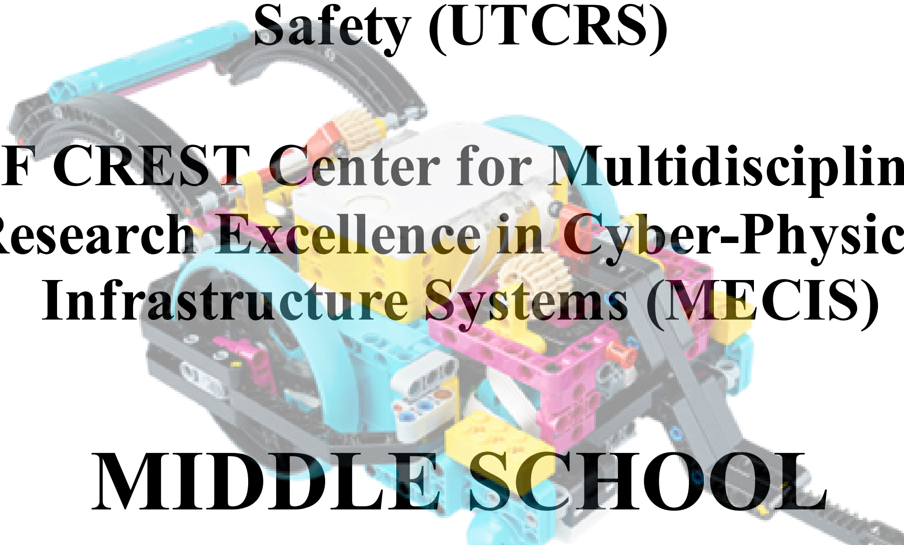
The University of Texas
Rio Grande Valley

University Transportation Center for Railway Safety (UTCRS)



NSF CREST Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)

MIDDLE SCHOOL STEM CURRICULUM

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Learning Objectives

Day 1

Activity #1: Introductions

The students will be able to …

1. define engineering from their prior knowledge and videos, and
2. describe the types of engineers and their jobs, the Engineering Design Cycle (Process), and the educational requirements that are needed to become a transportation engineer.

Activity #2: Team Building – Cup Challenge

The students will be able to …

1. experience how engineers work together to achieve a goal through a group exercise of stacking cups using strings and a rubber band,
2. discuss their knowledge of how engineers work in teams to achieve goals,
3. identify the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
4. recognize how to assign tasks based on the goals and needs of the team.

Activity #3: Railway Engineering

The students will be able to …

1. recognize what railway engineers do and what freight trains are, and
2. state the importance of transportation engineers to the rail industry.

Activity #4: Assign Team Roles

The students will be able to …

1. understand how engineers work in teams to achieve a common goal in their activities, and
2. determine their roles for their future activities/goals that are needed within their team.

Activity #5: Hot Wheels Challenge

The students will be able to …

1. explore how potential and kinetic energy play a role in the increase or decrease of motion in their Hot Wheel cars,
2. use problem-solving skills to construct efficient tracks with or without loops,
3. explain potential and kinetic energy from the experiment, and
4. create the “best” track with a loop that will allow the car to go through the loop completely and still have the car travel the farthest distance off the ramp.

Activity #6: Cleanup & Debrief

The students will be able to …

1. reflect on transportation engineering real-life challenges and solutions.

Day 2

Activity #1: Getting to Know LEGO® SPIKE™ Prime

The students will be able to …

1. recognize the different parts that make the LEGO® SPIKE™ Prime run, such as the hub, ports, sensors, and Bluetooth connection, and
2. use problem-solving skills to create, run, and test the different sensors by using the LEGO® SPIKE™ app.

Activity #2: Hopper Race

The students will be able to …

1. implement the engineering design process through testing, analyzing, and then optimizing the performance of their robot,
2. construct a hopper to race and then redesign to make the hopper faster,
3. use problem-solving skills to create, test, and run programs to command their robot,
4. apply their knowledge on how engineers work in teams to achieve a common goal,
5. demonstrate the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
5. plan to assign tasks based on the goals and needs of the team.

Activity #3: Uphill Challenge

The students will be able to …

1. construct a robot that goes uphill and downhill a fabricated ramp,
2. compare potential and kinetic energy through observation of how their bot performs,
3. describe how potential and kinetic energy are conserved and how one form of energy transforms into another,
4. apply their knowledge on how engineers work in teams to achieve a common goal,
5. demonstrate the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
6. explore how to assign tasks based on the goals and needs of the team.

Activity #4: Cleanup & Debrief

The students will be able to …

1. summarize the engineering design cycle (process) based on the performed activities, and
2. explain potential and kinetic energy as it relates to Activities #1 - #3.

Day 3

Activity #1: History of Trains and Exploring the Wheel-Axle Assembly

The students will be able to …

1. explore the concept of the Wheel-Axle Assembly in freight trains, as well as the critical role of forklifts in performing maintenance on railways and train wheels,

2. compare the two different wheel profile models to assess their effectiveness in wheel-axle assembly stability during steering, and
3. listen to the safety procedures in preparation for the engineering high bay tour.

Activity #2: Training Camp 1

The students will be able to …

1. create a practice Driving Base, making precise and controlled maneuvers using the LEGO® SPIKE™ Prime Kit, and
2. develop a code that programs the robot to move to a designated spot and stop and await further instructions.

Activity #3: Training Camp 2

The students will be able to …

1. apply the Engineering Design Cycle (Process) through a robotic challenge,
2. create a Driving Base with sensors to control motors and interact with objects on the designed route,
3. write a code that maneuvers the bot and any object it carries through the designed obstacle course,
4. build a practice Driving Base and program it to make precise and controlled movements,
5. apply their knowledge of how engineers work in teams to achieve common goals,
6. understand the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
7. choose their assigned tasks based on the goals and needs of the team.

Activity #4: Training Camp 3

The students will be able to …

1. apply the Engineering Design Cycle (Process) by creating a Driving Base and writing programs using the color sensor to make the Driving Base autonomous,
2. implement the Engineering Design Cycle (Process) through a robotic challenge,
3. apply their knowledge of how engineers work in teams to achieve common goals,
4. demonstrate the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
5. assign roles and tasks based on the goals and needs of the team.

Day 4

Activity #1: Visit to the UTRGV Engineering Building High Bay

The students will be able to …

1. identify features of a typical Engineering High Bay before heading to the tour,
2. observe and learn about the various machinery and equipment associated with an Engineering High Bay, and

3. reinforce their understanding of the different engineering fields as they interact with undergraduate and graduate students from different engineering majors during the tour.

Activity #2: Build and Program a Robot with Ultrasonic Sensor
The students will be able to …
1. apply problem-solving skills to create, test, and run program codes to control a robot, and
2. assess the performance of their robot design by identifying errors and implementing the engineering design cycle (process) to redesign and optimize the performance of their robot.

Activity #3: The Claw
The students will be able to …
1. build a robot and apply a specific code to complete a specific task, and
2. analyze the inputs and outputs for each line of code that will allow the robot to traverse through a short obstacle course successfully without incident.

Activity #4: Detect, Remove, and Relocate an Obstruction
The students will be able to …
1. modify the code they created for their robot to allow for traversing through a designed track while detecting, removing, and relocating an obstacle in that track.

