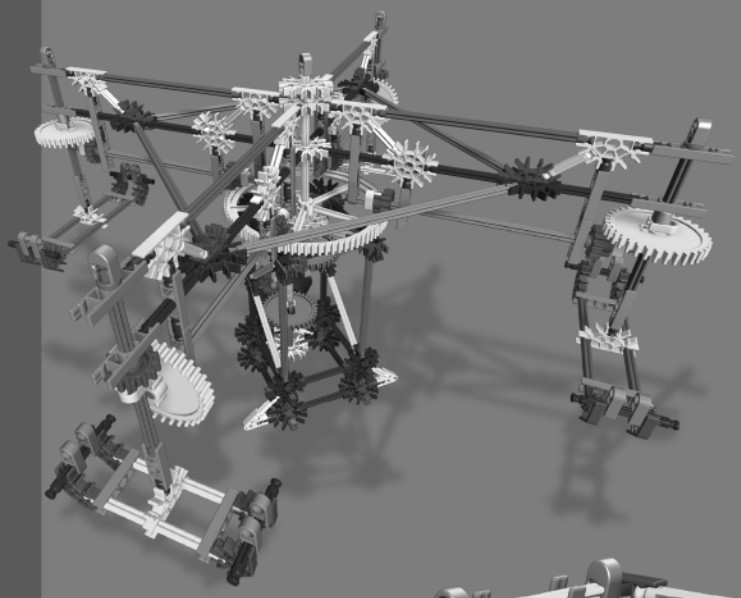
K'NEX® Education

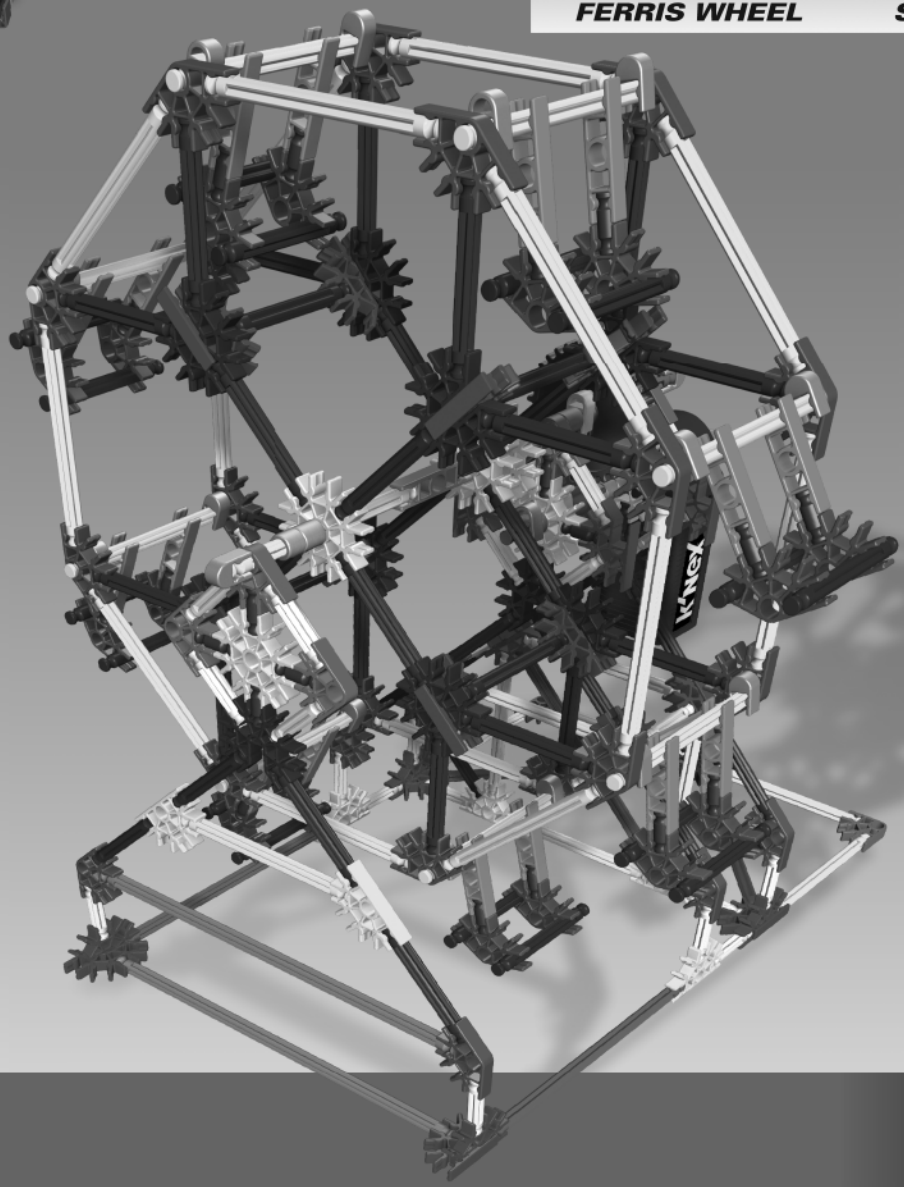
TEACHER'S GUIDE™

AMUSEMENT PARK EXPERIENCE™



FERRIS WHEEL

SCRAMBLER



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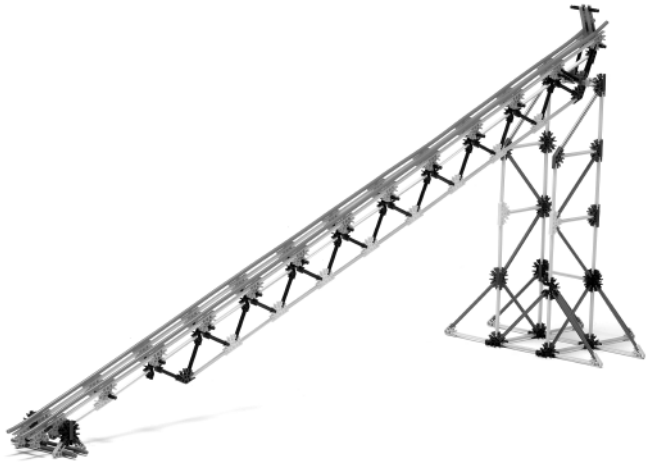

Lesson 1:
Understanding the Relationship Between Speed, Distance, and Time

Time

- *30 minutes (after construction of the model)*

Objectives

Students will:

- Identify and describe the relationship between the two components of speed: distance and time.
- Obtain accurate measurements of distance and time.

Materials

Each group will need:

- Materials from 1 K'NEX Education Amusement Park Experience set
- Building Instructions from CD-ROM: File – Inclined Plane II (for a ball)
- 4 different types of balls (minimum size 4.5 cm)
- Flexible (sewing) tape measure
- Stopwatch
- Water-based markers

Each student will need:

- Science notebook/journal
- Graph paper

Overview for the Teacher

The short ramp can be used as the basis for an introductory activity that allows students to practice some of the skills they will need as they investigate physical science concepts using the K'NEX Education Amusement Park Experience set. Students will, for example, take measurements of length using rulers, measurements of time using a stopwatch, and work with the concept of speed.

Teacher's Notes

- *Students should work in small groups of 3-4 to construct their models and undertake their investigations.*
- *The K'NEX Education Amusement Park Experience set will allow two inclined plane systems to be built simultaneously.*

Teacher's Notes

- *The Building Instructions for this model are found on the CD-ROM that accompanies the set. Students can access the instructions directly from a computer screen or from printed hard copies. If students work from the computer screen we recommend that they use the file displaying instructions in the 11" x 17" format. If you select hard copies for your students you will need to prepare them in advance. Choose either the file to print instructions on 11" x 17" paper or the file to print onto 8.5" x 11" paper.*
- *Each group will need access to a model of the K'NEX Inclined Plane II (for a ball). The model can either be built in-class with groups identifying and then allocating sub-assemblies for members to construct, or it can be built as an out-of-class activity.*
- *Students should be encouraged to record their predictions and observations in their science notebooks/journals.*

REVIEW

Students will be more successful with this activity if they understand the following concepts:

- How to measure distance in metric units.
- How to measure time (seconds, minutes, etc.) and use a stopwatch.
- What speed (velocity) represents.
- How to calculate the speed (velocity) of an object.

