



University Transportation Center for Railway Safety (UTCRS)

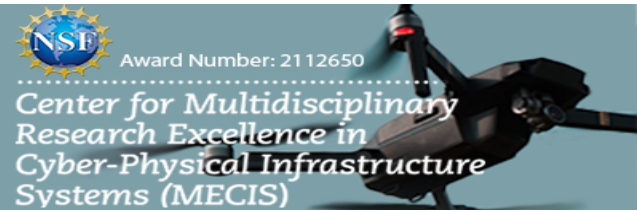
ELEMENTARY SCHOOL STEM CURRICULUM





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Learning Objectives

Day 1: Welcome Aboard

Activity #1: I See... I Think... I Wonder...

- Make observations and distinguish between what they see, think, and wonder.
- Generate questions about railway engineering and transportation.
- Connect prior knowledge to new learning experiences.

Activity #2: Team Building Activity

- Demonstrate teamwork and effective communication during a collaborative challenge.
- Apply problem-solving skills to accomplish a shared goal.
- Reflect on the importance of teamwork in engineering.

Activity #3: What is Engineering? (Think-Pair-Share)

- Describe the role of engineers in solving real-world problems.
- Identify examples of engineering in everyday life.
- Explain how engineering improves railway safety and communities.

Activity #4: Design Process Sort

- Identify and sequence the steps of the Engineering Design Process.
- Explain how engineers improve designs through testing and redesign.
- Apply the Engineering Design Process to future engineering challenges.

Activity #5: Ramp Railways

- Observe how changes in ramp height affect motion.
- Explain how gravity influences the movement of objects.
- Predict how changes to a ramp affect an object's motion.

Activity #6: Hot Wheels Lab

- Investigate how ramp height affects the motion of a Hot Wheels car.
- Analyze how gravity, force, and energy influence motion.
- Use evidence from an investigation to explain results.

Activity #7: Building a Biking Bot

- Build and program a LEGO® Education SPIKE™ Prime Biking Bot.
- Apply the Engineering Design Process to test and improve the robot.
- Demonstrate teamwork while solving an engineering challenge.

Activity #8: Hot Wheels Lab



- Design and test a prototype using the Engineering Design Process.
- Evaluate the effectiveness of a design using evidence from testing.
- Improve a prototype through redesign.

Day 2: Vaquero Station

Activity #1: Engineering Design Recap

- Recall the steps of the Engineering Design Process.
- Explain how engineers use testing and redesign to solve problems.
- Connect the Engineering Design Process to the day's engineering challenges.

Activity #2: Conductors in Training: Team Builder & Collaboration Lab

- Demonstrate effective teamwork and communication during a collaborative engineering challenge.
- Apply problem-solving skills to complete a shared task.
- Explain how collaboration supports engineering and railway safety.

Activity #3: Electrical Circuits

- Explain how electricity travels through a complete circuit.
- Differentiate between conductors and insulators.
- Predict which materials will allow electricity to flow.

Activity #4: Building Basic Circuits

- Construct a working electrical circuit using batteries, wires, and a light source.
- Test materials to identify conductors and insulators.
- Explain why a complete circuit is necessary for electricity to flow.

Activity #5: Why Conductors Matter

- Explain the roles of conductors and insulators in electrical systems.
- Identify how electricity powers railway safety systems.
- Describe how engineers design reliable electrical systems to improve railway safety.

Activity #6: Electricity in Railway Systems

- Identify ways electricity is used throughout modern railway systems.
- Explain how electrical systems improve railway safety.
- Connect circuits, conductors, and insulators to real-world railway technologies.

Activity #7: Building an Electromagnet

- Construct and test a simple electromagnet.
- Explain how electricity creates a magnetic field.
- Describe how electromagnets are used in transportation and railway technologies.

Activity #8: Electromagnet Challenge



- Apply the Engineering Design Process to improve an electromagnet.
- Test how design changes affect the strength of an electromagnet.
- Use evidence from multiple trials to evaluate and improve a design.

Day 3: Freight Transportation Engineers

Activity #1: Team Building Activity (Rock, Paper, Scissors War)

- Demonstrate teamwork, communication, and good sportsmanship during a collaborative activity.
- Explain why teamwork is essential in engineering and railway operations.
- Connect collaboration skills to real-world engineering careers.

Activity #2: Maintenance and Derailments

- Define a derailment and identify common causes of train derailments.
- Explain how routine inspections and maintenance improve railway safety.
- Describe how engineers use data and observations to prevent equipment failures.

Activity #3: Wheel and Axle Engineering

- Identify the functions of wheels, axles, and bearings in railway systems.
- Explain how wheel and axle design reduces friction and helps prevent derailments.
- Apply the Engineering Design Process to investigate and improve a wheel-and-axle model.

Activity #4: Railway Cargo Sorting

- Identify common freight railcars and the types of cargo they transport.
- Match cargo to the appropriate railcar based on its characteristics.
- Explain how engineers improve the safety and efficiency of freight transportation.

Activity #5: Simple Machines: Wheels and Axles

- Explain how wheels and axles function as simple machines.
- Describe how simple machines make moving heavy loads easier.
- Connect simple machines to real-world railway engineering applications.

Activity #6: Build and Program a LEGO® SPIKE™ Prime Forklift

- Build and program a LEGO® SPIKE™ Prime forklift using engineering instructions.
- Apply coding and the Engineering Design Process to test and improve the robot.
- Explain how robotics supports modern freight transportation.

Activity #7: Freight Transportation Challenge

- Program and operate a LEGO® SPIKE™ Prime forklift to transport cargo safely.
- Evaluate and improve a robotic solution through testing and redesign.
- Demonstrate teamwork and problem-solving while completing an engineering challenge.



Day 4: The Final Freight Challenge

Activity #1: High Bay Tour: Exploring Railway Engineering

- Observe how engineers apply STEM concepts to solve real-world railway transportation challenges.
- Identify engineering concepts explored throughout the week in a professional research environment.
- Connect classroom learning to engineering careers and railway safety.

