UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

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

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)

ELEMENTARY SCHOOL STEM CURRICULUM

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Learning Objectives

Day 1

Activity #1: Cup Challenge

The students will be able to …

1. demonstrate the importance of teamwork, communication, and listening skills, by voicing their prior knowledge,
2. collaborate by making a pyramid with 10 cups then 15 cups, given 15 cups, a rubber band, and a few strings for the icebreaker activity, and
3. identify what contributed to the success of the common goal of stacking the cups.

Activity #2: Rocket Balloon Racing

The students will be able to …

1. apply Newton's Third Law of Motion to a variety of scenarios, associated with their balloon race, and
2. analyze and explain action-reaction pairs in a variety of scenarios, from the videos and experiments.

Activity #3: Hot Wheels

The students will be able to …

1. apply the concepts of potential and kinetic energy using the Hot Wheels and by exploring the effect of different heights with the creation of their tracks,
2. identify the transfer and effects of potential to kinetic energy and vice versa through the Hot Wheels lab activity,
3. modify the setup (add loop) to observe the transformation of potential energy into kinetic energy from their experimental trials, and
4. calculate the speed of their vehicle using the information they gathered from their trials.

Day 2

Activity #1: Building the Basic Bot

The students will be able to …

1. identify the importance of teamwork by building and coding the EV3 LEGO® Bot,
2. express their assigned engineering roles by following specific roles they are given in a PowerPoint, and
3. practice the Engineering Design Cycle (Process), thereby developing long-term social and professional skills, in building their basic bot.

Activity #2: Calculating Speed

The students will be able to …

1. calculate the speed of their EV3 LEGO® Bot using a stopwatch, calculator, and a cardboard maze setup, and
2. apply mathematical principles to determine speed, reinforcing their understanding of measurement and calculation techniques in a practical engineering context.

Day 3

Activity #1: Rock, Paper, Scissors

The students will be able to …

1. collaborate in teams to comprehend the significance of teamwork and cultivate effective team dynamics by engaging in a rock-paper-scissors team-building activity, and
2. practice mutual support and cooperation, fostering essential interpersonal skills through the team-building exercise activity.

Activity #2: Wheel-Axle Assembly Design

The students will be able to …

1. examine the role of wheel shape and size in preventing train derailment through a foam cup wheel activity,
2. compare the two different wheel profile models to assess their effectiveness in wheel-axle assembly stability during steering, and
3. illustrate the collaborative efforts of engineers in designing solutions, while enhancing students' understanding of mechanical principles and problem-solving skills through this hands-on exercise.

Activity #3: Build and Program Forklift

The students will be able to …

1. observe the function of forklifts in replacing a train's wheel-axle assembly, emphasizing the significance of train maintenance,
2. integrate a forklift compartment into their EV3 LEGO® Bot to address the challenge of maneuvering and handling a wheel-axle assembly prototype, and
3. connect their understanding of mechanical systems, problem-solving abilities, and the practical application of engineering principles within this activity.

Day 4

Activity #1: Rail Flaw Detection and Ultrasonic Sensors

The students will be able to …

1. explore the significance of sensors in railway systems, by understanding their role in alerting engineers to necessary maintenance and preventing train derailments,
2. integrate sensors into their EV3 LEGO® Bot to simulate the process of moving a colored cuboid to predefined locations, and
3. establish practical exercises that aim to deepen understanding of sensor technologies, enhance their problem-solving skills, and illustrate the application of engineering principles in automation and control systems from their creation.

Day 5

Activity #1: Railway Safety EV3 Challenge

The students will be able to …

1. integrate their accumulated knowledge from Days 1 to 4 to tackle a challenge involving the manipulation of a wheel-axle assembly, showcasing their proficiency in building, coding, and teamwork within an instructor-designed maze,
2. apply engineering concepts, problem-solving abilities, and collaborative skills by completing the final challenge, and
3. modify their robot to fit the instructor's predefined criteria, for the winning group to be selected by the instructor.

**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 Essential Knowledge and Skills for Science

S 4.1B	The student is expected to use scientific practices to plan and conduct descriptive investigations and use engineering practices to design solutions to problems.
S5.3A	The student is expected to develop explanations and propose solutions supported by data and models.
S K.2.B	The student is expected to analyze data by identifying significant features and patterns.

