Lesson Plan

Subject: Transportation Activities Algebra/Geometry/Physical Science/Physics (6th-12th grades)

Lesson Focus: Transportation Engineering

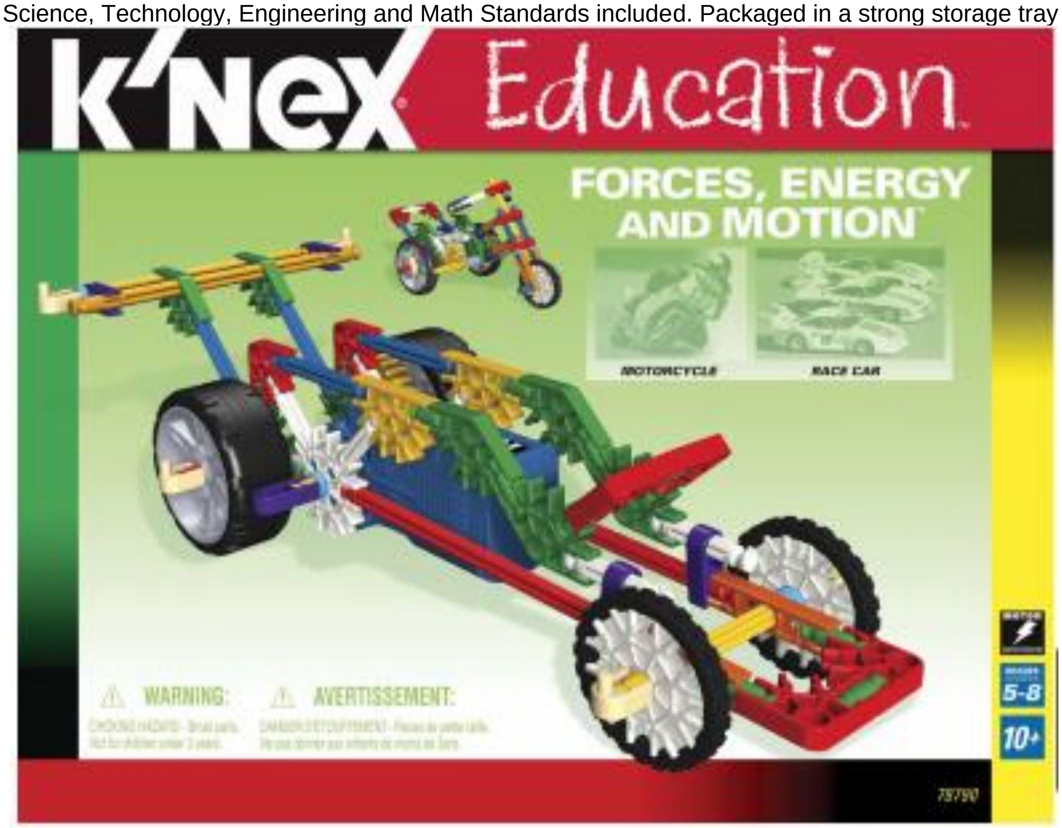
Curriculum Standards: Science (NSES) and Math (Common Core) are provided on last two pages of this document.

Resources:
PowerPoint Presentations, Handouts, and photos are attached (See tabs above.)

Materials (per group):

Materials from 1 K'NEX Education Forces, Energy, and Motion Set

(Set includes 442 K'NEX® parts, along with a Battery, Spring and Fly-wheel motor – enough to build 11 vehicles, up to four at a time. Supports 12- 16 students working in teams. Grades 5 - 9. Building instructions and comprehensive teacher's guide aligned to Science, Technology, Engineering and Math Standards included. Packaged in a strong storage tray with snap-on lid.)



Preparing the lesson:

1. Review the PowerPoints and Handouts

2. Contact Dr. Stephanie Ivey, ssalyers@memphis.edu, for additional information or to schedule a guest speaker.

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3. Set up testing area(s) as described for each challenge. This can be done in a long hallway or on the sidewalk. Imperfections in the sidewalk surface will add more of a challenge.

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4. Provide a KNex kit for each student team.