Activity #2: Team Building Challenge: Good Listener

- Demonstrate active listening, teamwork, and communication during a collaborative challenge.
- Apply quick decision-making skills by following verbal directions accurately.
- Explain how communication contributes to safe engineering and railway operations.

Activity #3: Railway Systems Review

- Review key concepts related to freight transportation, derailment prevention, and railway safety.
- Explain how inspections, maintenance, sensors, and signals improve railway operations.
- Connect engineering practices to the safe movement of freight.

Activity #4: Newton's Third Law in Action

- Explain Newton's Third Law using the concepts of action and reaction forces.
- Build and test a balloon-powered racer to investigate forces and motion.
- Apply the Engineering Design Process to evaluate and improve a design.

Activity #5: Final Engineering Challenge: Smart Railway Safety System

- Apply the Engineering Design Process to solve a simulated railway engineering challenge.
- Build, program, and operate a LEGO® Education SPIKE™ Prime forklift to complete a transportation mission.
- Demonstrate teamwork, problem-solving, and computational thinking while improving a robotic solution.



Science Texas Essential Knowledge and Skills (TEKS) TEKS

2021 Texas Essential Knowledge and Skills for Science

S.4.1(A)	The student is expected to ask questions and define problems based on observations or information from text, phenomena, models, or investigations
S.4.1(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.4.1(C)	The student is expected to demonstrate safe practices and the use of safety equipment during classroom and field investigations as outlined in Texas Education Agency-approved safety standards;
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.4.6(A)	The student is expected to classify and describe matter using observable physical properties, including temperature, mass, magnetism, relative density (the ability to sink or float in water), and physical state (solid, liquid, gas);
S.4.6(B)	The student is expected to investigate and compare a variety of mixtures, including solutions that are composed of liquids in liquids and solids in liquids; and
S.4.8(A)	The student is expected to investigate and identify the transfer of energy by objects in motion, waves in water, and sound

Math TEKS

2012 Texas Essential Knowledge and Skills for Mathematics

M.4.1(A)	Apply mathematics to problems arising in everyday life, society, and the workplace
M.4.1(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
M.3.7(A) (where applicable)	Represent fractions of halves, fourths, and eighths as distances from zero on a number line

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)
<u>3-5-ETS1-3</u>	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)
<u>K-2-ETS1-3</u>	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)
<u>2-PS1-2</u>	Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. (Page 11)



Day 1: Welcome Aboard! Engineering Design Process, Gravity, Tracks, and Energy

Day Overview

The first day of Railway Safety Camp introduces students to the exciting world of engineering while establishing the collaborative learning environment that will guide the remainder of the week. Students are welcomed into the program, introduced to the instructors and camp expectations, and provided with an overview of the learning experiences they will participate in throughout the week. These opening activities help students feel comfortable, build relationships with their peers, and begin thinking like engineers.

Throughout the day, students explore what engineering is and discover how engineers use creativity, science, mathematics, and teamwork to solve real-world problems. Through collaborative challenges, discussions, and hands-on investigations, students begin developing the communication, critical thinking, and problem-solving skills that engineers rely on every day.

Students are also introduced to the Engineering Design Process, which serves as the foundation for the entire curriculum. Rather than viewing mistakes as failures, students learn that engineers continuously test, evaluate, and improve their ideas. This mindset prepares students for the engineering challenges they will encounter throughout the remainder of the camp.

The day concludes with students making their first connections between engineering concepts and railway safety while becoming familiar with LEGO® Education SPIKE™ Prime materials that will be used throughout the week. By the end of Day 1, students will understand that engineering is a collaborative process focused on solving problems that improve the safety and quality of life for communities around the world.

Lesson Objectives:

By the end of Day 1, students will be able to:

- Describe the purpose and expectations of Railway Safety Camp.
- Demonstrate safe and respectful participation during collaborative activities.
- Explain that engineers solve problems by using science, mathematics, creativity, and teamwork.
- Identify characteristics of successful engineers.
- Describe the steps of the Engineering Design Process.
- Work collaboratively to complete a team-building challenge.
- Recognize that engineers improve designs through testing and redesign.
- Make connections between engineering and railway safety.
- Build confidence using LEGO® Education SPIKE™ Prime materials.

Essential Questions



- What is engineering?
- How do engineers solve problems?
- Why is teamwork important during engineering projects?
- How does the Engineering Design Process help engineers improve their ideas?
- How can engineering make rail transportation safer?

Day 1 at a Glance

Time	Activity	Focus / Goal
15 min	Welcome & Camp Introduction	Welcome students, review camp expectations, and introduce the week's learning goals.
10 - 15 min	I See... I Think... I Wonder...	Activate curiosity and encourage observation, questioning, and discussion using a railway-related image.
20–25 min	Team Building Activity	Develop communication, collaboration, and problem-solving skills that students will use throughout the camp.
10–15 min	What is Engineering? (Think-Pair-Share)	Introduce engineering through discussion and connect engineering to everyday life and railway safety.
15–20 min	Design Process Sort	Explore the steps of the Engineering Design Process through a collaborative sorting activity.
15–20 min	Ramp Railways	Investigate how ramps affect motion while introducing gravity, potential energy, and kinetic energy.
30–40 min	Hot Wheels Lab	Conduct an engineering investigation to observe how changes in a ramp affect the motion of a Hot Wheels car.
45–60 min	Building a Biking Bot	Build, program, and test a LEGO® SPIKE™ Prime model while applying the Engineering Design Process.
45–60 min	Egg Drop Challenge (Optional or Time Permitting)	Apply the Engineering Design Process to design, test, and improve a protective prototype.
5–10 min	Day 1 Reflection	Reflect on teamwork, engineering, and the Engineering Design Process while preparing for Day 2.



