Lesson Plan

Subjects: Algebra/Geometry/Physical Science (8th-12th grades)

Lesson Focus: Incline Plane, Loop, Redesign variations

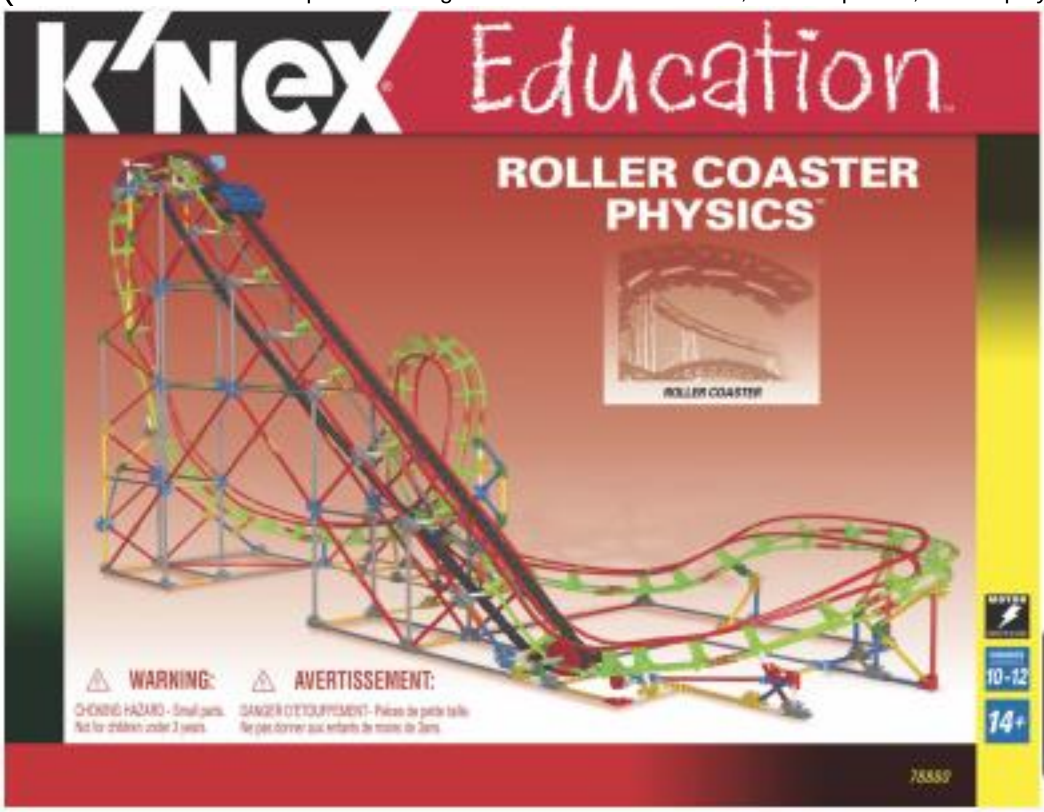
Curriculum Standards: Science (NSES) and Math (Common Core) are provided on last two pages of this document.

Resources: Photos of activities and sample structures.

Materials (per group):

Materials from 1 K'NEX Education Roller Coaster Physics Set

(Set includes 2039 K'NEX® parts – enough to build 11 roller coasters, inclined planes, and loop systems.)



- Computer
- Building instructions CD-ROM –File: Incline Plane II (for a ball) model
- Building instructions CD-ROM –File: Circular loop (for a ball) model
- 1 Golf ball per group
- 1 Ping Pong ball per group
- Ruler, Meter Stick or Metric/Standard Tape Measure
- Quad-ruled graph paper
- Science/Mathematics Journal

Preparing the lesson:

1. Divide students into small groups. (4-5 students)
2. Provide K'NEX and other materials for each group.

Teaching the Lesson:

1. Students will open their K'NEX set and familiarize themselves with the parts.
2. **CHALLENGE 1:** Students will open the "Inclined Plane II (for a ball) file" on the CD-ROM (Note: The colors on the CD-ROM do not match the colors in the set. Students will have to determine which parts correspond with the parts shown in the diagram.)
3. Students will work with their groups to build the ramp shown in the diagram.

Assessment: Award team points based on quickest completion.
1st place - 10 points, 2nd place – 8 points, 3rd place – 6 points, all other – 4 points

(Note: This is a good time to conduct the Brainstorming Activity.)

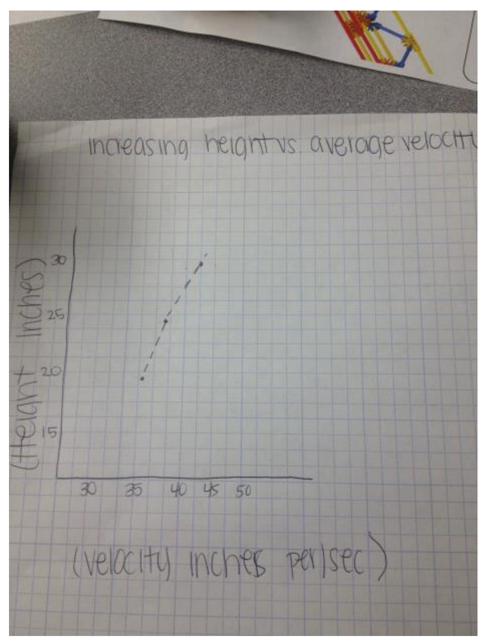
4. **CHALLENGE 2: Devise a way to determine the velocity of the ball, as it descends the ramp.**
5. Students will collect several measurements to determine the average velocity at the given height of the ramp. Record all data in journal.