Day 5

Activity #1: Railway Safety Cargo Races
The students will be able to …
1. explore cargo and freight trains for their final challenge,
2. review the Final Challenge Rules and Expectations, and
3. plan for the Final Challenge by making final design modifications to their robot and implementing edits and revisions to their programming code.

Activity #2: Closing Discussion and Cleanup
The students will be able to …
1. reflect on what they learned throughout the week in terms of conservation of energy concepts, Newton’s Laws of motion, teamwork, engineering design process, transportation engineering, sensor technologies, and effective planning.

**Note that these learning objectives may vary depending on the specific implementation of the curriculum.

**Note that some learning objectives may be repeated across activities that build upon each other to help students develop a deeper understanding of engineering concepts and principles.

Texas Essential Knowledge and Skills (TEKS)

SCIENCE TEKS

[2021 Texas Education Agency Science Standards]

S5.7(A)	Investigate and explain how equal and unequal forces acting on an object cause patterns of motion and transfer of energy.
S5.7(B)	Design a simple experimental investigation that tests the effect of force on an object in a system such as a car on a ramp or a balloon rocket on a string.
S5.8(A)	Investigate and describe the transformation of energy in systems such as energy in a flashlight battery that changes from chemical energy to electrical energy to light energy.
S5.8(C)	Demonstrate and explain how light travels in a straight line and can be reflected, refracted, or absorbed.
S6.7(A)	Identify and explain how forces act on objects, including gravity, friction, magnetism, applied forces, and normal forces, using real-world applications.
S6.7(B)	Calculate the net force on an object in a horizontal or vertical direction using diagrams and determine if the forces are balanced or unbalanced.
S6.7(C)	Identify simultaneous force pairs that are equal in magnitude and opposite in direction that result from the interactions between objects.
S6.8(B)	Describe how energy is conserved through transfers and transformations in systems such as electrical circuits, food webs, amusement park rides, or photosynthesis.
S6.2(A)	Identify advantages and limitations of models such as their size, scale, properties, and materials.
S6.1(B)	Use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems.
S6.2(D)	Evaluate experimental and engineering designs.
S6.1(G)	Develop and use models to represent phenomena, systems, processes, or solutions to engineerin problems.
S6.8(A)	Compare and contrast gravitational, elastic, and chemical potential energies with kinetic energ
S7.7(A)	Calculate average speed using distance and time measurements from investigations.
S7.7(B)	Distinguish between speed and velocity in linear motion in terms of distance, displacement, and direction.
S7.7(C)	Measure, record, and interpret an object's motion using distance-time graphs.
S7.7(D)	Analyze the effect of balanced and unbalanced forces on the state of motion of an object using Newton's First Law of Motion.
S7.8(A)	Investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation.

S7.8(C)	Explain the relationship between temperature and the kinetic energy of the particles within a substance.
S7.9(B)	Describe how gravity governs motion within Earth's solar system.
S8.7(A)	Calculate and analyze how the acceleration of an object is dependent upon the net force acting on the object and the mass of the object.
S8.7(B)	Investigate and describe how Newton's three laws of motion act simultaneously within systems such as in vehicle restraints, sports activities, amusement park rides, Earth's tectonic activities, and rocket launches.

MATH TEKS

2012 Texas Education Agency Math Standards

M6.12(B)	Use the graphical representation of numeric data to describe the center, spread, and shape of the data distribution.
M7.12(A)	Compare two groups of numeric data using comparative dot plots or box plots by comparing their shapes, centers, and spreads.
M7.3(A)	Add, subtract, multiply, and divide rational numbers fluently.
M7.3(B)	Apply and extend previous understanding of operations to solve problems using addition, subtraction, multiplication, and division of rational numbers.
M7.4(A)	Represent constant rates of change in mathematical and real world problems given pictorial, tabular, verbal, numeric, graphical, and algebraic representations, including d = rt.
M7.4(A)	Represent constant rates of change in mathematical and real-world problems given pictorial, tabular, verbal, numeric, graphical, and algebraic representations, including d = rt.
M7.4(B)	Calculate unit rates from rates in mathematical and real-world problems.
M7.4(D)	Solve problems involving ratios, rates, and percent, including multi-step problems involving percent increase and percent decrease, and financial literacy problems.
M7.4(D)	Solve problems involving ratios, rates, and percents, including multi-step problems involving percent increase and percent decrease.
M7.4(E)	Convert between measurement systems, including the use of proportions and use of unit rates.
M7.6(G)	Solve problems using data represented in bar graphs, dot plots, and circle graphs, including part-to-whole and part-to-part comparisons and equivalents.
M7.7(A)	Represent linear relationships using verbal descriptions, tables, graphs, and equations that simplify to the form y = mx + b.
M8.12(D)	Calculate and compare simple interest and compound interest earnings.

2017 Next Generation Science Standards 6-8

MS-PS2-1	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
MS-PS2-2	Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
MS-PS3-1	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2	Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
MS-PS3-4	Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
MS-PS3-5	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several. design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

International Technology and Engineering Educator Association (ITEEA) Standards

STEL-1J	Develop innovative products and systems that solve problems and extend capabilities based on individual or collective needs and wants.

STEL-1K	Compare and contrast the contributions of science, engineering, mathematics, and technology in the development of technological systems.
STEL-1L	Explain how technology and engineering are closely linked to creativity, which can result in both intended and unintended innovations.
STEL-1M	Apply creative problem-solving strategies to the improvement of existing devices or processes or the development of new approaches.
STEL-2M	Differentiate between inputs, processes, outputs, and feedback in technological systems.
STEL-2N	Illustrate how systems thinking involves considering relationships between every part, as well as how the system interacts with the environment in which it is used.
STEL-2O	Create an open-loop system that has no feedback path and requires human intervention.
STEL-2P	Create a closed-loop system that has a feedback path and requires no human intervention.
STEL-2Q	Predict outcomes of a future product or system at the beginning of the design process.
STEL-2R	Compare how different technologies involve different sets of processes.
STEL-2S	Defend decisions related to a design problem.
STEL-3E	Analyze how different technological systems often interact with economic, environmental, and social systems.
STEL-3F	Apply a product, system, or process developed for one setting to another setting.
STEL-3G	Explain how knowledge gained from other content areas affects the development of technological products and systems.
STEL-4K	Examine the ways that technology can have both positive and negative effects at the same time.
STEL-4L	Analyze how the creation and use of technologies consumes renewable and non-renewable resources and creates waste.
STEL-4M	Devise strategies for reducing, reusing, and recycling waste caused from the creation and use of technology.
STEL-4N	Analyze examples of technologies that have changed the way people think, interact, and communicate.
STEL-4O	Hypothesize what alternative outcomes (individual, cultural, and/or environmental) might have resulted had a different technological solution been selected.
STEL-5F	Analyze how an invention or innovation was influenced by its historical context.
STEL-5G	Evaluate trade-offs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors.