Day 1 Vocabulary

Term	Student-Friendly Definition	Day 1 Connection
Railway Safety	The rules, technologies, and engineering practices that help keep people, trains, and communities safe.	Students are introduced to the purpose of Railway Safety Camp and begin making connections between engineering, science, and the technologies used to keep rail transportation safe.
Engineer	A person who solves problems by designing, building, testing, and improving things.	Students learn that engineers solve real-world problems, including railway safety and transportation challenges.
Engineering Design Process	A set of steps engineers use to solve problems, test ideas, and improve designs.	Students are introduced to each step of the Engineering Design Process and apply it during the LEGO® SPIKE™ Prime Bike activity. The optional Egg Drop Challenge provides an additional opportunity to plan, test, and improve a design.
Gravity	A force that pulls objects toward Earth.	Students observe gravity during the Balloon Team Challenge, Hot Wheels ramp investigations, and while exploring how objects move on different surfaces and slopes.
Mass	The amount of matter, or “stuff,” inside an object.	Students compare how the size and mass of different objects influence movement during hands-on investigations with Hot Wheels cars and other classroom materials.
Potential Energy	Stored energy an object has because of its position.	Students observe potential energy when objects are placed at the top of ramps before being released and during activities that involve raising objects before motion begins.
Kinetic Energy	Energy an object has when it is moving.	Students observe kinetic energy as balloons, Hot Wheels cars, and LEGO® SPIKE™ Prime models move throughout the day's engineering investigations.



Activity #1: I See...I Think...I Wonder...

Activity Overview

The I See... I Think... I Wonder... thinking routine serves as the instructional launch for Railway Safety Camp by encouraging students to observe, analyze, and ask questions about the world around them. Before introducing engineering concepts, students are presented with an image related to railway transportation and are given time to carefully examine what they notice. They then distinguish between observations ("I see"), inferences ("I think"), and questions ("I wonder"), helping them understand the difference between evidence and assumptions.

This activity establishes a culture of curiosity and inquiry that will continue throughout the week. As students share their observations and ideas, they begin thinking like engineers by recognizing patterns, asking questions, and considering how engineering can be used to solve real-world transportation challenges. The discussion also provides teachers with valuable insight into students' prior knowledge of railways, engineering, and transportation systems.

Estimated Time: 10-15 minutes

Learning Objectives:

The students will be able to:

- Make careful observations using visual evidence.
- Distinguish between observations, inferences, and questions.
- Communicate ideas respectfully while participating in whole-group discussions.
- Generate questions that demonstrate curiosity about railway engineering and transportation.
- Connect prior knowledge to new learning experiences throughout the week.

Science TEKS:

- S.4.3.C – Listen actively to others' explanations to identify relevant evidence and engage respectfully in scientific discussion.
- S.5.3.A – Develop explanations and propose solutions supported by observations and evidence.

Math TEKS:

- M.3.1.B – Apply a problem-solving process that includes analyzing information, developing a plan, and evaluating solutions.

NGSS:

- K-2-ETS1-1 – Ask questions, make observations, and gather information about a situation people want to change in order to define a simple problem that can be solved through the development of a new or improved object or tool.

Materials Needed:



- Day 1 presentation
- Projector or interactive display
- Student science journals or engineering notebooks (optional)
- Pencils

Teacher Preparation

Prior to the lesson, display the "I See... I Think... I Wonder..." slide from the Day 1 presentation. Review the image and anticipate possible student observations and questions. Prepare to encourage multiple perspectives while reminding students that there are no "wrong" observations if they are supported by evidence from the image.

Facilitation Guide

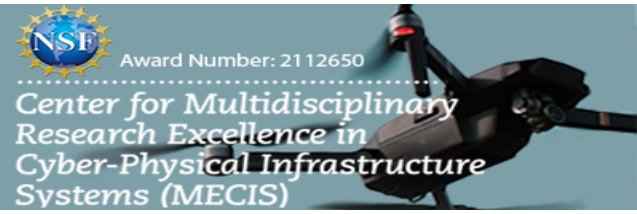
1. Display the "I See... I Think... I Wonder..." slide and ask students to silently observe the image for approximately 30 seconds without speaking. Encourage them to pay close attention to details they might otherwise overlook.
2. Invite students to share what they see. Remind them that observations should describe only what is visible in the image without making guesses or assumptions. Record several student responses for the class to reference.
3. Next, ask students what they think is happening in the image. Encourage them to explain the evidence that supports their thinking by referring back to specific observations.
4. Finally, ask students what they wonder about the image. Guide students to develop thoughtful questions that could be investigated through science or engineering.
5. Facilitate a class discussion by comparing student observations, ideas, and questions. Emphasize that engineers begin by carefully observing a problem, asking questions, and collecting information before developing solutions.
6. Conclude the activity by explaining that the same thinking process students just practiced will be used throughout the week as they investigate railway systems, explore engineering concepts, and solve design challenges.

Reflection & Discussion

Use the following questions to guide class discussion:

- What observations helped you better understand the image?
- How is an observation different from a guess?
- Why is it important for engineers to ask questions before solving a problem?
- Which question from our discussion would you most like to investigate this week?
- How do careful observations help engineers design safer transportation systems?

Teacher Tips



Allow students adequate wait time before asking them to share. Younger learners often notice additional details when given uninterrupted time to observe. Encourage students to support their ideas by referring to evidence they can see rather than relying solely on prior experiences. Reinforce that engineers rarely have all the answers immediately; instead, they ask thoughtful questions, gather evidence, and refine their understanding over time.

Differentiation

Support

- Provide sentence stems such as:
 - I see...
 - I think... because...
 - I wonder...
- Allow students to discuss their ideas with a partner before participating in the whole-group discussion.
- Model one example of an observation, an inference, and a question before students begin.

Extension

- Ask students to record one observation, one inference, and one question in an engineering notebook.
- Challenge students to identify one engineering problem suggested by the image and predict how engineers might solve it.
- Encourage students to revisit their original questions at the end of the week to determine which ones were answered through the camp activities.

Activity #2: Team Building

Activity Overview

The Team Building Activity introduces students to the importance of collaboration, communication, and problem-solving in engineering. Through a cooperative challenge, students learn that successful engineering depends on working together, listening to different perspectives, and contributing to a shared goal. This activity helps establish a positive team culture that will support students throughout the week as they complete engineering design challenges.