S 1.7.A	The student is expected to explain how pushes and pulls can start, stop, or change the speed or direction of an object's motion.
S 4.1.G	The student is expected to develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem.
S 5.1.E	The student is expected to collect observations and measurements as evidence.
S.1.7.B	plan and conduct a descriptive investigation that predicts how pushes and pulls can start, stop, or change the speed or direction of an object’s motion.
S.3.8.B	plan and conduct investigations that demonstrate how the speed of an object is related to its mechanical energy.
S.5.2.C	The student is expected to use mathematical calculation to compare patterns and relationships.
S.4.3.C	The student is expected to listen actively to others' explanations to identify relevant evidence and engage respectfully in scientific discussion.
S.1.1.B	The student is expected to use scientific practices to plan and conduct simple descriptive investigation and use engineering practices to design solutions to problems.
S.K.1.B	The student is expected to use scientific practices to plan and conduct simple descriptive investigations and use engineering practices to design solutions to problems.
S.2.1.B	The student is expected to use scientific practices to plan and conduct simple descriptive investigations and use engineering practices to design solutions to problems.
S.3.1.B	The student is expected to use scientific practices to plan and conduct descriptive investigations and use engineering practices to design solutions to problems.
S.5.1.B	The student is expected to use scientific practices to plan and conduct descriptive and simple experimental investigation and use engineering practices to design solutions to problems.
S.3.7.B	The student is expected to plan and conduct a descriptive investigation to demonstrate and explain how position and motion can be changed by pushing and pulling objects such as swings, balls, and wagons.
S.2.7.A	The student is expected to explain how objects push on each other and may change shape when they touch or collide.
S.2.7.B	The student is expected to plan and conduct a descriptive investigation to demonstrate how the strength of a push and pull changes an object's motion.
S.3.7.A	The student is expected to demonstrate and describe forces acting on an object in contact or at a distance, including magnetism, gravity, and pushes and pulls.

MATH TEKS

2012 Texas Essential Knowledge and Skills for Mathematics

M 3.1.B	Use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution. (Page 13)
M 4.9	Data analysis. The student applies mathematical process standards to solve problems by collecting, organizing, displaying, and interpreting data. (Page 20)
M 3.8.A	summarize a dataset with multiple categories using a frequency table, dot plot, pictograph, or bar graph with scaled intervals. (Page 16)
M 3.8.B	solve one- and two-step problems using categorical data represented with a frequency table, dot plot, pictograph, or bar graph with scaled intervals. (Page 16)
M 4.8.C	solve problems that deal with measurements of length, intervals of time, liquid volumes, mass, and money using addition, subtraction, multiplication, or division as appropriate. (Page 20)
M 4.9.A	represent data on a frequency table, dot plot, or stem-and-leaf plot marked with whole numbers and fractions. (Page 20)
M 4.9.B	solve one- and two-step problems using data in whole number, decimal, and fraction form in a frequency table, dot plot, or stem-and-leaf plot. (Page 20)
M 5.9.A	represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and leaf plots. (Page 22)
M 5.9.C	solve one- and two-step problems using data from a frequency table, dot plot, bar graph, stem-and-leaf plot, or scatterplot. (Page 24)
M 3.7	Geometry and measurement. The student applies mathematical process standards to select appropriate units, strategies, and tools to solve problems involving customary and metric measurement. (Page 15)

2017 Next Generation Science Standards Elementary

K-PS2-1	Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (Page 3)
3-PS2-1	Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (Page 16)
4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object. (Page 21)
K-PS2-2	Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. (Page 3)
2-PS1-1	Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. (Page 11)

K-2-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. (Page 14)
2-PS1-3	Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. (Page 11)
K-2-ETS1-1	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. (Page 14)
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. (Page 30)
3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. (Page 16)
4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (Page 21)
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. (Page 30)
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. (Page 30)
K-2-ETS1-3	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. (Page 14)
2-PS1-2	Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. (Page 11)

2020 Standards for Technological and Engineering Literacy

STEL-B	Explain the tools and techniques that people use to help them do things. (Page 23)
STEL 3	Apply concepts and skills from technology and engineering activities that reinforce concepts and skills across multiple content areas. (Page 38)
STEL-7W	Determine the best approach by evaluating the purpose of the design. (Page 62)
STEL-7X	Document tradeoffs in technology and engineering design process to produce the optimal design. (Page 62)
STEL-7BB	Implement the best possible solution to a design. (Page 104)
STEL-2J	Demonstrate how tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing. (Page 28)
STEL-2G	Illustrate how, when parts of a system are missing, it may not work as planned. (Page 31)
STEL-2K	Describe requirements of designing or making a product or system. (Page 98)

Day 1: Engineering Design Cycle (Process)

Day Overview: The students will gain an understanding of how engineers collaborate in teams to achieve common goals. They will also delve into the history and speed of trains, while continuing to explore the fundamental principles of aerodynamics. Additionally, they will have the opportunity to engage in and practice the Engineering Design Cycle (Process).

