Introduction

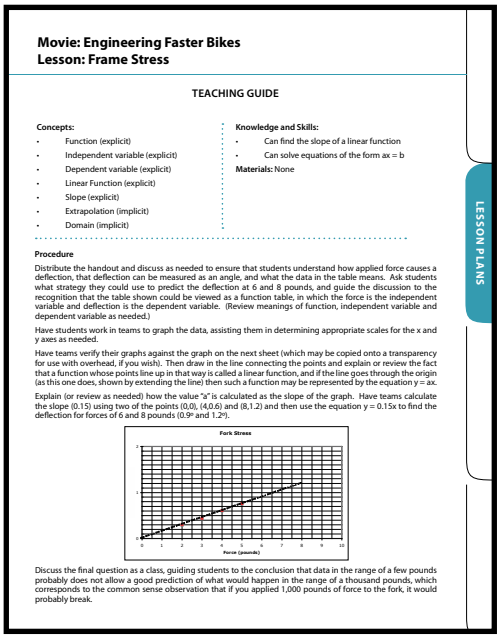
ABOUT THIS GUIDE

It is perhaps natural, when a student is introduced to algebra, for him or her to think of the subject as an abstract, cold symbology, with no connection to the real world around them. Yet nothing could be further from the truth.

Algebra in the Real World will enable you to show your students the excitement, the power, the range and the results of the applications of algebra in fascinating career fields. From astronomy to forestry, sports equipment design to saving endangered species, alternative energy to farming, algebra is shown in its vital role as the tool that allows us to create, to understand, and to improve our world.

This Curriculum Guide includes an algebra lesson plan for each movie included on the Algebra in the Real World DVD. Each lesson plan includes a Teaching Guide in addition to a Student Handout that can be printed out, copied and distributed amongst your students. To make this guide fast and easy to use, the Student Handouts have a different page design to help them stand out from the Teaching Guides.

TEACHING GUIDE



Movie: Engineering Faster Bikes
Lesson: Frame Stress

TEACHING GUIDE

Concepts:
- Function (explicit)
- Independent variable (explicit)
- Dependent variable (explicit)
- Linear Function (explicit)
- Slope (explicit)
- Extrapolation (implicit)
- Domain (implicit)

Knowledge and Skills:
- Can find the slope of a linear function
- Can solve equations of the form ax = b

Materials: None

LESSON PLANS

Procedure

Distribute the handout and discuss as needed to ensure that students understand how applied force causes a deflection, that deflection can be measured as an angle, and what the data in the table means. Ask students what strategy they could use to predict the deflection at 6 and 8 pounds, and guide the discussion to the recognition that the table shown could be viewed as a function table, in which the force is the independent variable and deflection is the dependent variable. (Review meanings of function, independent variable and dependent variable as needed.)

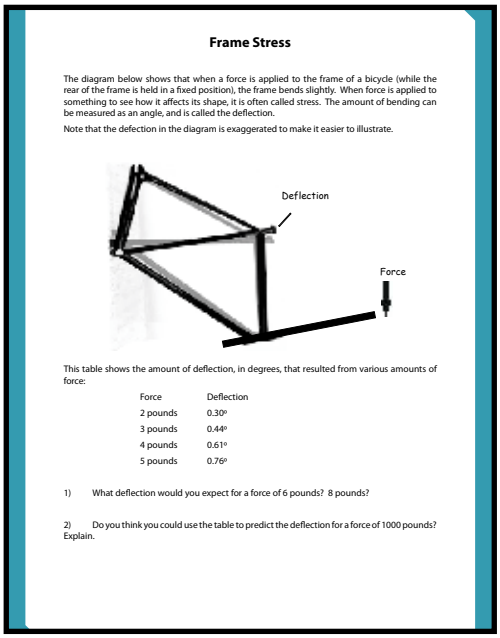
Have students work in teams to graph the data, assisting them in determining appropriate scales for the x and y axes as needed.

Have teams verify their graphs against the graph on the next sheet (which may be copied onto a transparency for use with overhead, if you wish). Then draw in the line connecting the points and explain or review the fact that a function whose points line up in that way is called a linear function, and if the line goes through the origin (as this one does, shown by extending the line) then such a function may be represented by the equation y = ax.

Explain (or review as needed) how the value "a" is calculated as the slope of the graph. Have teams calculate the slope (0.15) using two of the points (0,0), (4,0.6) and (8,1.2) and then use the equation y = 0.15x to find the deflection for forces of 6 and 8 pounds (0.9º and 1.2º).

Discuss the final question as a class, guiding students to the conclusion that data in the range of a few pounds probably does not allow a good prediction of what would happen in the range of a thousand pounds, which corresponds to the common sense observation that if you applied 1,000 pounds of force to the fork, it would probably break.

STUDENT HANDOUT



Frame Stress

The diagram below shows that when a force is applied to the frame of a bicycle (while the rear of the frame is held in a fixed position), the frame bends slightly. When force is applied to something to see how it affects its shape, it is often called stress. The amount of bending can be measured as an angle, and is called the deflection.

Note that the defection in the diagram is exaggerated to make it easier to illustrate.

This table shows the amount of deflection, in degrees, that resulted from various amounts of force:

Force	Deflection
2 pounds	0.30º
3 pounds	0.44º
4 pounds	0.61º
5 pounds	0.76º

1) What deflection would you expect for a force of 6 pounds? 8 pounds?

2) Do you think you could use the table to predict the deflection for a force of 1000 pounds? Explain.