Estimated Time: 20-25 min.

Learning Objectives

The students will be able to:

- Practice effective communication and teamwork.
- Collaborate to complete a shared challenge.



- Demonstrate problem-solving and critical thinking skills.
- Reflect on how teamwork contributes to successful engineering.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.3.C – Listen actively to others' explanations and engage respectfully in scientific discussion.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 – Generate and compare multiple possible solutions to a problem.

Materials Needed:

- Refer to the Day 1 PowerPoint for the materials needed for the selected team-building activity.

Teacher Preparation

Review the Team Building Activity in the presentation and gather all required materials prior to the lesson. Organize students into small groups and review expectations for respectful communication, active listening, and participation.

Facilitation Guide

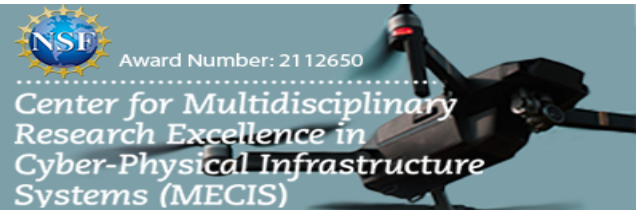
1. Introduce the team-building challenge using the Day 1 presentation.
2. Explain the objective, expectations, and any activity guidelines.
3. Divide students into small groups and distribute materials.
4. Allow teams time to complete the challenge while encouraging collaboration and communication.
5. Facilitate a brief class discussion to reflect on the teamwork strategies students used.

Reflection & Discussion

- What helped your team work well together?
- How did your team solve problems during the challenge?
- Why is teamwork important in engineering?

Teacher Tips

Focus on the teamwork process rather than the outcome of the challenge. Encourage students to listen to one another, share ideas, and recognize that different perspectives often lead to stronger solutions.



Differentiation

Support: Assign simple team roles (facilitator, recorder, materials manager, presenter) to help students participate.

Extension: Ask students to identify one teamwork strategy they will continue using during future engineering challenges.

Activity #3: What is Engineering? (Think-Pair-Share)

Activity Overview

Students participate in a Think-Pair-Share activity to activate their prior knowledge about engineering. Working independently and then with a partner, students discuss what they believe engineers do before sharing their ideas with the class. This discussion serves as an introduction to engineering and helps students make connections between engineering, innovation, and everyday life.

Estimated Time: 10-15 min.

Learning Objectives

The students will be able to:

- Describe what they think engineers do.
- Share ideas with a partner and the class.
- Identify examples of engineering in everyday life.
- Recognize that engineers solve problems and improve the world around us.

Science TEKS:

- S.4.3(C) – Listen actively and engage respectfully in collaborative discussions.
- S.4.1(B) – Use engineering practices to design solutions to problems.

Math TEKS:

- M.3.1(B) – Apply a problem-solving model to analyze information and develop solutions.

NGSS:

- K–2 ETS1-1 – Ask questions and gather information to define a problem that can be solved through engineering.

Materials Needed:

- Day 1 PowerPoint



- Projector or interactive display
- Whiteboard or chart paper (optional)

Teacher Preparation

Review the Think-Pair-Share prompt in the presentation. Be prepared to guide students from their own ideas about engineering to the understanding that engineers use creativity, science, mathematics, and teamwork to solve problems and improve everyday life.

Facilitation Guide

1. Display the **What is Engineering?** Think-Pair-Share slide.
2. Allow students time to think independently about the prompt.
3. Have students discuss their ideas with a partner.
4. Invite pairs to share their responses with the class and record key ideas.
5. Conclude by connecting student responses to the role engineers play in solving real-world problems, including railway safety.

Reflection & Discussion

- What does an engineer do?
- What are some examples of engineering you see every day?
- How do engineers help make our communities safer?

Teacher Tips

Encourage all student responses and build on their ideas throughout the discussion. Many students may associate engineers only with trains or construction. Use the conversation to broaden their understanding by highlighting the many ways engineers design solutions that improve everyday life.

Differentiation

Support: Provide sentence stems such as *"I think an engineer..."* or *"Engineers help by..."* to support student discussion.

Extension: Ask students to identify one engineering solution they encounter on their way to school and explain how it helps people.

Activity #4: Design Process Sort

Activity Overview



Students work collaboratively to sequence the steps of the Engineering Design Process using a Design Process Sort activity. As teams discuss and organize each step, they develop a deeper understanding of how engineers approach problem-solving. This activity reinforces that engineering is an iterative process in which ideas are tested, evaluated, and improved over time.

Estimated Time: 15-20 min.

Learning Objectives

The students will be able to:

- Identify the steps of the Engineering Design Process.
- Work collaboratively to organize the design process in the correct sequence.
- Explain the purpose of each step in the engineering process.
- Recognize that engineers revise and improve their designs through testing and evaluation.

Science TEKS:

- S.4.1(B) – Use engineering practices to design solutions to problems.
- S.4.3(C) – Listen actively and engage respectfully in collaborative discussions.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 – Generate and compare multiple possible solutions to a problem.
- 3–5 ETS1-3 – Plan and carry out tests to improve a design.

Materials Needed:

- Engineering Design Process Sort cards
- Day 1 PowerPoint
- Student work surface or table

Teacher Preparation

Print and organize one set of Design Process Sort cards for each group. Review the Engineering Design Process presented in the PowerPoint and be prepared to facilitate discussion as students justify their thinking.

Facilitation Guide

1. Divide students into small groups and distribute one set of Design Process Sort cards to each team.



2. Instruct students to work together to arrange the steps of the Engineering Design Process in the correct order.
3. Encourage teams to discuss the purpose of each step as they complete the sort.
4. Review the correct sequence as a class using the Day 1 presentation.
5. Discuss how engineers move through the design process and often revisit earlier steps as they improve their solutions.

