can also display **bar graphs**, **line graphs**, and **histograms** on a **graphing calculator**.)
4. Looking at the display of the different graphs, discuss how to approximate the **average** class height. Have students write a short essay making **predictions** about the mean.
5. Have students find the **mean**, **median**, **mode**, and **range** of the data each month.
6. In the sixth month, have the students **plot** their height for each of the previous months on a **coordinate plane**. Have students write a summary of their personal statistics for the previous months' data.
7. At the end of the year, have students **graph** the mean class height for each month. Discuss the concept of growth over time.
8. At the end of the year, have students make individual line graphs of their own growth. Have students write a short essay making **predictions** of their height at the end of the next year.

Grades 7 – 8

1. Have students decide how to get the most accurate measurement of their height. Ask students what units they should use and why. Students should discuss how to obtain the most accurate measurement with the tools they have. (Students could use a carpenter's level to help get accurate heights.)
2. Working in pairs, students should measure each other's height monthly and record the heights in centimeters, to the nearest tenth of a centimeter (see Activity Sheet 4, Part 1).
3. Have students organize class data into a **frequency table** and **cumulative frequency table** and display their results as histograms (see Activity Sheet 4, Part 2).
4. Have students find the mean, median, mode, and range of the data each month.
5. Compare students' heights in centimeters (the **metric system**) to their heights in feet and inches (the **English system**). Compare heights to the heights of famous people. Data are available on the Internet or in resource books (see Activity Sheet 5).
6. In the sixth month, have the students plot their height for each of the previous months on graph paper. Have students use their data to write a summary of their personal statistics.
7. At the end of the year, have students graph the mean for each month. Discuss the concept of growth over time.
8. At the end of the year, have students make individual line graphs of their own growth. Have students write a short summary making predictions of their height at the end of the next year.

Commencement Performance Indicators

Students will:

- Choose the appropriate tools for measurement.
- Use statistical methods including measure of central tendency to describe and compare data.
- Understand error in measurement and its consequence on subsequent calculations.
- Apply the normal curve and its properties to familiar contexts.
- Use statistical methods, including scatterplots and lines of best fit, to make predictions.
- Apply the conceptual foundation of rate of change.
- Determine optimization points on a graph.

Math A

1. Have students measure their height. Let them decide the unit of measure and how to get the most accurate measurement possible (see Activity Sheet 6, Part 1).
2. Have the students display the data graphically.
3. Have students find the **mean**, **median**, **mode**, and **range** for the class data.
4. Have students construct a **cumulative frequency distribution chart** and a **histogram** of the data (see Activity Sheet 6, Part 2).
5. Have students construct a **box and whisker plot** of the data. Have students write a short essay about what the plot represents.
6. Give each student a Medical Association Growth Chart, found on pages 103 – 104 or at www.cdc.gov/growthcharts. Have students find in which **percentile** their own height falls. Have students predict what their height will be in six months, one year, and two years (see Activity Sheet 6, Part 3).
7. Have students input their data into the statistical function of a graphing calculator and find the mean, median, mode, range, and **upper** and **lower quartiles** of the data.
8. Extension: Have students find the **line of best fit** for their data. Plot the data and the line of best fit on graph paper. Write a summary explaining where the best-fit line approximates the data. Be specific about where it fits well and where it does not. **Interpolate** half-year points and **extrapolate** points beyond the graph.

Math B

1. Have students obtain their height. Let them decide the unit of measure and how to get the most accurate measurement possible.
2. Have the students display the data graphically.
3. Find mean, median, mode, range, and **standard deviation** for the class. Compare the class data to a **normal distribution curve**. Discuss percentages.
4. Give each student a Medical Association Growth Chart. Have students find in which percentile their own height falls and predict what their height will be in six months, one year, and two years (see Activity Sheet 7).
5. Have students input their data into the statistical function of a graphing calculator.
6. Have students find the **equation of best fit** for their data. Plot the data and the equation of best fit on graph paper. Write a summary explaining where the best-fit equation approximates the data. Be specific about where it fits well and where it does not. **Interpolate** half-year points and **extrapolate** points beyond the graph.