STEL-6C	Compare various technologies and how they have contributed to human progress.
STEL-6D	Engage in a research and development process to simulate how inventions and innovations have evolved through systematic tests and refinements.
STEL-6E	Verify how specialization of function has been at the heart of many technological improvements.
STEL-7P	Illustrate the benefits and opportunities associated with different approaches to design.
STEL-7Q	Apply the technology and engineering design process.
STEL-7R	Refine design solutions to address criteria and constraints.
STEL-7S	Create solutions to problems by identifying and applying human factors in design.
STEL-7T	Assess design quality based upon established principles and elements of design.
STEL-7U	Evaluate the strengths and weaknesses of different design solutions.
STEL-7V	Improve essential skills necessary to successfully design.
STEL-8H	Research information from various sources to use and maintain technological products or systems.
STEL-8I	Use tools, materials, and machines to safely diagnose, adjust, and repair systems.
STEL-8J	Use devices to control technological systems.
STEL-8K	Design methods to gather data about technological systems.
STEL-8L	Interpret the accuracy of information collected.
STEL-8M	Use instruments to gather data on the performance of everyday products.

Day 1: A Future in Engineering

Day Overview: The planned activities introduce students to the basics of engineering, emphasizing the roles and responsibilities of transportation engineers. Through engaging in activities like the Cup Challenge and Hot Wheels Lab, students experience teamwork, problem-solving, and applying theoretical concepts to practical challenges. The day concludes with a reflective discussion, reinforcing the importance of collaboration and real-world application of engineering principles.

Activity #1: Introduction to Engineering

Estimated Time: 10 minutes

Lesson Overview: Students will learn about transportation engineering and will be assigned to groups.

Learning Objectives:
The students will be able to …

1. define engineering from their prior knowledge and videos, and
2. describe the types of engineers and their jobs, the Engineering Design Cycle (Process), and the educational requirements that are needed to become a transportation engineer.

TEKS:

1. S5.7(A)

NGSS:

1. MS-ETS1-1

Technology Standards:

1. STEL-1K
2. STEL-2P

Materials Needed:

1. PowerPoint Lesson

Lesson Flow: (Refer to the PowerPoint Presentation)

1. Welcome: During the introduction you want to get students excited about the lessons and what they are about to learn. Mention some of the projects and activities the students will be engaged in, and briefly discuss the daily challenges and the “Grand Challenge”. Introduce yourself and tell students a little about yourself.
2. Show video of different types of Engineers: What's an Engineer? Crash Course Kids #12.1

3. Have students identify what type of engineer they would want to be and discuss in groups.
4. Agenda: Go over the agenda for the day so students know the planned activities.

Activity #2: Team Building – Cup Challenge

Estimated Time: 50-60 minutes

Lesson Overview: Students will engage in an icebreaker while learning to work in teams and how to communicate effectively towards accomplishing a common goal.

Learning Objectives:
The students will be able to …

1. experience how engineers work together to achieve a goal through a group exercise of stacking cups using strings and a rubber band,
2. discuss their knowledge of how engineers work in teams to achieve goals,
3. identify the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
4. recognize how to assign tasks based on the goals and needs of the team.

TEKS:

1. **S5.8(A)**

NGSS:

1. **MS-EST-1**

Technology Standards:

1. **STEL-8H**

Materials Needed: (per group)

1. 15 Red Cups
2. One Rubber Band
3. 4-5 Strings (One String Per Team Member)

Lesson Flow: (Refer to the PowerPoint Presentation)

1. In this activity, the challenge is to build a pyramid of cups (as shown in the PowerPoint) by working as a team. Tie each team member's string to the rubber band. Team members CANNOT TOUCH CUPS, instead, they will have to work together to stretch the rubber band to grab a cup and place it in the desired location on the pyramid.
2. Give students directions for this activity and provide the needed materials.
3. Start the activity and monitor students to ensure they are working together and not touching the cups with their hands.
4. Do three rounds. The goal for the 1st round is to stack 10 cups in pyramid formation.
5. The 2nd round is to stack 15 cups in pyramid formation.

6. The 3rd round is to add a time factor and challenge the teams. Fastest team wins.

Use the following reflection questions and have students discuss and then answer to you:

1. What worked for your group? What didn't? How did you know?
2. What was challenging? How did you deal with those challenges?
3. How do you feel about your finished tower?
4. How is this activity like working on your project with your team?
5. How does the Engineering Design Process apply during the Cup Challenge?
6. Why is it important for each member to know their role?
7. Why is it important to assign tasks based on goals and needs of a team?

Activity #3: Railway Engineering

Estimated Time: 10 minutes

Lesson Overview: Teacher will present a lecture on the different engineering fields, duties and responsibilities of engineers, and an introduction to trains.

Learning Objectives:
The students will be able to …

3. recognize what railway engineers do and what freight trains are, and
4. state the importance of transportation engineers to the rail industry.

TEKS:

1. **S7.7(A)**

NGSS:

1. **MS-ETS1**

Technology Standards:

1. **STEL-1J**
2. **STEL-2O**

Materials Needed:

1. PowerPoint Lesson

Lesson Flow: (Refer to the PowerPoint Presentation)
Explain the infinity train

1. Watch Video: The Infinity Train Can Run Forever Using Only Gravity
2. Ask the following questions:
   a. What type of energy is used to charge the battery?
   b. Why is it called the infinity train?
   c. Name at least one energy transformation that occurs.
   d. How is gravitational potential energy increased?

   e. What does a transportation engineer do?
   f. What are the different specialties within transportation engineering?

Activity #4: Assign Team Roles

Estimated Time: 5 minutes

Lesson Overview: Students will be assigned to groups and given specific roles within their groups to create teams of engineers.

Learning Objectives:
The students will be able to …

1. understand how engineers work in teams to achieve a common goal in their activities, and
2. determine their roles for their future activities/goals that are needed within their team.

Materials Needed: N/A

Lesson Flow:

1. Make sure that students are in groups of 4-5.
2. Have students discuss and decide who will serve in each of the following roles:
   a. Lead Engineer.
   b. 2-3 Assistant Engineers.
   c. 1-2 Programmers (Programmers will not be needed until Activity #6).
3. Assure students that everyone will get the chance to serve in each of these roles at least once.

Activity #5: Hot Wheels Challenge

Estimated Time: 40 minutes

Lesson Overview: As an engineer, how would you build a track to get your Hot Wheels car to move through a loop without losing contact and travel as far as it can?

Learning Objectives:

The students will be able to …

1. explore how potential and kinetic energy play a role in the increase or decrease of motion in their Hot Wheel cars,
2. use problem-solving skills to construct efficient tracks with or without loops,
3. explain potential and kinetic energy from the experiment, and
4. create the "best" track with a loop that will allow the car to go through the loop completely and still have the car travel the farthest distance off the ramp.