Reflection & Discussion

- Which step was the most difficult to place? Why?
- Why is testing an important part of the Engineering Design Process?
- Why do engineers often return to earlier steps instead of following the process only once?

Teacher Tips

Encourage students to explain their reasoning rather than simply guessing the order of the cards. Remind them that the Engineering Design Process is flexible, and engineers frequently revisit earlier steps as they refine their designs.

Differentiation

Support: Provide the first and last steps of the process as starting points or allow students to reference the Engineering Design Process poster during the activity.

Extension: Challenge students to explain how they will use each step of the Engineering Design Process during the engineering challenges later in the week.

Activity #5: Ramp Railways

Activity Overview

Students explore how ramps influence the movement of objects by observing how changes in height and slope affect motion. Through guided discussion and demonstrations, students investigate concepts such as gravity, potential energy, and kinetic energy while making predictions about how objects move along a ramp. This activity prepares students for the Hot Wheels Lab by introducing the scientific concepts they will investigate through hands-on experimentation.

Estimated Time: 15-20 min.

Learning Objectives

The students will be able to:



- Observe how ramps affect the motion of objects.
- Make predictions based on changes in ramp height and slope.
- Describe how gravity causes objects to move down a ramp.
- Connect observations to the Engineering Design Process.

Science TEKS:

- S.4.1(B) – Use scientific and engineering practices to investigate questions and solve problems.
- S.4.5(A) – Explore the relationship between force, motion, and energy through investigations.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 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.

Materials Needed:

- Ramp demonstration materials
- Hot Wheels track or inclined ramp
- Hot Wheels car (teacher demonstration)
- Day 1 PowerPoint

Teacher Preparation

Set up the ramp demonstration before students arrive. Review the Ramp Railways slides and prepare to guide students through observations and predictions before introducing the Hot Wheels Lab.

Facilitation Guide

1. Introduce the Ramp Railways demonstration using the Day 1 presentation.
2. Demonstrate how changing the height or slope of a ramp affects the movement of a Hot Wheels car.
3. Ask students to make predictions before each demonstration and discuss their observations afterward.
4. Introduce the concepts of gravity, potential energy, and kinetic energy using student-friendly language.
5. Explain that students will apply these ideas during the Hot Wheels Lab.

Reflection & Discussion

- What happened when the height of the ramp changed?



- Why did the car move without being pushed?
- How do you think engineers use ramps when designing transportation systems?

Teacher Tips

Encourage students to explain *why* they think the car moved the way it did rather than simply describing what they observed. Accept all predictions and use the demonstrations to reinforce that engineers test ideas by collecting evidence.

Differentiation

Support: Demonstrate one variable at a time (such as changing only the ramp height) and encourage students to discuss observations with a partner.

Extension: Challenge students to predict how changing the ramp's height or angle might affect the distance a car travels during the Hot Wheels Lab.

Activity #6: Hot Wheels Lab

Activity Overview

Students investigate how changes to a ramp affect the motion of a Hot Wheels car. Working in teams, students make predictions, conduct multiple trials, record observations, and discuss how variables such as ramp height and slope influence the distance the car travels. Through this investigation, students apply the Engineering Design Process while exploring the relationship between force, motion, and energy.

Estimated Time: 30-40 min.

Learning Objectives

The students will be able to:

- Make predictions before conducting an investigation.
- Observe how changes to a ramp affect the motion of a Hot Wheels car.
- Collect and record observations during multiple trials.
- Use evidence to explain the results of the investigation.

Science TEKS:

- S.4.1(B) – Use scientific and engineering practices to investigate questions and solve problems.
- S.4.5(A) – Explore the relationship between force, motion, and energy through investigations.

Math TEKS:



- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3-PS2-1 – Plan and conduct an investigation to provide evidence of the effects of forces on the motion of an object.

Materials Needed:

- Hot Wheels track or ramp
- Hot Wheels car(s)
- Meter stick or measuring tape
- Student recording sheet
- Pencil
- Day 1 PowerPoint

Teacher Preparation

Assemble the Hot Wheels track before class and ensure each group has the necessary materials. Review the investigation procedures in the Day 1 presentation and identify the variable students will be investigating.

Facilitation Guide

1. Introduce the Hot Wheels Lab and review the investigation question.
2. Have students make predictions about how changing the ramp will affect the car's motion.
3. Allow teams to conduct multiple trials while recording their observations.
4. Encourage students to discuss patterns they notice and compare results with other groups.
5. Facilitate a class discussion to connect the investigation to force, motion, and the Engineering Design Process.

Reflection & Discussion

- Did the results match your prediction? Why or why not?
- What patterns did you observe during your investigation?
- How could engineers use investigations like this when designing transportation systems?

Teacher Tips

Encourage students to focus on collecting accurate observations rather than trying to achieve a "correct" answer. Remind them that engineers repeat investigations, analyze patterns, and use evidence to improve designs. Allow students time to discuss unexpected results and explain their thinking using evidence from their trials.



Differentiation

Support: Model the first trial as a class and provide a data table or recording sheet to help students organize their observations.

Extension: Challenge students to identify one variable they would change in a future investigation and predict how it might affect the results.

Activity #7: Building a Biking Bot

Activity Overview

Students apply the Engineering Design Process by building and programming a Biking Bot using LEGO® SPIKE™ Prime. Working in teams, students follow building instructions, test their model, and make adjustments to improve its performance. This activity introduces students to the relationship between engineering design, robotics, and computer programming while reinforcing the importance of collaboration and perseverance.

Estimated Time: 45-60 min.

Learning Objectives

The students will be able to:

- Build a Biking Bot using LEGO SPIKE Prime.
- Work collaboratively to complete a design challenge.
- Test and improve their model using the Engineering Design Process.
- Recognize how programming and engineering work together to solve problems.