6. Have students increase the height of the vertical tower by one section, then collect several measurements to determine the average velocity at the new height. Record all data in journal.

7. Repeat at additional heights, as time permits.

Since **Height** is the unit that the student controlled, that is the **Independent Variable**. **Velocity** is the **Dependent Variable**.

8. On the quad-ruled paper,
   - Plot Height vs. Velocity
   - Label Axes with proper units
   - Use a proper scale
   - Give the graph a title that will explain the experiment.



9. Let's postulate that there is a linear relationship between the height and the velocity. Find the line of best fit, using a straight edge.

10. Use the line of best fit to predict height for a certain velocity or predict velocity for a certain height. Discuss the slope (rise/run) of the graph and its relevance to the experiment. (SEE EXTENSION OPTION.)

11. **CHALLENGE 3:** ESPN wants to hire your company. They need for you to build a ramp for the Summer X Games.

Students will open the “Inclined Plane with Circular Loop (for a ball) file” on the CD-ROM (Note: The colors on the CD-ROM do not match the colors in the set. Students will have to determine which parts correspond with the parts shown in the diagram.)

12. Students will work with their groups to build the ramp/loop as shown in the diagram.

Assessment: Award team points based on quickest completion of a functional loop. 1st place - 10 points, 2nd place – 8 points, 3rd place – 6 points,
all other – 4 points

13. **Challenge 4 (Competition):** Design a KNex structure to launch a golf ball into a cardboard box. (Note: You have designed the incline plane and loop. You may modify that structure to complete the task or design something new.)

Rules:
Both the box and the structure must be on the floor.
You will launch the golf ball 10 times. Bouncing is allowed.
Each ball successfully launched into the box is awarded the number of feet the structure is from the box. Calculate the score for each team.

Assessment: Award team points based on ranking from challenge.
1st place - 10 points, 2nd place – 8 points, 3rd place – 6 points, all other – 4 points

14. **Challenge 5 (Competition):** Modify your KNex structure to launch 10 golf balls into three cardboard boxes, which are different distances from the structure.

Rules:
The boxes and the structure must be on the floor.
The boxes are placed 1ft, 2ft, and 4 ft away from structure.
You will launch the golf ball 10 times. Bouncing is NOT allowed.
(Note: Take more data while testing. Be sure.)
Each ball successfully launched into the box is awarded the number of feet the structure is from the box.
Calculate the score for each team.
(120 points on the line for this challenge.)

Assessment: Award team points based on ranking from challenge.
1st place - 120 points, 2nd place – 110 points, 3rd place – 100 points, all other – 90 points

15. **Final Challenge (Competition):** Modify your KNex structure to launch as many golf balls, as possible, into a box within 3 minutes. The structure’s pathway must go 4 feet in one direction, then turn 180 degrees and end at the start. (See photos.)

Rules:
The box and the structure must be on the floor.

The box is placed 1ft from the end of structure.
You will be given multiple golf balls.
Bouncing is NOT allowed.
A ball must exit the ramp before the next ball is launched.
Each ball successfully launched into the box is awarded the number of feet the structure is from the box.
Calculate the score for each team. (200 points are on the line for this challenge.)

Assessment: Award team points based on ranking from challenge.
1st place - 200 points, 2nd place – 175 points, 3rd place – 150 points, all other – 125 points

Journal writing: Journals should include notes from trials and modifications, including data and graphs. Also, **h**ave students reflect on their method(s) of problem solving and communicating. What did they do well? What could they have done differently to improve accuracy and efficiency?

Extension: Data can be analyzed for each challenge. Combining data from all groups and analyzing graphs can lead to rich discussions of scientific formulas.

Curriculum Standards: Science

NSES Content Standards Alignments

National Science Education Standards (Grades 9 - 12) *Students will develop an understanding of:*
UNIFYING CONCEPTS AND PROCESSES
• *Systems, order, and organization*
• *Evidence, models, and explanation*
• *Change, constancy, and measurement*
• *Form and function*
SCIENCE AS INQUIRY
• *Abilities necessary to do scientific inquiry*
• *Understanding about scientific inquiry*
PHYSICAL SCIENCE
• *Structure and properties of matter*
• *Motions and Forces*
Use laws of motion to calculate precisely the effects of forces on the motion of objects.
• *Conservation of energy and increase in disorder*
• *Interaction of energy and matter*
HISTORY AND NATURE OF SCIENCE
• *Nature of science endeavor*
• *Nature of science knowledge*
Recognise that science uses empirical standards, logical arguments, and skepticism.
Recognise that scientific explanations must be consistent with experimentation and observations, and must make accurate predictions.
• *Historical perspectives*

Curriculum Standards: Math

Common Core Standards Alignments

Common Core State Standards for Mathematics at the High School Level
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.
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, Quadratic, and Exponential Models
• *Interpret expressions for functions in terms of the situation they model.*