Activity Sheet 1

MY MONTHLY HEIGHT RECORD

_____**'s Height Record**

September	October	November	December	January
cm	cm	cm	cm	cm

I notice that

_____

_____

February	March	April	May	June
cm	cm	cm	cm	cm

The greatest difference was

_____

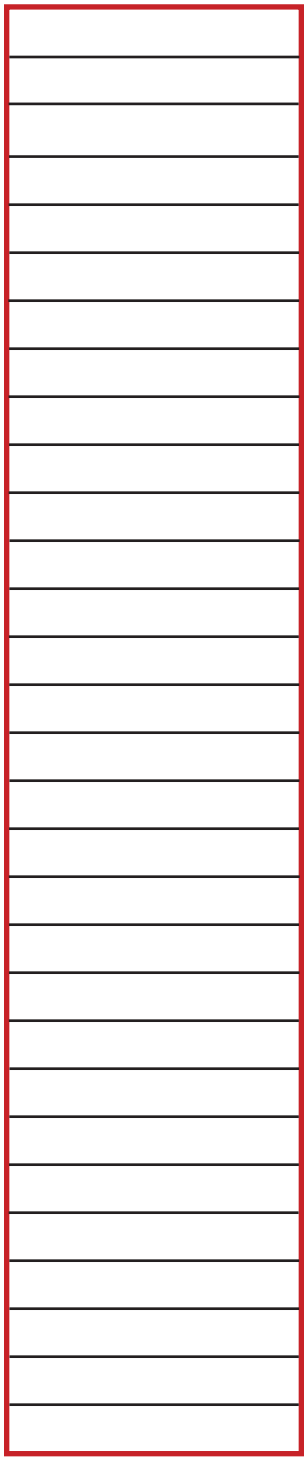
_____

Activity Sheet 2

MONTHLY HEIGHT RECORD

Month _____

Height (cm)



Describe how to find the **mean** and the **range** for the data.

mean _____

range _____

Activity Sheet 3

VISIBLY VERTICAL JOURNAL

First page should include the following information:

- Title (*Visibly Vertical*)
- School Year
- Name
- Class/Section
- Teacher

Project:
Working in pairs, students will measure each other's height on the first Friday of each month and record the data.

Journal Entries:

- After a small group discussion concerning the concept of *accuracy in measurement*, write a brief summary of the class data.
- Make a frequency table of the first month's heights and display results as a graph.
- After observing different types of graphs displayed on a graphing calculator and discussing how to calculate the class average, write a short summary about your prediction of the mean.
- Organize a chart to keep track of the mean, median, mode, and range of the data *each* month.
- In the sixth month, plot your height for each of the previous months on graph paper. Write a summary of your personal statistics for the previous months' data.
- At the end of the year, graph the class mean for each month and discuss growth over time.
- At the end of the year, make a line graph of your own growth. Predict your height at the end of the *next* school year and justify your prediction.
- Write a summary of what you learned from doing this project.

Activity Sheet 4

PART 1: VISIBLY VERTICAL—MONTHLY CHART

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Mean										
Median										
Mode										
Range										

PART 2

Heights for _____ (*month)*

Interval	Tally	Frequency

Interval	Cumulative Frequency

1. Construct a frequency histogram.
2. Construct a cumulative frequency histogram.
3. What is the difference between the frequency histogram and the cumulative frequency histogram?

May:
Make a graph of your own height for the previous months. Find the mean, median, mode, and range for your own growth. Using your data, write a short summary about what these statistics mean. Make predictions about what your height will be in six months, one year, and three years, if the current trend continues.

June:
Make a line graph of the mean class height for each month over the last 10 months. What trend do you see?