Science TEKS:

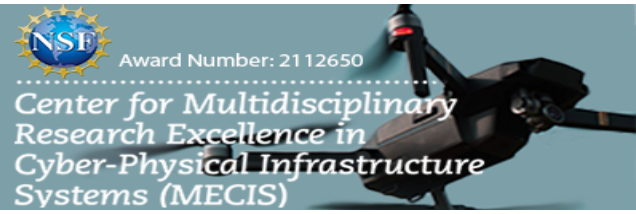
- S.4.1(B) – Use scientific and engineering practices to design solutions to problems.
- S.4.1(G) – Develop and use models to represent objects, systems, and design solutions.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 – Generate and compare multiple possible solutions to a problem.
- 3–5 ETS1-3 – Plan and carry out tests to improve a design.



Materials Needed:

- LEGO® SPIKE™ Prime kits
- Device with the LEGO SPIKE app
- Day 1 PowerPoint

Teacher Preparation

Ensure each team has a LEGO SPIKE Prime kit and access to the LEGO SPIKE app. Familiarize yourself with the Biking Bot lesson and verify that all hubs are charged and connected before beginning the activity.

Facilitation Guide

1. Introduce the Biking Bot challenge and review the building objective.
2. Have students work in teams to build the model following the LEGO SPIKE Prime instructions.
3. Guide students through programming and testing the Biking Bot.
4. Encourage teams to identify improvements and make adjustments to their design or program.
5. Facilitate a discussion about how the Engineering Design Process was used throughout the activity.

Reflection & Discussion

- What challenges did your team encounter while building or programming the Biking Bot?
- How did testing help improve your design?
- Why is it important for engineers to revise and improve their work?

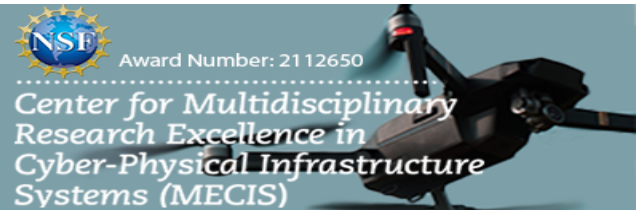
Teacher Tips

Remind students that successful engineering often requires multiple attempts. Encourage teams to troubleshoot together before asking for assistance, and celebrate perseverance as much as successful outcomes.

Differentiation

Support: Pair students strategically and provide additional guidance during the building and programming process as needed.

Extension: Challenge students to modify their Biking Bot's program or design to improve its performance or complete an additional task.



Activity #8: Egg Drop Challenge

Activity Overview

Students apply the Engineering Design Process to design and build a protective container that will keep an egg from breaking when dropped from a designated height. Working in teams, students brainstorm ideas, construct a prototype, test their design, and evaluate the results. This challenge reinforces the importance of creativity, collaboration, and perseverance while demonstrating that engineering often involves testing and improving solutions.

Estimated Time: 40-60 min.

Learning Objectives

The students will be able to:

- Apply the Engineering Design Process to solve a design challenge.
- Collaborate with teammates to design and build a prototype.
- Test and evaluate the effectiveness of their design.
- Use evidence from testing to identify possible improvements.

Science TEKS:

- S.4.1(B) – Use scientific and engineering practices to design solutions to problems.
- S.4.1(G) – Develop and use models to represent objects and design solutions.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 – Generate and compare multiple possible solutions to a problem.
- 3–5 ETS1-3 – Plan and carry out fair tests to improve a design.

Materials Needed:

- Raw eggs
- Assorted building materials (teacher-selected)
- Tape
- Scissors
- Measuring tools (optional)
- Day 1 PowerPoint

Teacher Preparation



Gather the challenge materials and identify a safe location for conducting the egg drop test. Review the challenge guidelines and establish any design constraints before students begin building.

Facilitation Guide

1. Introduce the Egg Drop Challenge and review the design criteria and constraints.
2. Divide students into teams and distribute materials.
3. Allow teams to brainstorm, sketch, and build their protective designs.
4. Conduct the egg drop test and observe the results.
5. Facilitate a discussion about which designs were successful, what students learned, and how they would improve their designs if given another opportunity.

Reflection & Discussion

- What worked well in your design?
- What changes would you make if you could redesign your prototype?
- How did your team use the Engineering Design Process during this challenge?

Teacher Tips

Emphasize that the goal is not simply to keep the egg from breaking, but to apply the Engineering Design Process and learn from testing. Encourage students to explain their design decisions using evidence from their results and celebrate creative thinking, teamwork, and perseverance.

Differentiation

Support: Encourage teams to sketch their ideas before building and provide guiding questions to support planning.

Extension: Challenge students to redesign their prototype using fewer materials or additional design constraints and explain how their modifications improve the design.



Day 2: Next Stop: Vaquero Station

Day Overview

Day 2 builds on the engineering concepts introduced on Day 1 by exploring how electricity powers modern railway systems. Students begin by reviewing the Engineering Design Process and participating in a collaborative team-building challenge that reinforces communication and problem-solving skills. They then investigate how electricity travels through simple circuits while learning the difference between conductors and insulators.

Through hands-on activities and demonstrations, students discover how electrical circuits allow energy to flow and why different materials either conduct or resist electricity. Students connect these concepts to real-world railway systems by exploring how electricity powers railroad signals, crossing gates, and other safety technologies that help trains operate safely.

The day concludes with students investigating electromagnets and constructing their own simple electromagnets. As they test and improve their designs, students continue applying the Engineering Design Process while making connections between electricity, magnetism, and the technology used throughout modern railway systems.

Lesson Objectives:

By the end of Day 2, students will be able to:

- Review and apply the Engineering Design Process.
- Demonstrate effective teamwork during collaborative engineering challenges.
- Explain how electricity flows through a simple circuit.
- Distinguish between conductors and insulators.
- Describe the importance of electricity in railway systems.
- Explain how electricity can create a magnetic field.
- Build and test a simple electromagnet.
- Connect electricity and magnetism to real-world railway technologies.

Essential Questions

- How does electricity travel through a circuit?
- What is the difference between a conductor and an insulator?
- Why is electricity important to railway systems?
- How do electromagnets work?
- How do engineers use electricity and magnetism to improve railway safety?