ACTIVITY 1: DISTANCE OVER TIME...WHAT MAKES IT HAPPEN?

PROCESS

Whole Class

Explain to the students that the first activity with the K'NEX Education Amusement Park set will involve using an inclined plane model (ramp) to develop their building skills, to gain practice in taking various types of measurements, and to acquire knowledge of some basic scientific and mathematical concepts. In the first activity they will investigate whether or not the height at which a ball is released down a ramp impacts distance over time. In the second activity they will find an answer to the question, "Does the incline of the ramp impact distance over time?"

In Groups

1. If models are to be built in-class, distribute the K'NEX Education Amusement Park Experience sets to groups and allow time for construction. Make sure that all students are familiar with how to use the materials.

2. When the models are completed, ask each group to:
   a. Use a water-based marker to label the following 5 positions on the model: the 3^{rd}, 5^{th}, 7^{th}, 9^{th}, and 11^{th} bright green supports. (These green supports are directly above the main support beams.)
   b. Make a prediction about which position will give the ball the fastest average speed. Record this prediction.
   c. Construct a four-column table in their individual journals in which to record their data. You may want to draw a table on the board.

Height of labeled position (m)	Distance from labeled position to end of track (m)	Time taken by ball from labeled position to end of track (s)	Speed of ball from labeled position: distance/time (m/s)

3. Students should then:
   a. Measure the distance from each of the labeled points to the end of the ramp and record these values in their table.
   b. Release a ball from the lowest position and time how long it takes to travel to the end of the ramp. Record the time.
   c. Repeat for each of the remaining positions.
   d. Calculate the speed of the ball from each of the positions.

4. They should record and analyze their data by:
   a. Drawing a line graph of their data. The height should be plotted on the x-axis and the speed on the y-axis.
   b. Describing the shape of the line that is formed.
   c. Stating if the shape of the line was expected or if it was a surprise.
   d. Describing what the shape of the line indicates.
   e. Predicting whether or not they will get the same shaped line when they make graphs using the other balls that have been provided.

Teacher's Notes
If your students have studied slope in their math class, they should be able to provide a sound explanation of what the shape of the line indicates.

5. Students should then:
   a. Repeat steps 3b - 4b with each of the other three balls.
   b. Compare the four line graphs and write a paragraph comparing the shapes of the graphs and whether or not there were any factors that impacted the speed of the ball.

Teacher's Notes
This is an excellent opportunity to open a discussion on 'sources of error.'

Whole Class

6. Each group should display their four graphs with those created by other groups. For example: all graphs for a golf ball should be grouped together, all graphs for a tennis ball should be grouped together, etc. They should make comparisons between the graphs using the same balls and also the graphs using different balls.
   Students may require some prompts to stimulate their comparisons:
   - Do all of the graphs for a given type of ball look the same?
   - Are the scales on each graph the same?
   - Do all of the graphs, as a whole, look generally the same?

7. Students should discuss:
   a. The factors that impacted their data and thus their graphs. Specifically, does the mass or the height impact the speed? They should **write a short statement** that indicates the effect of mass, or height, or both, from their point of view. Can the students identify other factors that may have affected the shape of the graphs? Statements should be supported with an explanation.
   b. Whether or not the graph(s) show a linear relationship between height of release and speed?

> ***Teacher's Notes***
> *Student groups may be asked to mention any problems they had with data collection that may have caused their graph(s) to appear different from the graphs of other groups. (In a discussion such as this, 'experimental error' or 'measurement errors' are often not discussed.)*

ACTIVITY 2: DOES THE INCLINE IMPACT DISTANCE OVER TIME?

PROCESS

Whole Class

Explain that in this activity students will vary the height of the ramp, and therefore the incline, to investigate what impact this has on the measurements of distance over time (or speed). The K'NEX Education Inclined Plane system allows the students to adjust the height of the end of the ramp. As the end of the ramp is lowered, the incline or slope of the ramp decreases. The students' investigations will help them to determine how the change in slope of the ramp affects the speed measured from each of the release marks they previously made on the track. In order to make this a 'fair test,' students will use only one of the balls that they used in Activity # 1.