Activity Sheet 5

HEIGHTS OF SOME FAMOUS PEOPLE

Angelina Jolie	**5′ 7″**
Brad Pitt	**6′ 0″**
Carmen Electra	**5′ 4″**
David Duchovny	**6′ 0″**
Gwyneth Paltrow	**5′ 10″**
Julia Roberts	**5′ 9″**
Leonardo DiCaprio	**6′ 0″**
Mel Gibson	**6′ 0″**
Reese Witherspoon	**5′ 6″**
Sandra Bullock	**5′ 8″**
Tyrone “Muggsy” Bogues	**5′ 3″**
Wilt Chamberlain	**7′ 1″**

Activity Sheet 6

PART 1: VISIBLY VERTICAL—HEIGHTS

HEIGHT
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.

HEIGHT
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.

1. Find the:
   - a. Mean _____
   - b. Median _____
   - c. Mode _____
   - d. Range _____
   - e. Upper quartile _____
   - f. Lower quartile _____

2. Construct a box and whisker plot that represents the heights of the class.

3. Input the class heights into a graphing calculator. Calculate the mean, median, mode, range, upper quartile, and lower quartile. Compare your results.

4. Calculator results:
   - a. Mean _____
   - b. Median _____
   - c. Mode _____
   - d. Range _____
   - e. Upper quartile _____
   - f. Lower quartile _____

5. Using a graphing calculator, create a box and whisker plot from the data. How does this graph compare to your box and whisker plot?

PART 2

Divide the range into 6 – 10 subdivisions of equal length.
Complete a frequency and a cumulative frequency distribution chart.

Interval	Tally	Frequency

Interval	Cumulative Frequency

Construct a cumulative frequency histogram from the data above.

PART 3

Find your height on the growth chart.

1. In what percentile is your height found?
2. What does the percentile represent?
3. Using your percentile curve, enter the height at each age according to the growth chart.

AGE (YEARS)	HEIGHT	AGE (YEARS)	HEIGHT
1		**10**	
2		**11**	
3		**12**	
4		**13**	
5		**14**	
6		**15**	
7		**16**	
8		**17**	
9		**18**	

Enter the data into your graphing calculator.
Using the statistics function, find the line of best fit.

1. What is the equation of the line of best fit?
2. What is the slope of the line of best fit?
3. What does the slope of this line represent?
4. What is the *y*-intercept?
5. What does the *y*-intercept of this line represent?
6. Write a summary explaining why, or why not, your equation is a good representation of your growth. Where does it fit best?
7. Interpolate. (How tall were you when you were 5 1/2 years old?)
8. Extrapolate. (According to the line, how tall will you be when you are 30 years old?)
9. Do these values make sense? Explain.

Activity Sheet 7

HEIGHT AND WEIGHT FOR GROWING CHILDREN

Background:
Doctors use charts to assess children's growth. They compare the height and weight of the child to that of other children of the same age. You have been given a copy of the chart they use to monitor a child's growth. In order to computerize this information, we need to translate the charts into functions.

Find your own height on the chart and determine in which percentile your height falls.

Comparing Models for a Child's Growth:
Construct a table of values for your percentile for each age on your curve (2 – 18). Use your calculator to determine the regression equations for your data. Check three different models: linear (LINReg), logarithmic (LNReg), and exponential (EXPReg). Construct a graph that includes all three functions and the actual data points. Compare each model (function) to the actual data. Write a description of how well each model fits the given data. Be specific about where it fits well and where it doesn't.

Construct the Best Model:
Break the data into sections and choose which type of model is best for each section. For each new section, find a new regression equation that fits. Construct a new chart that uses the different equations for the different sections of the curve (thus creating a perfect fit for your data). Describe how well your new model fits the data. Discuss the decisions you made about where and how to break up the data. Describe alternate solutions you tried.

Interpolate and Extrapolate:
Choose a point between two of your actual data points (half-year data point) and compare the values given by the different models. Which values make the most sense? Which would you throw out? Choose a data point after the values on your curve and compare the values given by the different models. Which values make the most sense? Which would you throw out?

Rate of Change:
Describe how the rate of change of a child's growth varies over the years. Describe how this is reflected in each of your models.

End Behavior of Models:
Describe what is happening to the growth of the child at the end of your curve. Compare this to the behavior of each of your models if the curve were continued. Discuss why your model will or will not give accurate values for an 80-year-old.