TEKS:

1. S5.7(A)
2. S5.7(b)

3. S5.8 (A)
4. M6.12(A)
5. M7.3(A)
6. M7.4(A)

NGSS:
1. MS-PS3-1
2. MS-PS2-2
3. MS-PS3-1

Technology Standards:
1. STEL-2Q
2. STEL-7Q
3. STEL-2R

Materials Needed: (per group)
1. 15 Hot Wheels Long Track Pieces
2. 10 Hot Wheels Short Track Pieces
3. 30 Hot Wheels Track Connecters
4. Hot Wheels Car
5. Tape Measure

Lesson Flow: (Refer to the PowerPoint Presentation)
1. **Engage:** Mini-Lab
   a. Connect 6 ramp pieces.
   b. Place the car on the flat ramp. Does it move?
   c. Elevate one side of the ramp about two inches and place the car on the ramp. Does it move?
   d. Continue this process until the ramp reaches 10 inches in height.
   e. What are you changing?
   f. How does this change in Potential Energy affect Kinetic Energy (motion)?
   g. Watch: The Yellow Driver's World Record Jump (Tanner Foust) | Team Hot Wheels | @HotWheels
2. **Pre-Lab Questions:**
   a. What did you notice about the design of the ramp in the video you just watched?
   b. How do you think the engineers got the car to do the jump?
   c. What did you notice about the track and the car?
   d. How was the car different from cars you usually see people drive?
   e. How were the tracks different from the streets in your neighborhood?

3. **HOT Wheels Lab:**
   a. Use the Hot Wheels cars, tracks, and other available materials. Work as a group to create the "best" track with a loop that will allow the car to go through the loop completely and still have the car travel the farthest distance off the ramp.
   b. With your group, create at least 4 different track designs.
   c. Record the design changes that you make to your track and loop after each new set of trials. (Draw/sketch, time, and Measure). Appendix A worksheet.
   d. Look at the data and decide what track design allowed the car to go through the loop completely and still have the car travel the farthest distance off the ramp.
   e. Calculate Speed using the formula: Speed = Distance/Time.
4. **Evaluate – Post-Lab Questions:**
   a. What do you think caused the car to go farther?
   b. What are some of the factors that could have affected your results?
   c. Do you think the type of car your group used affected your results?
   d. How would you improve your ramp design?

Activity #6: Cleanup & Debrief

Estimated Time: 15 minutes

Lesson Overview: Have students reflect on the challenges they faced during the day's activities and other challenges real transportation engineers face on a daily basis.

Learning Objectives:
The students will be able to …
1. reflect on transportation engineering real-life challenges and solutions.

Materials Needed: N/A

Lesson Flow:
1. Discuss real-life challenges and problems engineers face in their daily job functions and how they go about finding solutions for these engineering problems?
2. Make sure students count and put all materials back in the box and that no Lego parts are missing, misplaced, or left behind

Day 2: Getting to Know LEGO® SPIKE™ Prime

Day Overview: Each group will be provided an iPad an a LEGO® SPIKE™ Prime Kit. The students will get the chance to explore the different parts included such as motors, sensors, hub, and ports. Once students familiarize themselves with the different components of the kit, they will incorporate the engineering design process to complete the first lesson which is the Hopper Race. The students will then disassemble and work on the Uphill challenge for the second part of the day, where they will describe the energy transformations happening throughout this activity. The students will end the day with an exit ticket based on the engineering design process and the energy transformations challenge within the Uphill activity.

Activity #1: Getting to Know LEGO® SPIKE™ Prime

Estimated Time: 30-45 minutes

Lesson Overview: Teams will become familiar with all parts of the LEGO® SPIKE™ Prime kit.

Learning Objectives:

The students will be able to …

1. recognize the different parts that make the LEGO® SPIKE™ Prime run, such as the hub, ports, sensors, and Bluetooth connection, and
2. use problem-solving skills to create, run, and test the different sensors by using the LEGO® SPIKE™ app.

TEKS:

1. **S6.1(B)**
2. **S6.1(G)**
3. **S6.2(A)**
4. **S6.2(D)**

NGSS:

1. MS-PS3-3
2. MS-ETS1-2
3. MS-ETS1-3
4. MS-ETS1-4

Technology Standards:

1. STEL-8J
2. STEL-2M

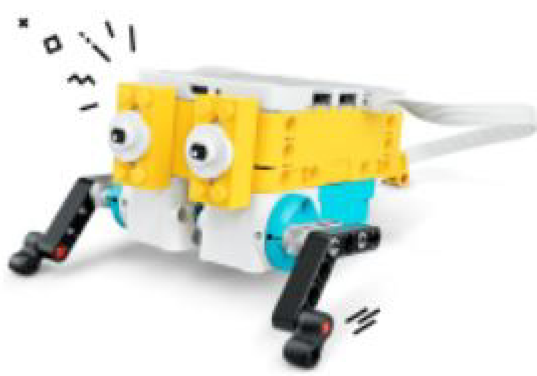
Materials Needed: (per group)

1. One LEGO® SPIKE™ Prime Robotics Kit
2. One LEGO® SPIKE™ Prime Robotics Kit Manual
3. One iPad with LEGO® SPIKE™ Prime Software Installed

Lesson Flow:

1. Explore the LEGO® SPIKE™ Prime Robotics Kit and its different components such as the hub, color sensor, touch sensor, distance sensor, and motors.
2. Utilize problem-solving skills to create, run, and test the different sensors.
3. Compare the different tutorials of the hub, sensors, and motors.

Activity #2: Hopper Race



Estimated Time: 60-90 minutes

Lesson Overview: Students will do the hopper build and race them against each other.

Learning Objectives:

The students will be able to …

1. implement the engineering design process through testing, analyzing, and then optimizing the performance of their robot,
2. construct a hopper to race and then redesign to make the hopper faster,
3. use problem-solving skills to create, test, and run programs to command their robot,

4. apply their knowledge on how engineers work in teams to achieve a common goal,
6. demonstrate the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
5. plan to assign tasks based on the goals and needs of the team.

TEKS:

1. **S6.1(B)**
2. **S6.1(G)**
3. **S6.2(A)**
4. **S6.2(D)**

NGSS:

1. **MS-PS3-3**
2. **MS-ETS1-2**
3. **MS-ETS1-3**
4. **MS-ETS1-4**

Technology Standards:

1. **STEL-8J**
2. **STEL-2M**
3. **STEL-7V**
4. **STEL-7Q**

Materials Needed: (per group)

1. One LEGO® SPIKE™ Prime Robotics Kit
2. One iPad with LEGO® SPIKE™ Prime Software Installed

Lesson Flow:

1. **Prepare**
   a. Read through the material in the LEGO® Education SPIKE™ App.
   b. Have each team build the initial bot using the SPIKE™ Prime App and race.
   c. Students will implement the engineering design process and use problem-solving skills to create, test, run programs, and reiterate to come up with an improved bot design that will make it faster and more efficient.
2. **Engage**
   a. Start a discussion related to this lesson with the students and challenge them to think about their initial design and the steps they took to optimize it. Ask them to reflect on what they did well and what they can improve upon moving forward.
   b. Use the video to explain the lesson.
3. **Explore**
   a. Have the students team up to build the Hopper model.

   b. Ask them to run their program to see how the Hopper moves.
   c. Have the students design and build new legs to propel the Hopper's body forward faster. Highlight that they cannot use wheels for this activity.
4. **Explain**
   a. Facilitate a discussion by asking the students to describe the methods they used to improve their Hopper's movement.
5. **Elaborate**
   a. Prepare the test track by setting up start and finish lines using LEGO® bricks.
   b. Give the teams 15 minutes to test and optimize their models before the final race.
   c. Time permitting, encourage them to give their Hoppers some character by adding bricks and other materials from around the classroom. They can also place bricks on the test track, creating an uneven surface that makes it more difficult to maneuver.
   d. Do not forget to leave some time for the cleanup.
6. **Evaluate**
   a. Give feedback on each student's performance.
   b. You can use the assessment rubrics provided to simplify the process.

