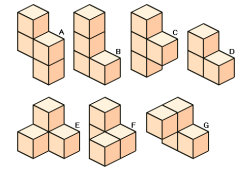


## Unit 1: The Puzzle Cube

### Solving single-variable linear equations

Students solve for the missing lengths in technical drawings by solving increasingly difficult single-variable equations. The technical drawings are schematics of 3-D puzzle pieces that students then build and fit together as a cube.



### Lesson Descriptions

#### Lesson 1: Using Variables

The first lesson of the unit explains the definition of variables and how they are used in mathematics. In this lesson, students sketch shapes that have dimensions described by variables. They then substitute values for variables to evaluate mathematical expressions. In subsequent lessons, students will expand these skills to build the pieces of the puzzle cube correctly.

#### Lesson 2: Solving 1-Step Equations

This lesson introduces solving 1-step linear equations with one variable. Students are given a diagram of the net that will fold into the first of seven pieces that will form the puzzle cube. The diagram has missing lengths that students must solve for by using the given information to write appropriate equations. After they solve for the missing lengths, students will construct the puzzle piece out of card stock.

#### Lesson 3: Solving 2-Step Equations

To solve for the missing dimensions on the next two puzzle pieces students must create the correct 2-step linear equations with one variable. They then solve this type of equation and construct the puzzle cube pieces. A homework assignment is included in the lesson.

#### Lesson 4: Solving Equations with the Distributive Property

Students learn how to solve equations that include use of the distributive property. They first review the concept of distributing multiplication over addition by using an area model. Next, they practice setting up and solving this type of equation by figuring out the dimensions of the next two pieces of the puzzle cube (pieces D and E) that they then construct. Finally, students review for and take a quiz on what they have learned so far in the unit. Homework assignments are included.

#### Lesson 5: Solving with Variables on Both Sides of the Equation

Equations with are variables on both sides are solved to calculate the dimensions of the final two pieces of the puzzle cube. When all seven of the puzzle pieces are constructed correctly, students solve the puzzle either individually or in groups. The class discusses how many unique solutions there are to the puzzle. Homework assignments are included.

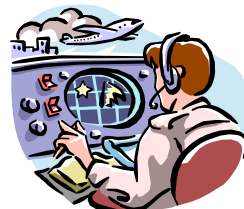
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## Unit 2: Air Traffic Control

### Graphing and interpreting two-variable linear equations

Students analyze the distance vs. time graphs of planes approaching the same airport at different speeds. Slope and intercept concepts are discussed. Students discover what happens to the graphs when orders are given to each plane to change their speed or direction. They then design an air traffic control plan that safely lands several planes in the shortest amount of time.



### Lesson Descriptions

#### Lesson 1: Data Tables, Coordinates, and Graphs

This is the first lesson of the unit introduces the role of air traffic control in the air transportation system. Students then analyze the progress of three different planes by filling out data tables and graphing the planes' distances from the airport given their speed and the elapsed time. During the process, students practice plotting coordinates and calculating distance, rate, and time relationships.

#### Lesson 2: Rates of Change

Students explore how rates of change are expressed graphically. They figure out that a constant rate of change, in this case the constant speed of a plane, will result in a straight line. The faster the rate, the steeper the graphed line will be. Students also have the opportunity to think about what a non-linear graph would express about a quantity's rate of change. A homework assignment is included in the lesson.

#### Lesson 3: Positive and Negative Slopes

Students are introduced to the formal definition of slope in this lesson, and they are asked to calculate and interpret the meaning of positive and negative slopes. Students are also asked to produce graphs of the progress of a plane traveling away from the airport at different speeds and to contrast their graphs with those of the plane moving toward the airport. A homework assignment is included in the lesson.

#### Lesson 4: The Slopes of Parallel Lines

Students continue to work with the concept of slope, this time exploring the relationship between slope and parallel lines. A homework assignment is included in the lesson.

#### Lesson 5: Safe Landings

Students apply what they have learned about slope and rate of change to act as air traffic controllers for the three planes they have been working with. Their goal is to land all of the planes safely at the airport while also meeting distance and timing constraints.

(Continued)

**Lesson 6: Writing Equations from Graphs**

Students learn how to write linear equations when given two points. They begin by setting up an equation to solve for the distance that corresponds with a given point in time when only two points are known on the line. Then students create the general equation of the line by replacing the specific time with a variable.

