# Pre-Algebra Mathematics Support Curriculum

## Unit 1: Wind Power

### Summary

The first unit of the summer mathematics support program asks students to design a wind turbine that will transfer the most wind energy into electricity. While learning about the design elements of a rotor, students will review how to perform arithmetic with fractions, how to measure angles, and how to properly graph data sets.

Expected Time: 1 week of a summer mathematics camp, or 3 weeks during the school year (50-minute periods)

**Lesson Descriptions**

**Lesson 1: The Engineering Notebook**
30 minutes
Students set up their engineering notebooks for use during the remainder of the course. The engineering notebook teaches effective and thorough note-taking skills, as well as good organization and study habits.

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**Lesson 2: Introduction to Wind Power**
120–150 minutes
The class learns the basic parts of a wind turbine. Fraction operations are reviewed in the context of measurement. To apply their fraction skills, students design and build a windmill tower to fulfill area and height constraints.

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**Lesson 3: Experiment with Blade Shapes**
150–180 minutes
Students review how to multiply fractions, create organized data tables, and appropriately scale graphs. They apply these skills during experiments on how blade shape affects voltage output of wind turbines.

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**Lesson 4: Angles of Attack**
120–150 minutes
Students practice using protractors to measure angles in a real-world application. They learn about angle of attack and its effect on the aerodynamics of a wind turbine rotor. Experiments with different blade shapes and angles of attack are performed to see how these characteristics affect voltage output.

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**Lesson 5: Rotor Design Contest**
240–270 minutes
Scrap material is discussed and percentages are calculated as students consider efficient rotor designs in terms of both voltage output and material usage. In groups, students combine the knowledge gained in this unit to design wind turbine rotors that produce the most electricity possible, given material constraints.

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## Unit 1: Wind Power
### Mathematics Skills and Concepts Covered

| Skill or Concept | California Mathematics Standard |
|---|---|
| Measurement–Linear units<br>Measurement–Area units<br>Measurement–Angles | Grade 7: Measurement and Geometry<br>1.2, 2.1, 2.2, 2.4 |
| Equivalent fractions<br>Add and subtract fractions<br>Multiply and divide fractions | Grade 7: Number Sense<br>1.2 |
| Calculate percentages | Grade 7: Number Sense<br>1.3, 1.6 |
| Express constraints and range of results as inequalities and compound inequalities | Grade 7: Algebra and Functions<br>1.1, 1.4 |
| Graph and interpret experimental results | Grade 7: Algebra and Functions<br>1.5<br>Statistics, Data Analysis, and Probability<br>1.2 |
| Find range, mean, and median value of the results | Grade 7: Statistics, Data Analysis, and Probability<br>1.2 |
| Build a working wind power generator to meet certain constraints<br>Compete in wind generator contest (optimize results) | Grade 7: Mathematical Reasoning<br>1.1, 1.3, 2.1, 2.2, 2.4, 2.7, 2.8, 3.1, 3.2 |
| Present wind generator design to class and justify design choices | Grade 7: Mathematical Reasoning<br>2.5, 2.6 |

# Pre-Algebra Mathematics Support Curriculum

## Unit 2: Blueprints and Models

### Summary

During the first half of this unit, students will learn about scale and proportional reasoning of all types. They then apply this knowledge to design and build a scale model of a wheelchair access ramp to Americans with Disabilities Act guidelines. The second half of the unit teaches students how to perform unit conversions, work with ratios, and solve percentage of change problems. The culminating project asks students to synthesize all of the skills to design a remodeling plan of a building to fulfill specific structural and space allocation constraints.

Expected Time: 2 weeks of a summer mathematics camp, or 6 weeks during the school year (50-minute periods)

**Lesson Descriptions**

**Lesson 1: Measure Your Space**
150 minutes
Students begin the unit by discovering that any unit can be used to measure a space. They develop their proportional reasoning by figuring out how to convert from unconventional units to inches and feet.

**Lesson 2: Map Your Space**
150 minutes
The class takes the measurements they made in the previous lesson to create an accurate map. In the process, they learn about scale and the importance of converting fractions and decimals.

**Lesson 3: Know the Materials**
150 minutes
Students increase their fluency with proportions by calculating the weights of different quantities of materials. They create a graphical representation of proportional growth and learn how slope communicates a rate of change. The class ends the lesson by working in groups to solve more challenging proportional reasoning problems.