Activity #1: Cup Challenge

Activity Overview: The students will use teamwork, collaboration, and creativity among team members through a series of challenges and activities centered around cups.

Estimated Time: 20-30 minutes

Learning Objectives:
The students will be able to …

1. demonstrate the importance of teamwork, communication, and listening skills, by voicing their prior knowledge,
2. collaborate by making a pyramid with 10 cups then 15 cups, given 15 cups, a rubber band, and a few strings for the icebreaker activity, and
3. identify how the different skills contributed to the success of the common goal of stacking the cups.

Science TEKS:

1. S 4.1.B
2. S 5.3.A

Math TEKS:

1. M 3.1.B

NGSS: N/A

Technology Standards:

1. STEL-B
2. STEL 3

Materials Needed:

1. 90 Solo Cups (15/group)
2. 30 (2 ft in Length) Pieces of Yarn/String (1/student)
3. 12 Rubber Bands (2/group)

Lesson Flow: (Refer to Day 1 Guided Presentation)

1. In this activity, the challenge is to build a pyramid of cups (as shown) by working together. Tie each group member's string to the rubber band. All team members will NOT touch the cups, but rather stretch the rubber band to grab a cup.
2. Give students directions for the activity and materials. Start the activity and monitor students to make sure they are working together and not touching the cups with their hands.
3. 1st round is 10 cups stacked.
4. 2nd round is 15 cups stacked.
5. Complete when groups have had enough time to collaborate and practice.

Use the following reflection questions and have students discuss and then answer within their group:

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 #2: Rocket Balloon Racing

Activity Overview: In this activity students will learn about Newton's 3rd Law of Motion (For every action, there is an equal and opposite reaction) by conducting a rocket balloon experiment.

Estimated Time: 30-45 minutes

Learning Objectives:
The students will be able to …

1. apply Newton's Third Law of Motion to a variety of scenarios, including their balloon race, and
2. analyze and explain action-reaction pairs in a variety of scenarios, from the videos and experiments.

Science TEKS:

1. S K.2.B
2. S 1.7.A

Math TEKS:

1. M 4.9

NGSS:

1. K-PS2-1
2. 3-PS2-1
3. 4-PS3-1

Technology Standards:
1. STEL-7W
2. STEL-7X
3. STEL-7BB

Materials Needed:
1. 12 (12 in) Balloons (2/group)
2. 32-40 ft of Fishing Line (2 setups)
3. Masking or Clear Tape (as needed)
4. Drinking Straws (Cut into 2 in) (1/setup)
5. 2 Pairs of Scissors (as needed)

Lesson Flow: (Refer to Day 1 Guided Presentation)
1. Students will anchor a fishing line with a threaded straw in between two chairs.
2. Next, students will tape a small balloon to the straw and observe the balloon's reaction when force is applied to the opposite end.
3. Then, students will increase potential energy by altering the variable of size to each balloon.

Use the following reflection questions and have students discuss and then answer within their group:
1. What is Newton's 3rd Law of Motion?
2. How was Newton's 3rd Law of Motion demonstrated during the balloon rocket experiment? How did you know where the forces were applied?
3. What would happen if you made your balloon bigger? smaller?
4. How did you demonstrate teamwork during this activity?

Activity #3: Hot Wheels

Activity Overview: Students will design and construct a functional Hot Wheels track to showcase creativity and engineering skills while exploring the concepts of potential and kinetic energy.

Estimated Time: 30-45 minutes

Learning Objectives:
The students will be able to …
1. apply the concepts of potential and kinetic energy using the Hot Wheels and by exploring the effect of different heights with the creation of their tracks,
2. identify the transfer and effects of potential to kinetic energy and vice versa through the Hot Wheels lab activity,
3. modify the setup (add loop) to observe the transformation of potential energy into kinetic energy from their experimental trials, and
4. calculate the speed of their vehicle using the information they gathered from their trials.