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**Lesson 7: Slope-Intercept and Standard Forms**

Students convert equations between slope-intercept and standard forms and explore which form is more useful for different applications. Homework is included.

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**Lesson 8: Air Traffic Control Project**

In this final lesson of the unit, students synthesize what they have learned about linear graphs and equations to engineer the safe and time-efficient landing of five planes arriving at an airport at various speeds and from two different flight paths.

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## Unit 3: Inequalities and Tolerances

### Solving and graphing linear inequalities

Inequalities are explored as a way to express different types of ranges and engineering tolerances. Students solve inequalities to calculate the proper tolerances for the construction of a small scissor lift. They then build the machine and communicate its range of motion and size as inequalities.



### Lesson Descriptions

#### Lesson 1: Single Variable Inequality Statements and Graphs

The first lesson introduces students to the building project that will be completed during the unit—a car jack-sized scissor lift. Students are taught how to express ranges as inequality statements through examining the specifications of different scissor lifts. A homework assignment is included.

#### Lesson 2: Solving Single-Variable Inequalities

Lesson 2 focuses on stating, solving, and graphing linear inequalities. Students are taught the main properties of inequalities and use those properties to justify how to solve inequalities. They then graph their solutions. Students will apply the mathematical skills taught in this lesson by calculating the correct design specifications for the scissor lift they will be building in class. A homework assignment is included.

#### Lesson 3: Describing Engineering Tolerances

Students are taught three ways of expressing engineering tolerances—compound inequalities,  $\pm$  notation, and absolute value statements. After practicing these different notations, students apply their knowledge to read design specifications and build the components of a scissor lift to satisfy real engineering tolerances. A homework assignment is included.

#### Lesson 4: Graphing 2-Variable Inequalities

In this lesson, students are taught how to graph two-variable inequalities, and they compare these graphs to two-variable linear equations that they have already worked with. After practicing graphing, students apply their knowledge to determine the feasible region of solutions for situations involving more than one inequality.

#### Lesson 5: Assembling the Scissor Lift

In this last lesson of the unit, groups of students assemble a working scissor lift from the components they built in previous lessons. Groups test to see if their product meets all of the required specifications.

## Unit 4: Visual F/X

### Graphing quadratic equations in vertex and standard forms

Students examine the graphs of quadratic equations in vertex and standard forms and draw conclusions about symmetry, the vertex, and roots. They apply their knowledge to design visual effects of falling, jumping, and thrown objects for a movie. A computer simulation of the jumps and throws aids students' visualization of the mathematics.



### Lesson Descriptions

#### Lesson 1: What is the Path of a Falling Object?

The first lesson introduces students to the design project that they will be completing during the unit—two movie scenes that require visual effects of thrown objects and jumping characters. The initial activity asks students to analyze and describe the motion of objects being dropped from a moving vehicle. They record and graph data points from time elapsed photographs of the falling objects.

#### Lesson 2: Exploring Parabolas — Vertex Form

Lesson 2 introduces students to the vertex form of the quadratic equation ( $y = a(x - h)^2 + k$ ). Students complete a graphing-calculator exploration of how the constants in the vertex form affect the shape of the graph. They then practice sketching graphs based on the values of  $a$ ,  $h$ , and  $k$ , and record their new knowledge on a study sheet. The lesson concludes with students applying their knowledge to create a general equation that models the paths of falling objects under the influence of earth's gravity.

#### Lesson 3: Placing the Manhole

Students discover that they must solve for the  $x$ -intercept of the parabola to know where a falling object will hit the ground. Doing this calculation provides the motivation for solving simple quadratic equations and interpreting the answers. At the end of the lesson, students apply what they have learned so far in the unit to design Scene 7a of the movie.

#### Lesson 4: Exploring Parabolas — Standard Form

Students are introduced to the second movie scene that they must design in this unit, this time using equations in standard form ( $y = ax^2 + bx + c$ ). Students explore the effects of changing the variables in the standard form equation on a parabolas shape, and they use their conclusions to begin designing the trajectory of jumps and thrown objects to meet certain requirements.