**Lesson 4: Design an Access Ramp**
330 minutes
In teams, students apply the knowledge gained in the previous lessons by designing an access ramp to fit ADA guidelines and the property owner's preferences. Students create a scale drawing of their design, as well as calculate precise materials lists before building a model ramp to the scale 1:24.

**Lesson 5: Cost the Materials**
120 minutes
Students practice unit conversions involving length, area, volume, and weight/mass measurements. Design teams price the materials needed to build their access ramp design.

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| Lesson Descriptions |
|---|
| **Lesson 6: Space Allocation**<br>150 minutes<br>The class looks at how space allocation in American homes has changed with time by analyzing the floor plans of residences from past and present. They communicate their findings using percents and pie charts. Students also calculate the percent of change and learn how to simplify ratios. |
| **Lesson 7: Remodeling Project**<br>450 minutes<br>The culminating project for this unit involves students in designing a remodeling plan for the first floor of a building. Different clients want to convert the floor into a single family home, a market, a gym, and office space. Each group tackles one of the design challenges and presents their work to the city planning commission for approval. |

## Unit 2: Blueprints and Models

### Mathematical Skills and Concepts Covered

| Skill or Concept | California Mathematics Standard |
|---|---|
| Measurement–Linear units<br>Measurement–Area units<br>Measurement–Angles | Grade 7: Measurement and Geometry<br>2.1, 2.2, 2.4 |
| Mapping space to scale | Grade 7: Measurement and Geometry<br>1.2 |
| Solving problems involving proportions and ratios | Grade 7: Algebra and Functions<br>4.2<br>Grade 7: Measurement and Geometry<br>1.2, 1.3, 2.4 |
| Understanding the slope of linear graphs as it relates to proportional growth | Grade 7: Algebra and Functions<br>1.5, 3.4, |
| Calculating and converting fractions, percents, and decimals | Grade 7: Number Sense<br>1.2, 1.3 |
| Performing unit conversions | Grade 7: Measurement and Geometry<br>1.1, 1.3 |
| Creating pie charts and understanding how they relate to ratios and percents | Grade 7: Statistics, Data Analysis, and Probability<br>1.1 |
| Calculating percent of increase or decrease | Grade 7: Number Sense<br>1.6, 1.7 |
| Designing and constructing a model of a building to fulfill specific constraints and preferences | Grade 7: Mathematical Reasoning<br>1.1, 1.2, 1.3, 2.1, 2.2, 2.5, 2.6, 2.7, 2.8, 3.1 |

# Pre-Algebra Mathematics Support Curriculum

## Unit 3: People Movers

### Summary

Railed transport systems are the practical application of concepts such as velocity, graphing, and integer operations. Students build a funicular up an incline that they analyze using the Pythagorean Theorem, and give the car's position and velocity using positive and negative numbers. The shape of graphs at constant speed, acceleration, and deceleration are explored. Finally, students design a transportation system timed to smoothly accommodate a certain volume of people.

Expected Time: 1.25 weeks of a summer mathematics camp, or 3 weeks during the school year (50-minute periods)

**Lesson Descriptions**

**Lesson 1: Going the Distance**
150 minutes
Students are introduced to the design and function of different people movers, such as ski lifts, cable cars, and funiculars. The class explores the Pythagorean Theorem and analyzes the sides of triangles. They then apply that knowledge to build a cardboard incline that a model funicular will eventually climb and descend.

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**Lesson 2: Up and Down, Back and Forth**
150 minutes
Students use the analogy of movement in opposite directions to learn about adding and multiplying integers. They practice the skills gained in the previous lesson to build a funicular car base that will keep the passenger car parallel to the ground while traveling up the incline.

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**Lesson 3: Rates of Transport**
150 minutes
Students graph positive and negative rates, including the velocity of different moving objects. The class solidifies their understanding of rates by interpreting existing graphs of constant and varying motion.

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**Lesson 4: Gear Ratios**
150 minutes
Students gain practical experience with altering speed by experimenting with gears and performing gear ratio calculations. They attach their model funicular bases to a geared motor to test the accuracy of their calculations.

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**Lesson 5: Finally, the Funicular**
180 minutes
Students apply all the knowledge gained in this unit to design a funicular system that meets the needs of a specific client. They consider wait time, ride length, and passenger comfort when deciding on the speed of the funicular and the design of the passenger car.