Science TEKS:
1. S 4.1.G
2. S 5.3.A
3. S 5.1.E

Math TEKS:
1. M 3.8.A
2. M 3.8.B
3. M 4.8.C
4. M 4.9.A
5. M 4.9.B
6. M 5.9.A
7. M 5.9.C

NGSS:
1. K-PS2-2
2. 2-PS1-1
3. K-2-ETS1-2

Technology Standards:
1. STEL-7X
2. STEL-7BB

Materials Needed:
1. 12 Hot-Wheel Cars (2/group)
2. 6 Hot Wheel Kits (Tracks and Connectors) (1/group)
3. Masking or Clear Tape (as needed)
4. Index Cards (for Modifications) (2/group)
5. 6 Stopwatches (1/group)
6. 6 Calculators (1/group)
7. Paper and Pencils (as needed)

Lesson Flow: (Refer to Day 1 Guided Presentation)
1. Set up your test track by creating a 10-foot length track.
2. The bottom of the ramp should rest on a hard, smooth surface.
3. You will establish a consistent distance for cars to travel and must contain one loop.
4. Run the car from the top of the ramp, measure how long it takes for the car to reach the bottom of the ramp.
5. Record your observations.

Use the following reflection questions and have students discuss and then answer within their group:

1. What do you think caused the car to go farther?
2. What are some of the factors that could have affected your results?
3. Do you think the type of car your group used affected your results?
4. How would you improve your car design?
5. How does this apply to Newton's Laws?
6. What law applies to adding weight on cars and testing speed?

Day 2: Building the Basic Bot and Calculating Speed

Day Overview: The students will review the engineering design process and Day 1 concepts to ensure proper retention for building the Basic EV3 Robot. They will also practice good communication and listening skills to learn how to work well in groups. After building their bot, students will engage in simple coding and calculating speed.

Activity #1: Building the Basic Bot

Activity Overview: The students will collaborate within their group to build and code the EV3 Lego Bot driving base.

Estimated Time: 1-2 hours

Learning Objectives:
The students will be able to …

1. identify the importance of teamwork by building and coding the EV3 LEGO® Bot,
2. express their assigned engineering roles by following specific roles they are given in a PowerPoint, and
3. practice the engineering design process, thereby developing long-term social and professional skills, in building their basic bot.

Science TEKS:

1. S.1.7.A
2. S.1.7.B
3. S.3.8.B

Math TEKS:

1. M 3.8.A
2. M 3.8.B
3. M 4.9.A
4. M 4.9.B
5. M 5.9.A
6. M 5.9.C

NGSS:

1. 2-PS1-3
2. K-2-ETS1-1
3. 3-5-ETS1-3

Technology Standards:

1. STEL-7X
2. STEL-7BB

Materials Needed:

1. 6 Lego EV3 Kits (1/group)
2. 6 Laptops or iPads (1/group)
3. 6 Cardboard Trifolds with Maze (36 in by 48 in) (1/group)
4. Electrical Tape (as needed to create mazes)
5. Masking Tape (as needed to practice going in a straight line or square)
6. 6 Meter Sticks (1/group)
7. 6 Stop Watches (1/group)
8. 6 Calculators (1/group)

Lesson Flow: (Refer to Day 2 Guided Presentation)

1. Students(teams) will be building and programming their own robot.
2. Teams will construct a basic driving base robot from LEGO® MINDSTORM® EV3 robotics kit using the LEGO® Education EV3 Classroom.

Use the following reflection questions and have students discuss and then answer within their group:

1. How was today's challenge applicable to Railway Engineering?
2. What are some real challenges engineers face?
3. What are some of your team's strengths and weaknesses?
4. What can you do tomorrow to improve your driving base/coding?

Activity #2: Calculating Speed

Activity Overview: Students will calculate the speed of an EV3 LEGO® Bot using time and distance measurements, while applying mathematical principles in a practical engineering context.

Estimated Time: 20-30 minutes

Learning Objectives:
The students will be able to …

1. calculate the speed of their EV3 LEGO® Bot using a stopwatch, calculator, and a cardboard maze setup, and
2. apply mathematical principles to determine speed, reinforcing their understanding of measurement and calculation techniques in a practical engineering context.