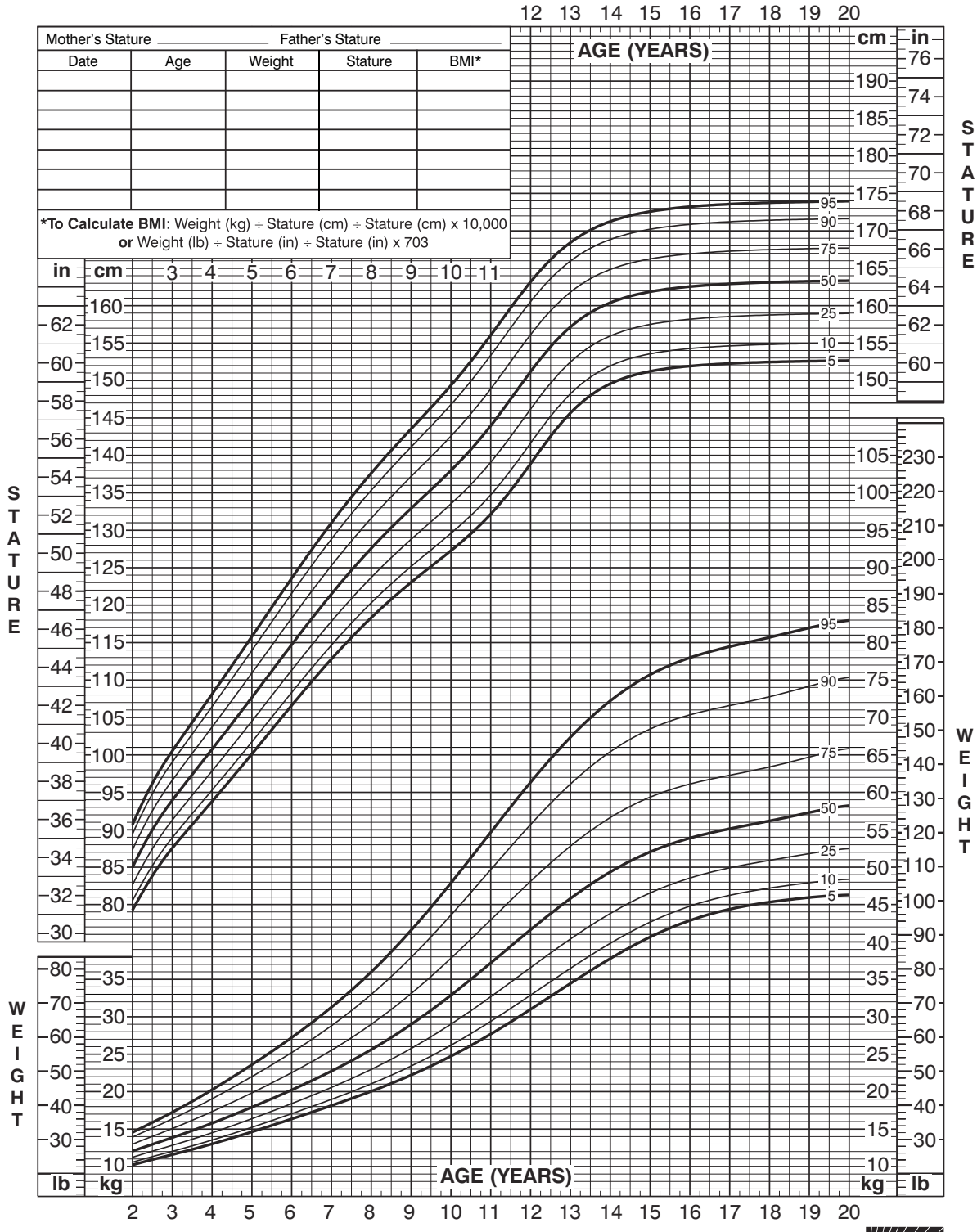
Summarize:
What function(s) would you use to model your percentile curve? Justify why this is the best model for the data. What unique observations, applications to the real world, or general rule do you feel fit this project? Elaborate.