Teaching the Lesson:

1. Intro (Show Intro to Transportation Engineering PowerPoint)
2. Icebreaker: Brainstorming Activity (See Tab above.)
3. Q: How many types of crashes can occur at an intersection (in general, think about angle of collision).
   A: Diverging, Merging, Crossing. (Show Intersection Operation PowerPoint)
   Q2: How many potential conflicts are there at a typical four-way intersection (not including pedestrian/bike)?
   A: 32 (Show Intersection Operation PowerPoint)

4. Discuss the goal of the transportation engineer in terms of safety at intersections.
5. **Knex Vehicle Challenge #1**

Build a vehicle that meets the following constraints (students may use the instruction manual for guidance, but the vehicle can be completely their design):

1. Only made of K'nex pieces
2. Uses only 1 spring motor (no other motors allowed).

Students must test their vehicle once built to determine distance traveled versus vehicle pull-back distance. Students will collect data and will plot the data so that they are able to predict how far the vehicle will travel based on the pull-back distance.

The Challenge: Students will be called to the competition stadium (hallway or sidewalk) and will be given a mystery distance that the vehicle must travel. Teams will have three minutes on the starting line to confer amongst team members to determine the pull-back distance they will use. Each team will be given two tries, and the best of the two is scored. Score will be based upon landing within a 2'x2' box square taped on the floor. Penalties will be assessed based upon shortest distance from vehicle to box. If only part of the vehicle lands outside of the box, penalty is assessed as the length of the vehicle extending from the box. Penalties will be recorded in inches.

Assessment (Scoring): 100 points is awarded to the top scoring team. Other teams are ranked from least to greatest penalty, and points are awarded with 10 points deducted for each successive rank.

6. **Technical Presentations**
   Following challenges, teams should give a technical presentation. (Show Technical Presentation PowerPoint.) Provide teams time to prepare and present.

7. Distribute “Driving Blind” handout. (Students complete handout in groups, then teacher leads discussion of danger of texting while driving.)

8. **Knex Vehicle Challenge #2**

Teams will build three (3) vehicles of their own design, and will collect time data for the vehicles to travel a 10-foot course (10 trials for each vehicle - use Data Collection Sheet – Vehicle Speeds.doc).

Once students have completed all of their trials, they will calculate speeds for each trial, and compute the average speed for each vehicle. Once teams have completed this task, they will discuss amongst their team members the factors influencing speed of the vehicles.

***only K’nex pieces may be used, and only ONE spring motor

9. **The Challenge:**
   Students will select one vehicle with the best speed performance, and will have forty-five minutes to try to improve the vehicle to achieve the highest possible speed for the 10-foot course.

   Assessment (Scoring): 200 points will be awarded to the team with the shortest time to traverse the 10-foot course (highest speed). Other teams will be ranked in ascending order of time recorded on the course, and points are awarded with 20 points deducted for each successive rank.

10. **Technical Presentations**
   Following challenges, teams should give a technical presentation. (Show Technical Presentation PowerPoint.) Provide teams time to prepare and present.

11. Brainstorming Activity: Roadway design considerations

Thinking about the users (drivers, bicyclists, pedestrians) that must be served on a typical roadway (not a freeway), create a chart that outlines the characteristics of each user type that you think a transportation engineer must consider for the roadway design. Teams have 20 minutes to brainstorm in groups and create the chart, with final 10 minutes for reporting and discussion.

12. Team Brainstorming – Livability
Teams will brainstorm a definition for community livability, and list factors that are important to making a community more livable. Teams will then create a table of these factors and indicate how the transportation system impacts each. Groups will report back to the class and conclude with wrap-up discussion

13. Knex Vehicle Challenge #3

The Challenge: Student teams will design a vehicle that traverses a 20-foot course with the greatest speed, lowest construction time, and that stops within a 2' square finish zone.

Constraints: Students must only use Knex pieces, and may use a maximum of two spring motors (no other motors). All members of the team must be able to build the vehicle, as a team member will be selected at random by the program directors to perform the timed vehicle assembly.

Assessment (Scoring): Scores will consist of the sum of the team's scores for travel time, construction time, and finish zone performance.

Travel time: the team with the lowest travel time will receive 100 points. All other teams will be ranked in ascending order of travel time, with 10 points deducted for each successive rank.

Construction time: the team with the lowest construction time will receive 100 points. All other teams will be ranked in ascending order of construction time, with 10 points deducted for each successive rank.