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## Unit 3: People Movers

### Mathematics Skills and Concepts Covered

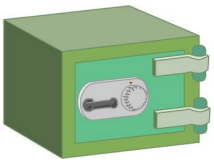
| Skill or Concept | California Mathematics Standard |
|---|---|
| Measurement–Linear units<br>Measurement–Area units<br>Measurement–Angles | Grade 7: Measurement and Geometry<br>2.1, 2.2, 2.4 |
| Building to scale | Grade 7: Measurement and Geometry<br>1.2 |
| Solving problems involving proportions and ratios, including gear ratios | Grade 7: Algebra and Functions<br>4.2<br>Grade 7: Measurement and Geometry<br>1.2, 1.3, 2.4 |
| Interpreting the meaning of linear and non-linear graphs | Grade 7: Algebra and Functions<br>1.5. 3.3 |
| Understanding the slope of linear graphs of distance vs. time and velocity vs. time | Grade 7: Algebra and Functions<br>1.5, 3.3, 3.4 |
| Performing arithmetic with negative numbers | Grade 7: Number Sense<br>1.2 |
| Understanding and solving problems using the Pythagorean Theorem | Grade 7: Measurement and Geometry<br>3.3 |
| Simplifying square roots | Grade 7: Number Sense<br>2.4 |
| Designing and constructing a model of a building to fulfill specific constraints and preferences | Grade 7: Mathematical Reasoning<br>1.1, 1.2, 1.3, 2.1, 2.2, 2.5, 2.6, 2.7, 2.8, 3.1 |

# Pre-Algebra Mathematics Support Curriculum

## Unit 4: Safe Combinations

### Summary

The rules of exponents and solving equations are the two main concepts covered in the last unit of the summer camp. Students build their own combination lock out of wood and metal washers, and analyze how many possible combinations are possible. They then "code" their lock combinations in complex equations and challenge their peers to open the lock by solving the equations.



Expected Time: 1 week of a summer mathematics camp, or 3 weeks during the school year (50-minute periods)

**Lesson Descriptions**

**Lesson 1: How Many Possible Combinations? Part I**
150 minutes
The class is introduced to the workings of a combination lock and begins to build a safe. Students create organized diagrams to figure out how many possible combinations there are given the number of choices in a combination lock. They express the results in exponential form.

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**Lesson 2: How Many Possible Combinations? Part II**
150 minutes
In pairs, students begin building a combination lock to specifications. They analyze what happens to the number of possible combinations when the number of wheels in the lock chamber changes and draw the analogy to the rules of multiplication and division of exponents.

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**Lesson 3: Coding the Combination: Part I**
150 minutes
The class demonstrates the rate of exponential growth in a graph. Students finish assembling the combination lock, attach it to the safe, and figure out the correct combination to unlock it. The class is then asked to "code" their lock combinations by rewriting each combination number as an order of operations problem.

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**Lesson 4: Coding the Combination: Part II**
120 minutes
Students are introduced to the concept of equivalent equations as they "code" their lock combinations as equations. They also review exponent rules.

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**Lesson 5: Safe Breaking**
180 minutes
Students solve equations by "undoing" the coding of the combinations that they did in the previous lesson and translate sentences into equations. They check their answers by actually opening each others' locks. Finally, they consider whether it is smarter to keep money in a bank instead of a safe and explore exponents as they relate to compound interest.

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## Unit 4: Safe Combinations

### Mathematics Skills and Concepts Covered

| Skill or Concept | California Mathematics Standard |
|---|---|
| Measurement–Linear units<br>Measurement–Area units<br>Measurement–Angles | Grade 7: Measurement and Geometry<br>1.2, 2.1, 2.2, 2.4 |
| Tree diagrams and permutations | Grade 7: Statistics, Data Analysis, and Probability<br>1.1 |
| Definition of exponents, graphing exponential growth | Grade 7: Algebra and Functions<br>1.5, 2.1, 3.1 |
| Rules of exponents | Algebra I<br>2.0 |
| Order of operations | Grade 7: Algebra and Functions<br>1.2 |
| Inverse operations | Grade 7: Algebra and Functions<br>1.3 |
| Equivalent equations and solving 1–5 step equations | Grade 7: Algebra and Functions<br>4.1<br>Algebra I<br>4.0, 5.0 |
| Translating sentences into algebraic equations | Grade 7: Algebra and Functions<br>1.1, 1.4 |
| Building a working safe with a combination lock to specifications | Grade 7: Mathematical Reasoning<br>1.1, 1.3, 2.1 |