Science TEKS:

1. S.5.2.C
2. S.4.3.C
3. S.1.1.B

Math TEKS:

1. M 3.7

NGSS:

1. 3-PS2-2
2. 4-PS3-4
3. 3-5-ETS1-2

Technology Standards:

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

Materials Needed:

1. 6 EV3 LEGO® Bot (1/group)
2. 6 Laptops or iPads (1/group)
3. 6 Stopwatches or Timers (1/group)
4. 6 Calculators (1/group)
5. 6 Cardboard Maze Setup with Marked Distances (1/group)
6. 6 Measuring Tapes or Rulers (1/group)

Lesson Flow: (Refer to Day 2 Guided Presentation)

1. Introduce the concept of speed in the context of robotics and engineering.
2. Discuss why measuring and understanding speed is important for robotics applications.
3. Set up the cardboard maze with clearly marked distances (e.g., 1 meter, 2 meters, etc.).
4. Ensure the EV3 LEGO® Bot is programmed and ready to run through the maze.
5. Record the time taken (in seconds) and the distance traveled (in meters).
6. Have students calculate the speed using the formula.
7. Use the calculator to perform the division and determine the speed in meters per second (m/s).
8. Compare the speeds calculated for different distances.

Day 3: Wheel-Axle Assembly

Day Overview:
The students will engage in team-building exercises to learn the importance of teamwork. They will explore the method and concept of Wheel-Axle Assembly, as well as the critical role of forklifts in performing maintenance on railways and train wheels. Students will also gain an understanding of safety procedures in preparation for the engineering high bay tour. Finally, students will build a forklift component, integrate it into their EV3 driving base, and code it to pick up and release a replica of a wheel-axle assembly.

Activity #1: Rock, Paper, Scissors

Activity Overview:
Students will participate in an interactive game of Rock, Paper, Scissors while reinforcing decision-making skills, strategic thinking, and the concept of probability.

Estimated Time: 10 minutes

Learning Objectives:
The students will be able to …
1. collaborate in teams to comprehend the significance of teamwork and cultivate effective team dynamics by engaging in a rock-paper-scissors team-building activity, and
2. practice mutual support and cooperation, fostering essential interpersonal skills through the team-building exercise activity.

Science TEKS:
1. S.K.1.B
2. S.1.1.B
3. S.2.1.B
4. S.3.1.B
5. S.4.1.B
6. S.5.1.B

Math TEKS:
1. M 3.8.A
2. M 3.8.B
3. M 4.9.A
4. M 4.9.B
5. M 5.9.A
6. M 5.9.C

NGSS: N/A

Technology Standards:
1. STEL-2G
2. STEL-2K

Materials Needed:
1. Class participants

Lesson Flow: (Refer to Day 3 Guided Presentation)
1. Students will first compete with members in their group.
2. The winner from each duo will then compete with another winner from a different duo.
3. Those that have lost will follow a winner and cheer them on.
4. Once all members in the group have played, they can then move on to compete with other winners from different groups.
5. Last person to win will be considered the classroom champion.

Use the following reflection questions and have students discuss and then answer within their group:
1. How did you feel as a supporter/winner?
2. How is support important in a team?

Activity #2: Wheel-Axle Assembly Design

Activity Overview: The students will analyze the history of trains and explore the function of the wheel-axle assembly on trains.

Estimated Time: 20-30 minutes

Learning Objectives:
The students will be able to …
1. examine the role of wheel shape and size in preventing train derailment through a foam cup wheel activity,
2. compare the two different wheel profile models to assess their effectiveness in wheel-axle assembly stability during steering, and
3. illustrate the collaborative efforts of engineers in designing solutions, while enhancing students' understanding of mechanical principles and problem-solving skills through this hands-on exercise.

Science TEKS:
1. S.1.1.B
2. S.2.1.B
3. S.3.1.B

Math TEKS:
1. M 4.9.B

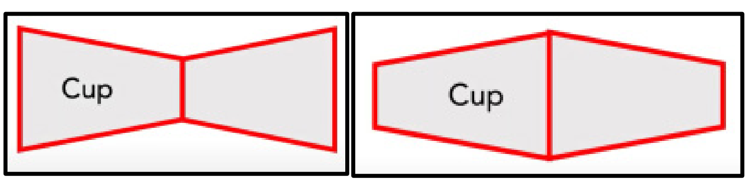
2. M 5.9.A
3. M 5.9.C

NGSS:
1. K-PS2-1 and K-PS2-2
2. 3-PS2-1
3. 5-PS1-3
4. 3-5-ETS1-2 and 3-5-ETS1-3

Technology Standards:
1. STEL-2J
2. STEL-2G
3. STEL-2K

Materials Needed:
1. 24 Plain Foam Cups (4/group)
2. Masking Tape (as needed to tape cups together)
3. 12 Meter Sticks (2/group)
4. 6 Chairs (1/group)
5. 6 EV3 Lego Kits (1/group)
6. 6 Laptops or iPads (1/group)

Lesson Flow: (Refer to Day 3 Guided Presentation)
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.