Activity #3: Uphill Challenge

Estimated Time: 60-90 minutes

Lesson Overview: Students will use their knowledge of the SPIKE™ Prime kit to build the uphill challenge and relate it to potential and kinetic energy.

Learning Objectives:
The students will be able to …
1. construct a robot that goes uphill and downhill a fabricated ramp,
2. compare potential and kinetic energy through observation of how their bot performs,
3. describe how potential and kinetic energy are conserved and how one form of energy transforms into another,

4. apply their knowledge on how engineers work in teams to achieve a common goal,
5. demonstrate the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
6. explore how to assign tasks based on the goals and needs of the team.

TEKS:

1. **S6.8(A)**
2. **S6.8(B)**

NGSS:

1. **MS-PS3-3**
2. **MS-ETS1-2**
3. **MS-ETS1-3**
4. **MS-ETS1-4**

Technology Standards:

1. **STEL-8J**
2. **STEL-2M**
3. **STEL-7V**
4. **STEL-7Q**

Materials Needed: (per group)

1. One LEGO® SPIKE™ Prime Robotics Kit
2. One iPad with LEGO® SPIKE™ Prime Software Installed

Lesson Flow:

1. **Engage**
   a. The main objective of this lesson is to introduce students to energy transformations. The students will learn that in order for a biker to maintain a constant speed (i.e., constant kinetic energy) when going uphill (i.e., to gain potential energy), they need to input energy. This lesson uses a model of an electric bike. Its energy will come from an increase in its motor's power consumption. In a real-life situation, this energy would come from extra effort expended by the bicyclist.
   b. Use various engineering applications as examples to engage your students on the topic of energy transformations.
2. **Ignite a Discussion**
   Start a discussion by asking questions related to the lesson. Here are a few suggestions:
   a. What will happen to your speed when you go up a hill?
   b. What type of energy do you store as you go uphill?
   c. What is the Conservation of Energy Principle?
   d. How is energy conserved in this example?

   e. Have the students write down their thoughts as a hypothesis.

3. **Explore**
   a. Have the students build a smart bike that can record its motor's power consumption and the angle of a sloped incline. They can create their own models or follow the building instructions in the App to build the Smart Bike model.
   b. Ask the students to try out their models on a flat surface using the suggested program in the SPIKE™ Prime App.
   c. Ask the students to look at the graph and document what they see. Why do the two plotted lines behave like that?
4. **Explain**
   a. Have your students repeat the experiment using an inclined slope, which they can create using the SPIKE™ Prime box and a plank.
   b. Ask the students to explain how the smart bike's motor adds energy to maintain a constant speed.
   c. Have the students explain the relationship between the motor's power consumption and the angle of the inclined slope.
   d. Ask the students to export their data as a CSV file, so they can manipulate it in other mathematical software if they wish.
5. **Elaborate**
   a. If the students still have access to their SPIKE™ Prime Sets, have them complete the tasks from the SPIKE™ App, to enhance their hands-on experiential learning. For example:
      - Challenge the students to create their own track. Ask them to create a track that includes a flat surface, and uphill and downhill slopes.
      - Have the students trace what they think the graph of the motor's power consumption should look like. Then ask them to run their bike along the designed track to see if their predictions were right.
   b. If the students do not have access to their SPIKE™ Prime Sets, have them complete their Student Inventor Notebook, or work on analyzing the data collected during this activity to practice data plotting and result presentation.
   c. Facilitate an "ideas" sharing session in which the students exchange their thoughts and results from this experiment. This can be done using any method/tool that is most efficient (i.e., in-person or online).
6. **Evaluate**
   a. Provide feedback to each student on their overall performance and allow them time for self-reflection.

Activity #4: Cleanup and Discussion

Estimated Time: 15 minutes

Lesson Overview: Have the students reflect on real-life challenges transportation engineers face daily.

Learning Objectives:

The students will be able to …

1. summarize the engineering design cycle (process) based on the performed activities, and
2. explain potential and kinetic energy as it relates to Activities #1 - #3.

TEKS:

1. S6.2(D)

NGSS:

1. MS-ETS1-2
2. MS-ETS1-3
3. MS-ETS1-4

Technology Standards:

1. STEL-8J
2. STEL-2M
3. STEL-8L

Lesson Flow:

1. What is a prototype?
2. What is the benefit of having multiple options for a solution?
3. How do you usually generate ideas before prototyping them?
4. Have you ever prototyped an idea? How did you do it?
5. Discuss how engineers would go about solving the challenge presented in Activity #3, and what possible solutions they might come up with.
6. Make sure the students perform an inventory of all materials used and place it back in the box. Ensure that no LEGO® parts are misplaced, left behind, or missing.

Day 3: Training Camp

Day Overview: The students will be able to explore the history of trains and the wheel-axle assembly. The students will use the LEGO® SPIKE™ Prime Kit and will explore the different components included such as motors, sensors, hubs, and ports, incorporating the engineering design cycle (process), to complete the first lesson – Training Camp 1. Then, the students will work on Training Camp 2 for the second part of the day where they will implement sensors to control motors and interact with objects. The students will end the day by applying the Engineering Design Cycle (Process) through a Robotic Challenge. Students will build a Driving Base and write programs using the color sensor to make the driving base autonomous.

Activity #1: History of Trains and Exploring the Wheel-Axle Assembly

Estimated Time: 30-45 minutes

Lesson Overview: The students will be briefly introduced to the history of trains and will explore the function of the wheel-axle assembly on a train

Learning Objectives:

The students will be able to …

1. explore the concept of the Wheel-Axle Assembly in freight trains, as well as the critical role of forklifts in performing maintenance on railways and train wheels,
2. compare the two different wheel profile models to assess their effectiveness in wheel-axle assembly stability during steering, and
3. listen to the safety procedures in preparation for the engineering high bay tour.

TEKS:

1. **S6.7(A)**
2. **S7.8(A)**

NGSS:

1. **MS-PS2-3**
2. **MS-ETS1-3**

Technology Standards:

1. **STEL-1J**
2. **STEL-6C**
3. **STEL-7Q**
4. **STEL-7U**
5. **STEL-8J**
6. **STEL-8L**

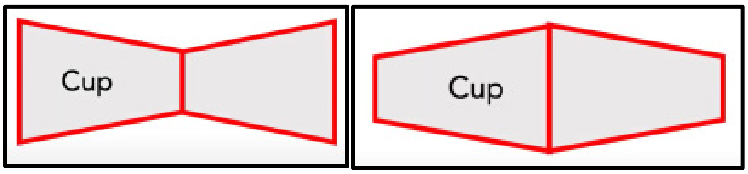
Materials Needed: (per group)

1. 4 Plastic Cups
2. Tape

3. Two 1-Meter Sticks

Lesson Flow:

1. Tape 2 cups together to form the two sets of wheels as shown in the schematic diagram below. https://www.youtube.com/watch?v=l9NpcJqclSY

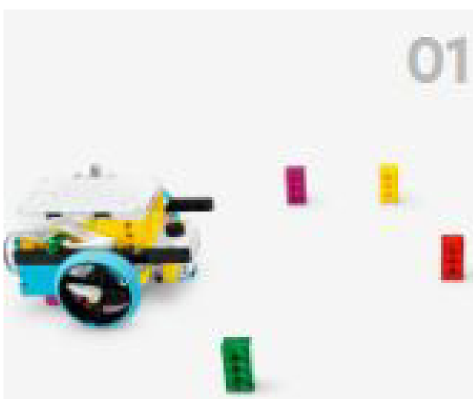


2. Set up the two 1-meter sticks into an inclined plane and tape them in place an appropriate distance apart to form tracks simulating rail tracks.
3. Place your cups (wheels) above the tracks at the top of the incline and release.
4. Explain which of the wheel sets traveled efficiently down the tracks with no incident.

