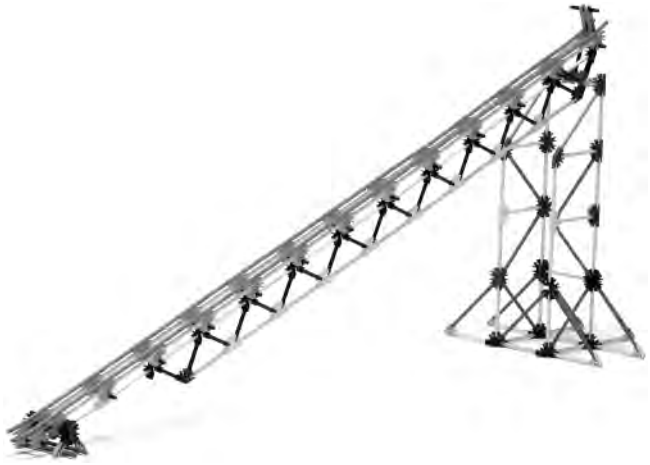

Lesson 1: Understanding the Relationship Between Speed, Distance, and Time

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.