Growth Chart I

2 to 20 years: Girls
Stature-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____



Published May 30, 2000 (modified 11/21/00).

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

CDC
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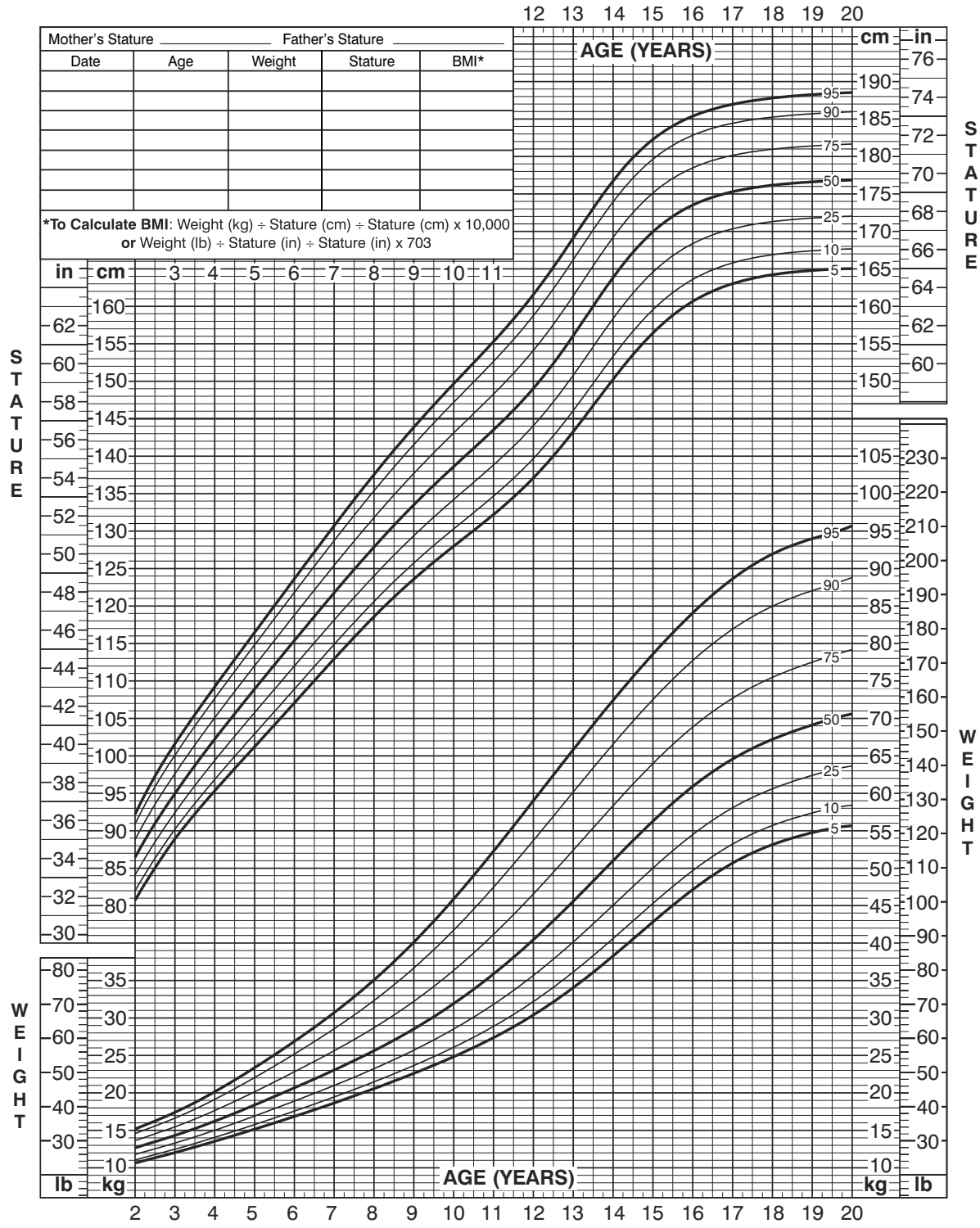
Growth Chart II

2 to 20 years: Boys
Stature-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____



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