The following pages in the introduction include several guides to help you find an appropriate movie by

- Concept and Topic
- Knowledge and Skills
- Common Core Standards

CONCEPT AND TOPIC INDEX

KNOWLEDGE AND SKILLS INDEX

Can use positive and negative numbers to represent a situation in which an initial investment is recouped over a period of time.

Solar Energy: Photovoltaics

Can plan and execute a survey with responses to a set of questions from a set of individuals, and summarize the results using appropriate statistical measures and graphical representations.

Solar Energy: Photovoltaics

Can evaluate expressions by substituting values for variables.

First One in the Ballpark

Can simplify expressions using correct order of operations

First One in the Ballpark

Can do basic operations on both sides of an equation in such a way as to preserve the equality.

First One in the Ballpark

Can use linear equation to model a situation in which an initial investment is recouped at a constant rate.

Solar Energy: Photovoltaics

Can identify variables in a real world situation.

Aquarium Makers

Landscape Architects

Can create expressions and equations that describe quantities and relationships involving variables in a real world situation.

Landscape Architects

Can find the slope of a linear function.

Engineering Faster Bikes

The Lundberg Farms

Can solve equations of the form $ax = b$.

Engineering Faster Bikes

The Lundberg Farms

Can solve an equation involving powers by taking roots.

The Wind Business

Can find the specific equation for a rational function that fits given data.

Testing the Robotic Hand

Can plot a point in a two-dimensional coordinate system, given the coordinates.

Aquarium Makers

Roller Coasters

Reliable Robots

Structural Engineering

Testing the Robotic Hand

Saving the Bald Eagle

Designing Stronger Skateboards

Can find a linear function that closely matches a set of ordered pairs.

Aquarium Makers

Structural Engineering

The Lundberg Farms

Saving the Bald Eagle

Designing Stronger Skateboards

The Forester

Can find a quadratic function that closely matches a set of ordered pairs.

Roller Coasters

Can find a cubic function that closely matches a set of ordered pairs.

Structural Engineering

Can extrapolate a graph when a pattern exists.
- Reliable Robots
- The Lundberg Farms

Can relate aspects of a graphical model to the real world situation which is being modeled
- Aquarium Makers
- Reliable Robots
- Testing the Robotic Hand
- Saving the Bald Eagle
- Designing Stronger Skateboards

Understands that linear functions are characterized by the fact that the ratio of change in independent variable to change in dependent variable is constant
- Reliable Robots

Can solve an equation involving a trigonometric ratio.
- The Starshade

Can perform operations with numbers written in scientific notation
- The Starshade

Can solve a multi-step problem, using equations
- Maglev Trains

Can solve a quadratic equation by factoring
- Maglev Trains

Can find the slope of a linear graph
- Building & Testing Wheels

Can interpret the meaning of a graph's slope in relation to the context of the data being graphed
- Building & Testing Wheels

Can recognize a parabolic shape
- Windsails

Can determine the equation of a quadratic function that contains three given points
- Windsails

Can investigate how a family of curves can be produced by changing one parameter
- Windsails

Can simplify quadratic expressions
- Windsails

Can relate the coefficients of a quadratic function to their influence on the shape and position of the parabolic graph of that function
- Windsails

COMMON CORE STANDARDS GUIDE

GRADE 6

Expressions & Equations

2. Write, read, and evaluate expressions in which letters stand for numbers.

First One in the Ballpark
Roller Coasters

6. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

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The Wind Business
Solar Energy: Photov
Roller Coasters
Windsails
Reliable Robots
Maglev Trains
Structural Engineering
Engineering Faster Bikes
Building & Testing Wheels
Solar Energy: Photov
Testing the Robotic Hand
Landscape Architects
The Lundberg Farms
Saving the Bald Eagle
Designing Stronger Skateboards
The Starshade
The Forester

9. Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

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GRADE 7

Expressions & Equations

3. Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

First One in the Ballpark
Solar Energy: Photovoltaics

4. Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

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First One in the Ballpark
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GRADE 8

Expressions & Equations

2. Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational.

The Wind Business
Roller Coasters

5. Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.

Engineering Faster Bikes
Building & Testing Wheels

7. Solve linear equations in one variable.

Solar Energy: Photovoltaics
The Lundberg Farms
Saving the Bald Eagle
The Forester

Functions

1. Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

The Wind Business

2. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a linear function represented by a table of values and a linear function represented by an algebraic expression, determine which function has the greater rate of change.

Roller Coasters
Windsails

3. Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear.

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The Wind Business
Solar Energy: Photov
The Lundberg Farms
The Forester

4. Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

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COMMON CORE STANDARDS GUIDE continued

5. Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

The Wind Business
Saving the Bald Eagle

HIGH SCHOOL: ALGEBRA

Creating Equations

1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

Maglev Trains

2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

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Reasoning with Equations & Inequalities

2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.

Roller Coasters

3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

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Saving the Bald Eagle
Designing Stronger Skateboards

4. Solve quadratic equations in one variable.

Windsails
Maglev Trains

10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

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Roller Coasters

HIGH SCHOOL: FUNCTIONS

Interpreting Functions

4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.

Aquarium Makers

5. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

Engineering Faster Bikes
Building & Testing Wheels

Building Functions

1. Write a function that describes a relationship between two quantities.

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The Forester

Linear, Quadratic, & Exponential Models

1. Distinguish between situations that can be modeled with linear functions and with exponential functions.

Saving the Bald Eagle

5. Interpret the parameters in a linear or exponential function in terms of a context.

Aquarium Makers