Use the following reflection questions and have students discuss and then answer within their group:
1. Did the shape of the wheel matter?
2. Was your hypothesis correct?
3. What other uses could this design have in everyday life?

Activity #3: Build and Program Forklift

Activity Overview: Using the Medium Motor, students will build a functioning forklift to grab and release.

Estimated Time: 90 minutes

Learning Objectives:
The students will be able to …
1. observe the function of forklifts in replacing a train's wheel-axle assembly, emphasizing the significance of train maintenance,
2. integrate a forklift compartment into their EV3 LEGO® Bot to address the challenge of maneuvering and handling a wheel-axle assembly prototype, and
3. connect their understanding of mechanical systems, problem-solving abilities, and the practical application of engineering principles within this activity.

Science TEKS:
1. S.4.3.C
2. S.1.1.B
3. S.5.2.C
4. S.3.7.B

Math TEKS:
1. M 4.9.B
2. M 5.9.A
3. M 5.9.C

NGSS:
1. 2-PS1-3
2. K-2-ETS1-1 and K-2-ETS1-3
3. 3-5-ETS1-2 and 3-5-ETS1-3

Technology Standards:
1. STEL-2G
2. STEL-2K

Materials Needed:
1. 6 EV3 LEGO® Bot Kits (1/group)
2. 6 Laptops or iPads (1/group)

Lesson Flow: (Refer to Day 3 Guided Presentation)
1. Using the Medium Motor, students will build a functioning forklift.
2. Students will use the forklift to lift a “wheel-axle assembly” and place it at the drop-off section

of the board with maze.

3. Once done, they need to park their robot at the "UTRGV Railway Safety Parking Area."

Use the following reflection questions and have students discuss and then answer within their group:

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. How do you feel about your finished project?

Day 4: Rail Flaw Detection and Forklift Component

Day Overview: Students will investigate the critical maintenance required for train tracks, wheels, and bearings to prevent accidents and malfunctions. They will learn about the use of ultrasonic sensors and other advanced systems that train engineers employ to detect rail flaws. Additionally, students will have the opportunity to add an ultrasonic sensor to their EV3 bot, simulating real-world scenarios where engineers identify and address issues with malfunctioning wheel-axle assemblies. Finally, students will have time to practice and prepare for the challenge on Day 5.

Activity #1: Rail Flaw Detection and Ultrasonic Sensors

Activity Overview: An ultrasonic sensor will be added to the EV3 LEGO® Bot to measure the distance, in centimeters, to an object in front of it.

Estimated Time: 60-120 minutes

Learning Objectives:
The students will be able to …
1. investigate the significance of ultrasonic sensors in railway systems, by understanding their role in alerting engineers to necessary maintenance and preventing train derailments,
2. integrate ultrasonic sensors into their EV3 LEGO® Bot to simulate the process of moving a colored cuboid to predefined locations, and
3. establish practical exercises that aim to deepen understanding of sensor technologies, enhance their problem-solving skills, and illustrate the application of engineering principles in automation and control systems from their creation.

Science TEKS:
1. S.1.7.A
2. S.1.7.B
3. S.2.7.A
4. S.2.7.B
5. S.3.7.A
6. S.3.7.B

Math TEKS:
1. M 3.8.B
2. M 4.8.C
3. M 5.9.A

NGSS:
1. 2-PS1-2
2. K-2-ETS1-1 and K-2-ETS1-3
3. 3-5-ETS1-2 and 3-5-ETS1-3

Technology Standards:

1. STEL-2J
2. STEL-2G
3. STEL-2K

Materials Needed:

1. 6 EV3 LEGO® Bot Kits (1/group)
2. 6 Laptops or iPads (1/group)

Lesson Flow: (Refer to Day 4 Guided Presentation)

Scenario: Your team has been hired by the CREST-MECIS Railway Company to design a robot to detect rail flaws, which is important to prevent railway accidents, such as an object lying on the tracks. Your challenge is to (1) program your robot ('train') to stop in front of an object ('cuboid') on the 'tracks', (2) lower its arm to collect the cuboid, and (3) move the cuboid 90 degrees to the left. In doing so, you will prevent your train from colliding with the cuboid and causing harm to personnel and cargo.