> ***Teacher's Notes***
> *If students have not completed Activity 1 (above) ask them to use a water-based marker to label the following 5 positions on the model: the 3^{rd}, 5^{th}, 7^{th}, 9^{th}, and 11^{th} bright green supports. (These green supports are directly above the main support beams.)*

In Groups

1. Ask the groups to:
   a. Predict whether changing the incline of the ramp will impact the speed of the ball they have been assigned. They should explain their reasoning, or the basis for their prediction.
   b. Predict whether lowering the incline to 2/3 of its original incline will impact the speed by some factor.
   c. Predict whether lowering the incline to 1/3 of its original incline will impact the speed by some factor.

2. Students should then construct 3 tables in their notebooks/journals. These will be similar to the data table constructed for Activity 1. The following titles should be added to their tables:
   Table 1: Ramp in highest position on tower (largest incline)
   Table 2: Ramp in middle position on tower (incline 2/3 of original)
   Table 3: Ramp in lowest position on tower (incline 1/3 of original)

Teacher's Notes
Only Tables 2 and 3 will be necessary if they completed Activity # 1 as they will already have one set of completed data.

FOR EXAMPLE:

Table 2: Ramp in middle position on tower (incline 2/3 of original)

Height of labeled position (m)	Distance from labeled position to end of track (m)	Time taken by ball from labeled position to end of track (s)	Speed of ball from labeled position: distance/time (m/s)

Teacher's Notes
Students may not need to undertake steps 3 and 4 below if Activity 1 was completed, instead they can begin their investigations at step 5 below.

3. Students should then:
   a. Measure the distance from each of the labeled points to the end of the ramp and record this in their table.
   b. Release a ball from the lowest position and time how long it takes to travel to the end of the ramp.
   c. Repeat for each of the remaining positions.
   d. Calculate the speed of the ball from each of the positions.

4. They should record and analyze their data by:
   a. Drawing a line graph of their data. The height should be plotted on the x-axis and the speed on the y-axis.
   b. Describe the shape of the line that is formed and indicate if the shape of the line was expected or was a surprise. Describe what the shape of the line indicates.

5. Students should then:
   a. Lower the ramp one level on the tower and complete steps 3a - 3d a second time using the same ball.
   b. Graph the data as a second line on the previous graph using a different color. Note the colors, and the ramp height they represent, in a key on their graph paper.
   c. Lower the ramp one more level on the tower and complete steps 3a – 3d a third time.
   d. Using a third color to display it, plot the data obtained on the existing graph. Note the color and release height in the key.

6. Students will compare the speed of the ball for the same start positions, but with different ramp inclines, to see if each of their predictions (step 1, above) accurately reflects the factor by which the speed declined when the short ramp was moved to a lower position.

7. Using the graph as a guide, they should write a paragraph discussing the impact of lowering the ramp on the speed of the ball.

Whole Class

8. Students should share their predictions and their findings concerning (i) the speed of the ball when the incline is lowered and (ii) the factor by which the speed was impacted.

9. Encourage them to discuss the effect that lowering the ramp had on the speed of the ball.

Review

- Concepts associated with accurate measurements of distance and time.
- Calculating speed.
- Construction of graphs to represent data.
- Analyzing graphs.

Assessment

- Predictions and conclusions recorded in notebooks/journals.
- Graphs constructed during the activities.

NSES Content Standards Alignments

National Science Education Standards (Grades K - 4) *Students will develop an understanding of:*
UNIFYING CONCEPTS AND PROCESSES
• *Systems, order, and organization.*
• *Evidence, models, and explanation.*
• *Constancy, change, and measurement.*
SCIENCE AS INQUIRY (CONTENT STANDARD A)
• *Abilities necessary to do scientific inquiry*
• *Identify questions that can be answered through scientific investigations.*
• *Design and conduct a scientific investigation.*
• *Use appropriate tools and techniques to gather, analyze, and interpret data.*
• *Develop descriptions, explanations, predictions, and models using evidence.*
• *Think critically and logically to make relationships between evidence and explanations.*
• *Recognize and analyze alternative explanations and predictions.*
• *Communicate scientific procedures and explanations.*
• *Use mathematics in all aspects of scientific inquiry.*
• *Understanding about scientific inquiry.*
PHYSICAL SCIENCE (CONTENT STANDARD B)
• *Motions and Forces*
• *Transfer of Energy*
HISTORY AND NATURE OF SCIENCE (CONTENT STANDARD G)
• *Nature of Science*