Discussion Questions:

1. What is a wheel, and why is it considered one of humanity's greatest inventions?
2. What are some challenges faced in railway construction?
3. What are some notable technological advancements in rail transportation over time?
4. Reflect on the future of rail transportation and possible technological advancements.

Activity #2: Training Camp 1



Estimated Time: 60-90 minutes

Lesson Overview: Students will build a Practice Driving Base and make precise and controlled maneuvers.

Learning Objectives:

The student will be able to …

1. create a practice Driving Base, making precise and controlled maneuvers using the LEGO® SPIKE™ Prime Kit, and
2. develop a code that programs the robot to move to a designated spot and stop and await further instructions.

TEKS:

1. S6.7(A)
2. S7.8(A)

NGSS:

1. MS-PS2-3
2. MS-ETS1-3

Technology Standards:

1. STEL-1J
2. STEL-6C
3. STEL-7Q
4. STEL-7U
5. STEL-8J
6. STEL-8L

Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual
2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed
4. One Journal (Notebook) and Pen or Pencil

Lesson Flow: (Refer to the PowerPoint Presentation)

1. **Prepare:** Read through the material in the LEGO® Education SPIKE™ using Day 3 PowerPoint. This will help familiarize the students with LEGO® Education SPIKE™ Prime.
2. **Engage:** Initiate a group discussion with the students related to this lesson and try to engage everyone in the conversation to gauge their knowledge. Use the video to explain the lesson.
3. **Explore:** Have the students work in pairs to build the Practice Driving Base model. Give them some time to use the programming stacks provided to explore the mobility of the Driving Base. Ask them to change the values and parameters of the blocks and to observe the effects.
4. **Explain:** Facilitate a discussion about the importance of planning each step of their program. Explain what pseudocode is and how it can help in their program planning.
5. **Elaborate:** Have the students find a way to move their Driving Base in a square. Set up a navigation challenge and encourage the students to test their skills. Do not forget to leave some time for the cleanup.
6. **Evaluate:** Give feedback on each student's performance. You can use the assessment rubrics provided to simplify the process.
7. **Ignite a Discussion:** Navigating through obstacles in robotics competition fields is a key

to success. Engage the students in a discussion by asking them to: Describe a field tactic associated with their favorite sport. List all the motions they think their Driving Base should be able to perform.

Activity #3: Training Camp 2

Estimated Time: 60-90 minutes
Lesson Overview: Students will use sensors to control motors and interact with objects on a designed obstacle course (or track).
Learning Objectives:
The students will be able to …

1. apply the Engineering Design Cycle (Process) through a robotic challenge,
2. create a Driving Base with sensors to control motors and interact with objects on the designed route,
3. write a code that maneuvers the bot and any object it carries through the designed obstacle course,
4. build a practice Driving Base and program it to make precise and controlled movements,
5. apply their knowledge of how engineers work in teams to achieve common goals,
6. understand the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
7. choose their assigned tasks based on the goals and needs of the team.

TEKS:

1. **S6.7(A)**
2. **S7.8(A)**

NGSS:

1. **MS-PS2-3**
2. **MS-ETS1-3**

Technology Standards:

1. **STEL-1J**
2. **STEL-7T**
3. **STEL-7U**
4. **STEL-8J**
5. **STEL-8L**

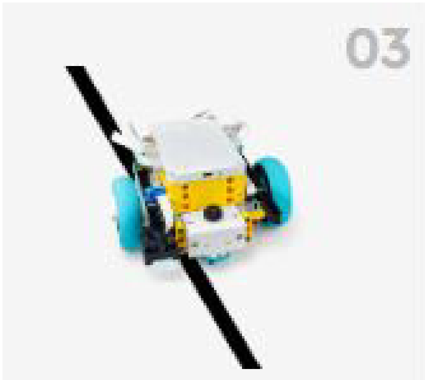
Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual
2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed

Lesson Flow: (Refer to the PowerPoint Presentation)

1. **Prepare:** Read through the material in the LEGO® Education SPIKE™ App.
2. **Engage (Ignite a Discussion):** Use the following ideas to engage the students in a discussion about competition robots and how they must find objects and move them around: Ask the students to describe situations where they have seen robots move objects from one place to another. Inform the students that their Driving Base can use sensors to detect objects and use an extra motor and arm to collect these objects. Explain to the students that they are programming an autonomous robot. Ask them why autonomous mode is important in competitions. Have the students watch the video in the PowerPoint Presentation so they can see what they are about to do.
3. **Explore:** Have the students work in pairs to build the Practice Driving Base, arm, marker, and cube. Ask them to try the two programming stacks to see which one will make their Driving Base stop at the marker. Have the students add extra programming blocks to their Driving Base to make the arm lower, collect, and return the cube from a distance of at least 12 in.(30 cm) away from the marker.
4. **Explain:** Facilitate a discussion about how the Distance Sensor can be used to measure distance.
5. **Elaborate:** Have the students complete the relay race and see which team is the fastest!
6. **Evaluate:** Give feedback on each student's performance and allow some time for self-reflection.

Activity #4: Training Camp 3



Estimated Time: 60-90 minutes

Lesson Overview: Students will write programs using the Color Sensor to make the Driving Base autonomous.

Learning Objectives:

The students will be able to …

1. apply the Engineering Design Cycle (Process) by creating a Driving Base and writing programs using the color sensor to make the Driving Base autonomous,
2. implement the Engineering Design Cycle (Process) through a robotic challenge,
3. apply their knowledge of how engineers work in teams to achieve common goals,
4. demonstrate the importance of each member's role and functions, and how they contribute to accomplishing the overall objective of the task at hand, and
5. assign roles and tasks based on the goals and needs of the team.