Day 2 at a Glance

Time Frame	Activity	Focus / Goal
10 min	Engineering Design Recap	Review the Engineering Design Process and connect it to today's engineering challenges.
20–25 min	Conductors in Training: Team Builder & Collaboration Lab	Strengthen teamwork, communication, and collaboration through a cooperative engineering challenge.
15–20 min	Electrical Circuits	Introduce electricity, circuits, conductors, and insulators.
30–40 min	Building Basic Circuits	Build and test simple circuits while identifying conductors and insulators through investigation.
15–20 min	Why Conductors Matter	Connect electrical conductivity to railway safety systems and transportation infrastructure.
15–20 min	Electricity in Railway Systems	Explore how electricity powers railroad signals, crossing gates, and other safety technologies.
30–40 min	Building an Electromagnet	Construct and test a simple electromagnet using batteries, wire, and nails.
15–20 min	Electromagnet Challenge	Improve electromagnet designs to lift the greatest number of paper clips using the Engineering Design Process.
5–10 min	Day 2 Reflection	Reflect on teamwork, electricity, magnetism, and their role in railway safety.

Day 2 Vocabulary

Students should review the following vocabulary before beginning the Day 2 activities. These terms will be used throughout the day during discussions about electricity, magnets, railway systems, crossings, and robotics.



Term	Student-Friendly Definition	Day 2 Connection
Electricity	A form of energy that can power lights, motors, and other devices.	Students explore how electricity travels through a circuit and powers railway systems.
Circuit	A complete path that allows electricity to flow.	Students build simple circuits to investigate how electricity moves from a battery to a light bulb.
Conductor	A material that allows electricity to flow easily.	Students test different objects to determine which materials conduct electricity.
Insulator	A material that does not allow electricity to flow easily.	Students compare insulating materials with conductors while building simple circuits.
Electromagnet	A magnet created when electricity flows through a wire wrapped around metal.	Students build and test their own electromagnets and explore how they are used in railway technology.
Magnetic Field	The invisible area around a magnet where magnetic forces act.	Students observe how electricity creates a magnetic field that allows an electromagnet to attract metal objects.
Railway Signal	A device that uses lights or signs to tell trains when it is safe to move.	Students learn how electricity powers railway signals to help keep trains and communities safe.
Collaboration	Working together to solve a problem or complete a task.	Students practice collaboration during the team-building challenge and engineering investigations.

Activity #1: Engineering Design Recap

Activity Overview

Students review the Engineering Design Process introduced on Day 1 and discuss how engineers use it to solve problems through planning, testing, evaluating, and improving their designs. This brief review reinforces the engineering mindset and prepares students to apply the design process during today's investigations involving electricity, circuits, and electromagnets.



Estimated Time: 10 min.

Learning Objectives

The students will be able to:

- Recall the steps of the Engineering Design Process.
- Explain why engineers test and improve their designs.
- Recognize that the Engineering Design Process will be used throughout today's activities.

Science TEKS:

- S.4.1(B) – Use scientific and engineering practices to investigate questions and design solutions to problems.
- S.4.3(C) – Listen actively and engage respectfully in collaborative discussions.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 – Generate and compare multiple possible solutions to a problem.

Materials Needed:

- Day 2 PowerPoint
- Engineering Design Process visual
- Projector or interactive display

Teacher Preparation

Display the Engineering Design Process slide before students arrive. Encourage students to reflect on how they used the design process during the previous day's engineering challenges and prepare to make connections to today's activities.

Facilitation Guide

1. Display the Engineering Design Recap slide.
2. Ask students to recall the steps of the Engineering Design Process from Day 1.
3. Review each step together and discuss how students applied the process during previous activities.
4. Explain that today's engineering challenges will continue using the same design process as students explore electricity and railway systems.

Reflection & Discussion



- Which step of the Engineering Design Process did you use the most yesterday?
- Why is testing an important part of engineering?
- How do you think today's activities will use the Engineering Design Process?

Teacher Tips

Keep this review interactive by encouraging students to explain the design process in their own words and share examples from Day 1. Reinforce that engineers continually improve their ideas and that today's investigations will build upon the same engineering practices.

Differentiation

Support: Display the Engineering Design Process visual throughout the discussion and allow students to work with a partner to recall the steps.

Extension: Ask students to predict which step of the Engineering Design Process they think will be most important during today's investigations and explain their reasoning.

Activity #2: Conductors in Training: Team Builder & Collaboration Lab

Activity Overview

Students participate in a collaborative engineering challenge by working together to build a cup pyramid using a rubber band and strings. The activity requires communication, teamwork, and problem-solving as students coordinate their movements to complete the task. After the challenge, students connect their experience to the railroad industry by exploring how conductors, engineers, signal workers, and maintenance crews work together to keep railway systems operating safely.

Estimated Time: 20-25 min.

Learning Objectives

The students will be able to:

- Demonstrate effective teamwork and communication.
- Collaborate to complete a shared engineering challenge.
- Reflect on how teamwork contributes to successful problem-solving.
- Explain how collaboration supports railway safety.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.3.C – Listen actively to others' explanations and engage respectfully in scientific discussion.



Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 – Generate and compare multiple possible solutions to a problem.

Materials Needed:

- 10–15 plastic cups
- 1 rubber band
- 4–6 pieces of yarn or string
- Day 2 PowerPoint

Teacher Preparation

Prepare one set of materials for each team and review the challenge instructions. Organize students into small groups and remind them that success depends on communication, cooperation, and shared responsibility.

Facilitation Guide

1. Introduce the Conductors in Training challenge and review the activity rules.
2. Divide students into teams and distribute the materials.
3. Have teams work together to build a 10-cup pyramid using the rubber band and strings. Encourage teams to attempt the 15-cup pyramid if time allows.
4. Facilitate a class reflection on the teamwork strategies students used during the challenge.
5. Connect the activity to the railroad industry by discussing how conductors, engineers, signal workers, and maintenance crews rely on teamwork to operate trains safely.