Standards for Technological Literacy: Content for the Study of Technology

Standards for Technological Literacy: Content for the Study of Technology (Grades 6 - 8) *Students will develop an understanding of:*
THE NATURE OF TECHNOLOGY
Core Concepts of Technology
• *Input, processes, output, and at times feedback.*
• *Systems thinking.*
• *Malfunctions.*
• *Sets of processes.*
• *Controls.*
• *Systems interaction.*
Connections between technology and other fields of study.
• *Knowledge gained from other fields.*
DESIGN
Engineering design.
• *Brainstorming.*
• *Modeling, testing, evaluating, and modifying.*
The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
• *Troubleshooting.*
• *Invention and innovation.*
ABILITIES FOR A TECHNOLOGICAL WORLD
Standards 11. Students will develop abilities to apply the design process.
• *Apply a design process.*
• *Specify criteria and constraints.*
• *Model a solution to a problem.*
• *Test and evaluate.*
• *Make a product or system.*

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Standards for Technological Literacy: Content for the Study of Technology

Standards for Technological Literacy: Content for the Study of Technology (Grades 5-8) *Students will develop an understanding of:*
THE NATURE OF TECHNOLOGY
Core Concepts of Technology
• *Systems*
• *Processes*
• *Requirements*
• *Trade-offs*
DESIGN
The Attributes of Design
• *Design leads to useful products and systems*
• *There is no perfect design*
Engineering Design
• *Brainstorming*
• *Modeling, testing, evaluating, and modifying*
The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving.
• *Troubleshooting*
• *Invention and innovation*
• *Experimentation*
ABILITIES OF A TECHNOLOGICAL WORLD
Apply Design Process
• *Apply design process*
• *Identify criteria and constraints*
• *Model a solution to a problem*
• *Test and evaluate*
• *Make a product or system*

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NCTM Standards Alignments

National Council of Teachers of Mathematics Education Standards and Expectations for Grades 6 - 8
NUMBER AND OPERATIONS
• *Understand numbers, ways of representing numbers, relationships among numbers, and number systems.*
• *Understand meanings of operations and how they relate to one another.*
• *Compute fluently and make reasonable estimates.*
ALGEBRA
• *Understand patterns, relations, and functions.*
• *Represent and analyze mathematical situations and structures using algebraic symbols.*
• *Use mathematical models to represent and understand quantitative relationships.*
• *Analyze change in various contexts.*
GEOMETRY
• *Analyze characteristics and properties of two & three-dimensional geometric shapes.*
• *Apply transformations and use symmetry.*
MEASUREMENT
• *Understand measurable attributes of objects and the units, systems, and processes of measurement.*
• *Apply appropriate techniques.*
DATA ANALYSIS AND PROBABILITY
• *Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.*
• *Develop and evaluate inferences and predictions that are based on data.*
PROBLEM SOLVING
• *Build new mathematical knowledge through problem solving.*
• *Solve problems.*
• *Apply and adapt a variety of appropriate strategies.*
REASONING AND PROOF
• *Recognize reasoning and proof as fundamental aspects of mathematics.*
• *Make and investigate mathematical conjectures.*
• *Select and use various types of reasoning and methods of proof.*
COMMUNICATIONS
• *Organize and consolidate mathematical thinking.*
• *Communicate their mathematical thinking.*
• *Use the language of mathematics.*

CONNECTIONS
• *Recognize and use connections among mathematical ideas.*
• *Recognize and apply mathematics in contexts outside of mathematics.*
REPRESENTATIONS
• *Create and use representations.*
• *Select, apply, and translate among mathematical representations.*
• *Use representations to model and interpret physical, social and mathematical phenomena.*