TEKS:

1. **S6.7(A)**
2. **S7.8(A)**

NGSS:

1. **MS-PS2-3**
2. **MS-ETS1-3**

Technology Standards:

1. **STEL-1J**
2. **STEL-1M**
3. **STEL-2Q**
4. **STEL-8L**

Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual

2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed
4. One Journal (Notebook) and Pen or Pencil

Lesson Flow: (Refer to the PowerPoint Presentation)

1. **Prepare:** Read through the material in the LEGO® Education SPIKE™ App. You will need a thick black line on a white or light surface for this lesson. Draw a black line on a sheet of white paper or use electrical tape on a light surface. Use a spare black axle element from the LEGO® SPIKE™ Core Set.
2. **Engage (Ignite a Discussion):** Engage the students in a discussion about competition fields and the lines that are often part of the obstacle course or track. Ask the students how they could use these lines to help make their Driving Base program more effective. Explain the different types of lines and intersections:
    a. Thin Lines
    b. Right Angles
    c. T-Junction Lines
    d. Non-Continuous Lines
    e. Black Lines Cut by a Colored Line
    f. Create a Maze
3. **Explore:** Have the students work in pairs to build the Driving Base with a Color Sensor. Ask them to run the first programming stack to get their Practice Driving Base to move forward and stop perpendicular to a black line. Have them try the second programming stack and ask them to describe what happens.
4. **Explain:** Facilitate a discussion about how the Color Sensor detects the black line.
5. **Elaborate:** Have the students work through the next program to get their Driving Base to follow a black line. Ask them to optimize this code to create an even better line-follower program.
6. **Evaluate:** Give feedback on each student's performance and allow some time for self-reflection.

Day 4: Rail Flaw Detection

Day Overview: The students will be given a guided tour of the University of Texas Rio Grande Valley Engineering Building High Bay where they will learn about the various machinery, equipment, and laboratories that engineering students use for testing of railroad bearings and wheel-axle assemblies. The tours will be provided by UTRGV faculty and students involved in the centers' research activities. Upon completion of the tours, students will return to their respective classrooms to finish working on their robot design from Day 3. Students will focus on refining both the design and the coding to optimize the functionality of the robot in removing an obstruction and maneuvering through the obstacle course (track).

Activity #1: Visit to the UTRGV Engineering Building High Bay

Estimated Time: 60 minutes

Lesson Overview:

1. Field trip to the University of Texas Rio Grande Valley Engineering Building High Bay and the University Transportation Center for Railway Safety (UTCRS) laboratories and testing facilities.
2. Learn from and interact with faculty, undergraduate, and graduate students involved in the centers' research activities. Students will have a chance to ask questions and relate the camp activities to the work being performed in the engineering laboratories.

Learning Objectives:

The students will be able to …

1. identify features of a typical Engineering High Bay before heading to the tour,
2. observe and learn about the various machinery and equipment associated with an Engineering High Bay, and
3. reinforce their understanding of the different engineering fields as they interact with undergraduate and graduate students from different engineering majors during the tour.

TEKS:

1. S6.7(A)
2. S7.8(A)

NGSS:

1. MS-PS2-3
2. MS-ETS1-3

Technology Standards:

1. STEL-1K
2. STEL-1L
3. STEL-2M
4. STEL-2N

5. STEL-2R
6. STEL-2S
7. STEL-3E
8. STEL-3G
9. STEL-5F

Materials Needed: (per person)
1. Personal Protective Equipment (Provided)
2. Proper Laboratory Attire (Closed-Toed Shoes, Long Pants – NO Shorts)

Lesson Flow:
1. Students will explore the UTRGV Engineering Building High Bay and become acquainted with the equipment, machinery, and laboratories used by engineering students and faculty to perform their research activities.
2. Students will tour several laboratories where they will get the opportunity to ask faculty, undergraduate, and graduate students questions pertaining to engineering, transportation, sensor technologies, and railway safety.
3. Ask students:
   a. How many of you know what you want to study in college?
   b. How many of you want to be an engineer?
   c. In what fields do you think engineers need to collaborate?
   d. Do you think engineering is important to other career fields?
4. Discuss why it is helpful to start exploring higher education and professional career options from a young age.

Activity #2: Build and Program a Robot with Ultrasonic Sensor

Estimated Time: 60 minutes

Lesson Overview: Students will build a robot with an ultrasonic sensor attachment as well as create, test, and run program codes to control their robot. Students will also watch a series of videos depicting incidents that highlight the importance of Train Track Maintenance with Ultrasonic Sensors and their role in mitigating catastrophic accidents.

Learning Objectives:
The students will be able to …
1. apply problem-solving skills to create, test, and run program codes to control a robot, and
2. assess the performance of their robot design by identifying errors and implementing the engineering design cycle (process) to redesign and optimize the performance of their robot.

TEKS:
1. S5.7(A)

2. S6.7(C)
3. S7.7(A)
4. S7.7(D)
5. M7.3(A)
6. M7.3(B)
7. M7.4(B)
8. M7.4(E)

NGSS:

1. MS-ETS1-2
2. MS-ETS1-3

Technology Standards:

1. STEL-1J
2. STEL-1M
3. STEL-2Q
4. STEL-2S
5. STEL-4O
6. STEL-5F
7. STEL-6C
8. STEL-7Q
9. STEL-7R
10. STEL-7T
11. STEL-7U
12. STEL-8J
13. STEL-8L

Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual
2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed
4. One Journal (Notebook) and Pen or Pencil

Lesson Flow: (Refer to the PowerPoint Presentation)

1. Watch the video on the importance of train track maintenance.
2. Watch the video on the importance of rail flaw detection using ultrasonic sensors.
3. Discuss with the entire class the similarities between echolocation used in bats and the function of an ultrasonic sensor.
4. Discuss the importance of ultrasonic sensors as it relates to railway safety.
5. Use the iPad with the SPIKE™ Prime tutorial to build a robot with the ultrasonic sensor.
6. Ask students to program their robot to move towards the wall and stop 20 cm away from

it with the use of the ultrasonic sensor attachment.

7. Have the students revise their code to alter variables like the movement speed and direction so they can enhance the accuracy of the robot stopping 20 cm from the wall.
8. As an additional challenge, students will place their robots in a central location and test to see if the robots avoid each other or collide. This will gauge the success of programming the ultrasonic sensor.
9. Students will be calculating the average speed of their robot throughout this activity.

Activity #3: The Claw

Estimated Time: 30 minutes

Lesson Overview: Teams will design and build a robot that incorporates a claw and utilizes the ultrasonic sensor attachment to detect, remove, and relocate an obstruction.

Learning Objectives:
The students will be able to …

1. build a robot and apply a specific code to complete a specific task, and
2. analyze the inputs and outputs for each line of code that will allow the robot to traverse through a short obstacle course successfully without incident.

TEKS:

1. **S5.7(A)**
2. **S5.7(B)**
3. **S6.7(A)**
4. **M7.3(A)**
5. **M7.3(B)**
6. **M7.4(E)**

NGSS:

1. **MS-ETS1-2**
2. **MS-ETS1-3**
3. **MS-ETS1-4**

Technology Standards:

1. **STEL-1J**
2. **STEL-5G**
3. **STEL-7Q**
4. **STEL-7R**
5. **STEL-7T**
6. **STEL-7U**
7. **STEL-8J**
8. **STEL-8L**

Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual
2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed
4. One Journal (Notebook) and Pen or Pencil

Lesson Flow:

1. Direct students to the appropriate building blocks on the SPIKE™ Prime App on their iPads.
2. Have students design and build their robot incorporating what is needed to accomplish the tasks in the upcoming challenge.
3. Tape the track on the floor next to each group.
4. Familiarize students with the correct coding sequence to allow for a successful completion of the upcoming challenge.