Building Cuboid and extensions: (15- 20 minutes)

1. Follow the instructions prompted on your screen.
2. Pair your robot to the laptop or iPad.
3. Press play and make observations.
4. Make sure you read the yellow block.

Program the Driving Base to use the ultrasonic sensor: (45-60 minutes)

1. Stop in front of the cuboid.
2. Lower the arm to collect the cuboid.
3. Move the cuboid 90 degrees to the left.

Use the following reflection questions and have students discuss and then answer within their group:

1. How do ultrasonic sensors detect the distance of an object in front of it?
2. How was today's challenge applicable to Railway Engineering?

Day 5: Railway Safety EV3 Challenge

Day Overview: Teams will use their creativity and the knowledge of engineering and programming they gained throughout the week in a freestyle design challenge to solve railway transportation issues. Apply principles of engineering and programming to design their own transportation safety LEGO® MINDSTORM® EV3 robot and follow a predesigned path using motors and color sensor.

Activity #1: Railway Safety EV3 Challenge

Activity Overview: Students will design and construct their EV3 robot to challenge and solve railway transportation issues.

Estimated Time: 4 hours

Learning Objectives:
The students will be able to …
1. integrate their accumulated knowledge from Days 1 to 4 to tackle a challenge involving the manipulation of a wheel-axle assembly, showcasing their proficiency in building, coding, and teamwork within an instructor-designed maze,
2. apply engineering concepts, problem-solving abilities, and collaborative skills by completing the final challenge, and
3. modify their robot to fit the instructor's predefined criteria (as shown on guiding presentation), for the winning group to be selected by the instructor.

Science TEKS:
1. S.K.1.B
2. S.1.1.B
3. S.2.1.B
4. S.3.1.B
5. S.4.1.B
6. S.5.1.B

Math TEKS:
1. M 3.8.B
2. M 4.8.C
3. M 5.9.A

NGSS:
1. K-2-ETS1 and K-2-ETS1-3
2. 3-5-ETS1-2 and 3-5-ETS1-3

Technology Standards:
1. STEL-2J
2. STEL-2G

3. STEL-2K

Materials Needed:

1. 6 LEGO® MINDSTORM® EV3 Robotics Kits (1/group)
2. 6 Laptops or iPads (1/group)
3. 6 Meter Sticks (1/group)
4. Electrical and Masking Tape (as needed)

Lesson Flow: (Refer to Day 5 Guided Presentation)

1. The final challenge will be to build a robot and program it to have at least two mechanisms in place. This is designed to be an open-ended challenge.
2. Explain the rules for the final competition and the selection criteria to be used during the Final Challenge for selecting the winning team.
3. Guide students to use their creativity and imagination, coupled with all of the engineering concepts and knowledge they have gained about transportation issues to build and program a robot that addresses one (or more) transportation safety issue(s).
4. The robot must have a color sensor and medium motor forklift.
5. Teams can be creative in their designs by following the Engineering Design Cycle (Process).

Use the following reflection questions and have students discuss and then answer within their group:

1. How is speed calculated?
2. Determine the speed if a train is traveling 100 meters in 45 seconds.
3. How do you increase the potential energy during the Hot Wheels activity?
4. Where does kinetic energy reach a maximum in the Hot Wheels activity?
5. Explain Newton's 3rd Law of Motion as demonstrated in the Balloon Rocket activity.

Appendices

Appendix A: Calculating Speed of Hot Wheels Car – [Link to Access Google Drive]

Calculating Speed of Hot Wheels

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

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 of a Ballon – [Link to Access Google Drive]

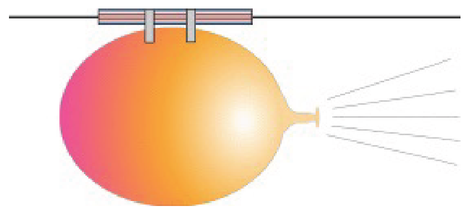
Calculating Speed of a Balloon

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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