Common Core Standards Alignments

Common Core State Standards for Mathematics in Grades 6 - 9
MATHEMATICAL PRACTICES - ASSOCIATED WITH MATHEMATICS AT ALL GRADE LEVELS
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.
MATHEMATICS GRADE 6
In Grade 6, instructional time should focus on four critical areas:
• *Connecting ratio and rate to whole number multiplication and division and using concepts of ratio and rate to solve problems.*
• *Writing, interpreting, and using expressions and equations.*
• *Developing understanding of statistical thinking.*
GRADE 6
Ratios and Proportional Relationships
• *Understand ratio concepts and use ratio reasoning to solve problems.*
The Number System
• *Compute fluently with multi-digit numbers and find common factors and multiples.*
Expressions and Equations
• *Apply and extend previous understandings of arithmetic to algebraic expressions.*
• *Reason about and solve one-variable equations*
• *Represent and analyze quantitative relationships between dependent and independent variables.*
Statistics and Probability
• *Develop understanding of statistical variability.*
MATHEMATICS GRADE 7
In Grade 7, instructional time should focus on four critical areas:
• *Developing understanding of and applying proportional relationships.*
• *Developing understanding of operations with rational numbers and working with expressions and linear equations.*
• *Drawing inferences about populations based on samples.*
GRADE 7
Ratios and Proportional Relationships
• *Analyze proportional relationships and use them to solve real-world and mathematical problems.*

The Number System
• *Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.*
Expressions and Equations
• *Use properties of operations to generate equivalent expressions.*
• *Solve real-life and mathematical problems using numerical and algebraic expressions and equations.*
MATHEMATICS GRADE 8
In Grade 8, instructional time should focus on three critical areas:
• *Grasping the concept of a function and using functions to describe quantitative relationships*
GRADE 8
Expressions and Equations
• *Analyze and solve linear equations.*
Functions
• *Define, evaluate, and compare functions.*
• *Use functions to model relationships between quantities.*
Statistics and Probability
• *Investigate patterns of association in bivariate data.*

Common Core State Standards for Mathematics in Grades 9 - 12

NUMBER AND QUANTITY
The Real Number System
• *Use properties of rational and irrational numbers.*
Quantities
• *Reason quantitatively and use units solve problems.*
The Complex Number System
• *Perform arithmetic operations with complex numbers.*
ALGEBRA
Seeing Structure in Expressions
• *Write expressions in equivalent forms to solve problems.*
Creating Equations
• *Create equations that describe numbers or relationships.*
Reasoning with Equations and Inequalities
• *Understand solving equations as a process of reasoning and explain the reasoning.*
• *Solve equations and inequalities in one variable.*
• *Solve systems of equations.*
• *Represent and solve equations... graphically.*
FUNCTIONS
Linear, Quadratics, and Exponential Models
• *Interpret expressions for functions in terms of the situation they model.*

MODELING
Modeling links classroom mathematics and statistics to everyday life, work, and decision-making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand the better, and to improve decisions. Quantities and their relationships in physical, economic, public policy, social, and everyday situations can be modeled using mathematical and statistical methods. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data. *A model can be very simple, such as writing total cost as a product unit price and number bought, or using a geometric shape to describe a physical object like a coin. Even such simple models involve making choices. It is up to us whether to model a coin as a three-dimensional cylinder, or whether a two-dimensional disk works well enough for our purposes. Other situations- modeling a delivery route, a production schedule, or a comparison of loan amortizations- need more elaborate models that use other tools from the mathematical sciences. Real-world situations are not organized and labeled for analysis; formulating tractable models, representing such models, and analyzing them is appropriately a creative process.*
STATISTICS AND PROBABILITY
Interpreting Categorical and Quantitative Data
• *Summarize, represent, and interpret data on a single count or measurement variable.*
• *Interpret linear models.*
Making Inferences and Justifying Conclusions
• *Make inferences and justify conclusions from sample surveys, experiments and observational studies.*

Authors: National Governors Association Center for Best Practices, Council of Chief State School Officers; Title: Common Core State Standards (insert specific content area if you are using only one); Publisher: National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C.; Copyright Date: 2010