Activity #4: Detect, Remove, and Relocate an Obstruction

Estimated Time: 45 minutes

Lesson Overview: Students will guide their robots to an obstruction to remove and relocate it using and manipulating the coding contained in the SPIKE™ Prime application while traversing a more difficult track

Learning Objectives:
The students will be able to …

1. modify the code they created for their robot to allow for traversing through a designed track while detecting, removing, and relocating an obstacle in that track.

TEKS:

1. S5.7(A)
2. S5.7(B)
3. S6.7(A)
4. M7.3(A)
5. M7.3(B)
6. M7.4(E)

NGSS:

1. MS-ETS1-2
2. MS-ETS1-3
3. MS-ETS1-4

Technology Standards:

1. STEL-1J
2. STEL-5G

3. **STEL-7Q**
4. **STEL-7R**
5. **STEL-7T**
6. **STEL-7U**
7. **STEL-8J**
8. **STEL-8L**

Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual
2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed
4. One Journal (Notebook) and Pen or Pencil

Lesson Flow:

1. Guide students to correct any errors in their robot design and programming code.
2. Mark the track on the floor for each group using masking tape or electrical tape.
3. Provide examples on how to code for the robot's movement, claw movement, and how to piece the code together to allow for successful relocation of the obstruction.
4. Students may be guided to have their robots traverse a more difficult obstacle course if the initial track provided is less challenging.
5. Students will be calculating the average speed of their robot as it traverses the course.

Day 5: Railway Safety Cargo Delivery Race

Day Overview: The primary activity involves an interactive hands-on engineering challenge where student teams use LEGO® SPIKE™ Prime Robotics kits to design, build, and program a cargo delivery system. This system needs to pick up a wheel-axle assembly, deliver it to a designated location, and return to the starting point without incident. Following the Cargo Delivery Races, students will engage in a reflective discussion on real-world challenges that transportation engineers face daily. The day will conclude with a review of key engineering concepts learned during the week-long activities followed by a cleanup.

Activity #1: Railway Safety Cargo Races

Estimated Time: 180 minutes

Lesson Overview: Teams will use their creativity and the engineering and programming knowledge they gained throughout the week in a freestyle design challenge related to a rail transportation safety issue.

Learning Objectives:
The students will be able to …

1. explore cargo and freight trains for their final challenge,
2. review the Final Challenge Rules and Expectations, and
3. plan for the Final Challenge by implementing final design modifications to their robot and making edits and revisions to optimize their programming code.

TEKS:

1. **S5.7(A)**
2. **S6.7(A)**
3. **S7.7(D)**
4. **S8.7(A)**
5. **M7.7(A)**
6. **M7.12(A)**
7. **M7.12(B)**

NGSS:

1. **PS2-1**
2. **PS2-2**

Technology Standards:

1. **EST1-2**
2. **ETS1-3**

Materials Needed: (per group)

1. LEGO® SPIKE™ Prime Robotics Kit Manual

2. LEGO® SPIKE™ Prime Robotics Kit
3. One iPad with LEGO® SPIKE™ Prime Software Installed
4. One Journal (Notebook) and Pen or Pencil
5. Meter Stick
6. Masking Tape or Black Electrical Tape to Delineate the Challenge Course (Track)

Lesson Flow:

1. Design a special lift that will pick up a wheel-axle assembly using the same driving base. Students may use building instructions from previous lessons.
2. The objective is to efficiently pick up cargo, drop it off, and return to the original starting point safely with no derailments or incidents (i.e., stay on the path).
3. Students should use what they have learned throughout the week to accomplish the task.
4. Remind students to follow the Engineering Design Cycle (Process).
5. Begin Challenge: Remember, the Train (robot) that delivers the wheel-axle assembly efficiently and returns to the start point the quickest, wins the challenge.

Activity #2: Closing Discussion and Cleanup

Estimated Time: 35 minutes

Lesson Overview: Have the students reflect on real-life challenges that transportation engineers face daily. Get students excited about careers in STEM and ask them to remain engaged.

Learning Objectives:
The students will be able to …

1. reflect on what they learned throughout the week in terms of conservation of energy concepts, Newton's Laws of motion, teamwork, engineering design process, transportation engineering, sensor technologies, and effective planning.

TEKS:

1. **S6.8(B)**
2. **S7.8(A)**
3. **S7.9(B)**
4. **M7.12(C)**

NGSS:

1. **ETS1-1**
2. **ETSA-4**

Technology Standards:

1. **EST1-2**
2. **ETS1-3**

Materials Needed: N/A

Lesson Flow:

1. Discuss the real-life challenges engineers face in performing their duties, and how they go about coming up with possible solutions that are creative and innovative.
2. Concept review
   a. What are you measuring?
   b. Reinforce units!!! What are units for distance? Units for time? Units for speed?
   c. After the challenge, review each team's performance and have students reflect on what they did well and what they can improve upon for better results.
   d. What are some coding or other challenges they faced?
3. Closing Discussion
   a. How was today's challenge applicable to Railway Engineering?
   b. What are some real-world challenges engineers face?
   c. What are some of your team's strengths and weaknesses?
4. Announce the winning team and let them know that they will be advancing to the Final Competition (if there is a Final Competition planned). Otherwise, announce the 1st, 2nd, and 3rd place winners.
5. Cleanup
   Have students perform an inventory and put all materials back in the box ensuring that all LEGO® parts are accounted for and there are no misplaced or missing items.

Appendices

Appendix A: Calculating Speed Worksheet – Hot Wheels

Calculating Speed of Hot Wheels

Formula: $\text{Speed } (s) = \dfrac{\text{Distance } (d)}{\text{Time } (t)}$

d = Distance (ft)
t = Time (seconds)
s = Speed (ft/s)

Trial	Height (m)	Distance (ft)	÷	Time (s)	=	Speed (ft/s)
1	0.5	13.75				
2	1.0	13.75				
3	1.5	13.75				
	Average					

- Calculate the *Speed* of your Hot Wheels Car
- Use the following:
  - Distance (measure the length of your track in feet).
  - Time (Use your stopwatch to record the time in seconds).
  - Speed (Use the provided formula to calculate the speed of the Hot Wheels car in feet/second).
  - Complete the 3 trials and calculate the average speed.

Demonstrate your knowledge!!!

Identify in which trial is potential energy the highest? Explain why?

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Appendix B: Calculating Speed Worksheet – Balloon

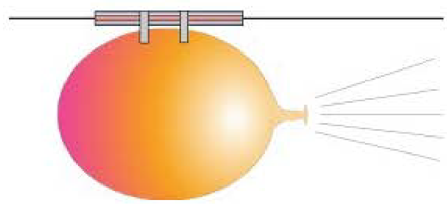
Calculating Speed of a Balloon

Formula: Speed (s) = $\frac{\text{Distance (d)}}{\text{Time (t)}}$

d = Distance (ft)

t = Time (seconds)

s = Speed (ft/s)



	Distance (ft)	÷	Time (s)	=	Speed (ft/s)
1	15				
2	15				
3	15				
4	15				
5	15				
Average					

- Calculate the speed of your balloon
- Use the following:
  - Distance (15 feet).
  - Time (Use your stopwatch to record the time in seconds).
  - Speed (Use the provided formula to calculate the speed of the balloon).
  - Repeat the activity 5 times and take the average of all 5 trials.

Demonstrate your knowledge!!!

Identify which trial had the fastest speed? Explain why?

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