#### Lesson 5: Designing the Scene for Scenario 2

Lesson 5 is the culminating experience for this unit. Students design the three trajectories involved in the movie scene 14c and express them as quadratic equations in standard form. They then program the trajectories in a computer application that animates the scene.

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## Unit 5: The Catapult Game

### Solving quadratic equations by factoring and the quadratic formula

A game manufacturer would like to bring a catapult game to market, and has asked the class for design suggestions. Students determine the dimensions and area of rectangular targets to practice factoring and multiplying polynomials. They then determine where to place a catapult to hit targets at different heights by solving quadratic equations.



#### Lesson Descriptions

##### **Lesson 1: Multiplying Binomials and Finding Area**

Students are introduced to their project during this unit, which is to design the targets, playing area, and scoring system for a new catapult game. The first lesson focuses on how to find the areas of rectangular targets by multiplying their dimensions. Students multiply binomials, simplify the answers, and suggest scores for hitting the each target according to its relative size.

##### **Lesson 2: Graphs of Equations in Factored Form**

In the previous lesson, the area of each target was expressed as a product of two binomials. Students graph quadratic functions that communicate the possible areas for each target. They calculate the zeroes of each function to find what values for  $x$  would result in impossible targets (zero or negative area). In the process students discover the convenience of equations in factored form.

##### **Lesson 3: Finding Dimensions By Factoring**

Lesson 3 asks students to determine the dimensions of rectangular targets given their areas expressed as second degree polynomials. In groups, students devise a process for factoring polynomials that makes sense to them.

##### **Lesson 4: Analyze Catapult Trajectories**

The game manufacturer must now decide which of several different catapults should be used with the targets designed during the previous lessons. Students are asked to calculate the distance each catapult should be placed from a target in order for its projectile to hit that target at a given height. In the process, students learn how to solve quadratic equations by factoring and the quadratic equation.

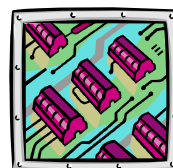
##### **Lesson 5: Play the Catapult Game**

The culminating experience of this unit allows students to play the catapult game they helped design. Students use their graphing calculator to find the quadratic regression of projectiles launched from a real catapult. They solve appropriate forms of their quadratic equation to calculate the best placement of their catapult to hit targets at various heights.

## Unit 6: Electrical Resistance

### Simplifying rational expressions and solving rational equations

Students explore Ohm's Law and how to calculate the total resistance in an electrical circuit when the resistors are connected in series and in parallel. To calculate total resistance students must learn how to manipulate rational expressions and solve rational equations. Students also review scientific notation and setting up equations from word problems and situations.



#### Lesson Descriptions

##### Lesson 1: Introduction to Circuits and Ohm's Law

Students learn how to measure voltage, current, and resistance in simple circuits that they build on their own using breadboards. Students then use mathematical reasoning to figure out Ohm's Law from their measurements and practice solving for unknown voltages, currents, and resistances by using the law.

##### Lesson 2: Rating Resistors

In this lesson, students learn how standard resistors are color coded to communicate the amount of resistance they add to a circuit. Students code and decode resistors and record their stated resistances using scientific notation. They also calculate the range of actual resistance each resistor can have according to its stated tolerance and communicate those ranges with compound inequalities.

##### Lesson 3: Series Circuits

Students build series circuits and use empirical reasoning to determine the rule for calculating a series circuit's total resistance. Students will add rational expressions in various forms and solve rational equations involving total resistance.

##### Lesson 4: Parallel Circuits

Students learn how to calculate and measure the total resistance in parallel circuits, which provide the context for working with rational expressions in a different, more challenging form:

$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$ . During the first day of the lesson, students will learn the mathematics involved

in calculating total resistance and will practice using it. During the second day, they will build circuits to corroborate their mathematical calculations.

##### Lesson 5: Combination Circuits

Students build and analyze combination circuits that have resistors both in series and parallel. As they explore the circuits, students will be asked to make conjectures about how total resistance is determined in a combination circuit and then revise them. They will then learn a proven strategy for calculating the total resistance of a combination circuit. In the culminating project of this unit, students are asked to apply their knowledge of resistance to design a circuit that will successfully support a single light bulb with specific voltage and current requirements. As an extension, students may design circuits that support two bulbs (with same voltage and current restrictions) connected in series and in parallel.