Finish zone performance: 100 points is awarded to the top performing team (no penalty). Other teams are ranked from least to greatest penalty, and points are awarded with 10 points deducted for each successive rank. Penalty is assessed based upon the shortest distance from the vehicle to the box. If only part of the vehicle lands outside of the box, penalty is assessed as the length of the vehicle extending from the box. Penalties will be recorded in inches.

14. Technical Presentations
Following challenges, teams should give a technical presentation. (Show Technical Presentation PowerPoint.) Provide teams time to prepare and present.

15. **Stopping Sight Distance Activity** (Show "Stopping Sight Distance" PowerPoint and use PIEV handout.)

16. Group Brainstorming Activity: Freight Movement

Teams will brainstorm all the ways that goods can be moved from mainland China to Memphis. Teams should include discussion of factors that would effect decisions regarding goods movement. Groups will prepare posters (large stickies) to use in their group presentation to the class. Conclude with discussion about Memphis (IFTI video: http://www.youtube.com/watch?v=79vQiCBcVbo).

17. Knex Challenge #4

The Challenge: Student teams will design a vehicle that traverses a 20-foot course with the greatest speed, lowest construction time, that stops within a 2' square finish zone, and transports cargo. Students will have the option of including 1-4 cargo containers (golf balls) in their vehicle.

Constraints: Students must only use Knex pieces, and may only use spring motors (no restriction on the number of motors). All members of the team must be able to build the vehicle, as a team member will be selected at random by the program directors to perform the timed vehicle assembly.

Scoring: Scores will consist of the sum of the team's scores for travel time, construction time, finish zone performance, and cargo delivery.

Travel time: The team with the lowest travel time will receive 100 points. All other teams will be ranked in ascending order of travel time, with 10 points deducted for each successive rank.

Construction time: the team with the lowest construction time will receive 100 points. All other teams will be ranked in ascending order of construction time, with 10 points deducted for each successive rank.

Finish zone performance: 100 points is awarded to the top performing team (no penalty). Other teams are ranked from least to greatest penalty, and points are awarded with 10 points deducted for each successive rank. Penalty is assessed based upon the shortest distance from the vehicle to the box. If only part of the vehicle lands outside of the box, penalty is assessed as the length of the vehicle extending from the box. Penalties will be recorded in inches.

Cargo Delivery: The team will receive 25 points for each cargo container successfully delivered (maximum of 100 points – 4 golf balls). Successful delivery is judged as traveling at least a 20-foot distance.

18. Technical Presentations

Following challenges, teams should give a technical presentation. (Show Technical Presentation PowerPoint.) Provide teams time to prepare and present.

19. Final Challenge

The Challenge: Student teams will design a vehicle that traverses a course with the greatest speed, lowest construction time, lowest cost, and that stops within each of three destination 'cities', while transporting cargo. Students begin the journey with four cargo containers (golf balls), and will remove one at each stop (thus will return to the base city with one remaining container).

Constraints: Students must only use Knex pieces, and may only use spring motors (no restriction on the number of motors). All members of the team must be able to build the vehicle, as a team member will be selected at random by the program directors to perform the timed vehicle assembly.

Assessment (Scoring): Scores will consist of the sum of the team's scores for travel time, construction time, delivery performance, and cost.

Travel time: the team with the lowest travel time will receive 100 points. All other teams will be ranked in ascending order of travel time, with 10 points deducted for each successive rank.

Construction time: the team with the lowest construction time will receive 100 points. All other teams will be ranked in ascending order of construction time, with 10 points deducted for each successive rank.

Cost: the team with the lowest cost for the vehicle (based upon cost sheets provided) will receive 100 points. All other teams will be ranked in ascending order of cost, with 10 points deducted for each successive rank.

Delivery Performance: To complete a delivery, the vehicle must stop within the city boundaries. All refuels are charged $50 and any repair to the vehicle (including replacing dropped freight) is charged $100.

20. Technical Presentations

Following challenges, teams should give a technical presentation. (Show Technical Presentation PowerPoint.) Provide teams time to prepare and present.

Closing Activity or Extension: Have students do additional research on career opportunities in Transportation Engineering or other branches of Civil Engineering.

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*

Standards: Science

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.*