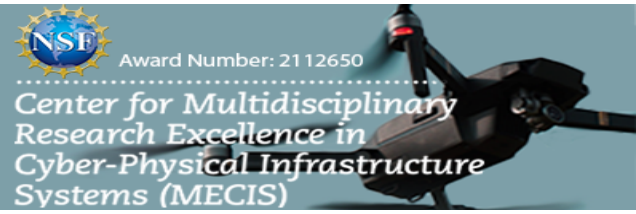
Reflection & Discussion

- What teamwork strategies helped your group succeed?
- What challenges did your team encounter, and how did you solve them?
- Why is communication important for both engineers and railroad teams?

Teacher Tips

Resist the urge to solve problems for students. Instead, encourage teams to communicate, adjust their strategies, and learn from each attempt. During the reflection, emphasize that successful engineering and railway operations depend on every team member working toward a common goal.

Differentiation



Support: Assign simple team roles (communicator, materials manager, encourager, recorder) to help students participate.

Extension: Challenge students to identify similarities between their teamwork during the activity and the collaboration required among conductors, engineers, signal workers, and maintenance crews to keep railway systems safe.

Activity #3: Electrical Circuits: Electricity, Conductors, and Insulators

Activity Overview

Students are introduced to the basic components of an electrical circuit and explore how electricity travels through a complete path. Through discussion and guided instruction, students learn the difference between conductors and insulators and make predictions about which everyday materials allow electricity to flow. This lesson prepares students for the hands-on circuit investigation that follows.

Estimated Time: 15-20 min.

Learning Objectives

The students will be able to:

- Describe how electricity travels through a simple circuit.
- Differentiate between conductors and insulators.
- Predict which materials will allow electricity to flow.
- Explain why electrical circuits are important in everyday life and railway systems.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.8(A) – Identify and demonstrate that electrical energy travels in a complete circuit.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 4-PS3-2 – Make observations to provide evidence that energy can be transferred from place to place.

Materials Needed:



- Day 2 PowerPoint
- Sample circuit kit (teacher demonstration)
- Assorted classroom objects for discussion (optional)

Teacher Preparation

Review the Electrical Circuits presentation and prepare a simple circuit demonstration, if available. Be ready to introduce the terms circuit, conductor, and insulator, and encourage students to predict how different materials will behave before testing them.

Facilitation Guide

1. Introduce the concept of an electrical circuit using the Day 2 presentation.
2. Explain that electricity travels through a complete path called a circuit.
3. Define conductors and insulators using examples from the presentation.
4. Ask students to predict which common materials they think will conduct electricity and which will not.
5. Explain that students will test their predictions during the next hands-on investigation.

Reflection & Discussion

- What is an electrical circuit?
- What is the difference between a conductor and an insulator?
- Why do you think some materials allow electricity to flow while others do not?

Teacher Tips

Use familiar examples, such as metal spoons, plastic utensils, or coins, to help students understand the difference between conductors and insulators. Encourage students to make predictions without worrying about being correct—the next activity will allow them to test their ideas using evidence.

Differentiation

Support: Display pictures or real objects while introducing conductors and insulators and allow students to discuss predictions with a partner.

Extension: Challenge students to identify examples of conductors and insulators they use at home or school and explain why each material is useful for its purpose.

Activity #4: Building Basic Circuits

Activity Overview



Students build and test a simple electrical circuit using batteries, wires, and a light bulb or LED. As they investigate how electricity travels through a complete circuit, students test a variety of materials to determine whether they are conductors or insulators. This hands-on investigation reinforces the relationship between electricity and engineering while preparing students to explore how electrical systems support railway operations.

Estimated Time: 30-40 min.

Learning Objectives

The students will be able to:

- Build a complete electrical circuit.
- Test materials to identify conductors and insulators.
- Observe how electricity flows through a complete circuit.
- Explain why a complete circuit is necessary for electrical devices to function.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.8(A) – Identify and demonstrate that electrical energy travels through a complete circuit.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 4-PS3-2 – Make observations to provide evidence that energy can be transferred from place to place.

Materials Needed:

- Basic circuit kit (battery pack, wires, and light bulb or LED)
- Assorted test materials (metal, plastic, wood, paper, etc.)
- Student recording sheet
- Day 2 PowerPoint

Teacher Preparation

Assemble the circuit materials for each student or group before class. Verify that batteries are working and that each circuit kit functions properly. Review the investigation procedures and prepare a variety of materials for students to test as conductors and insulators.

Facilitation Guide



1. Demonstrate how to build a simple electrical circuit using the materials provided.
2. Have students work in pairs or small groups to assemble their own circuits.
3. Once the circuit is functioning, have students test different materials to determine whether they complete the circuit.
4. Record observations and classify each material as a conductor or an insulator.
5. Facilitate a discussion about why some materials allowed electricity to flow while others did not.

Reflection & Discussion

- What happened when the circuit was complete?
- Which materials acted as conductors? Which acted as insulators?
- Why is it important for engineers to understand how electricity flows through a circuit?

Teacher Tips

Encourage students to troubleshoot their circuits before asking for assistance. If a circuit does not work, guide students to check each connection and determine whether the circuit forms a complete loop. Reinforce that engineers test, identify problems, and make improvements rather than expecting a solution to work perfectly the first time.

Differentiation

Support: Demonstrate how to assemble the first circuit as a class and provide a recording sheet with a T-chart for conductors and insulators.

Extension: Challenge students to predict whether unfamiliar materials will conduct electricity before testing them and explain their reasoning using evidence from their investigation.

Activity #5: Why Conductors Matter

Activity Overview

Students connect their understanding of conductors and insulators to real-world railway systems by exploring how electricity powers railroad signals, crossing gates, and other safety technologies. Through guided discussion, students discover why conductors are essential for carrying electrical energy and why insulators help protect people and equipment. Students consider how electrical failures could affect railway safety and recognize the important role engineers play in designing reliable transportation systems.

Estimated Time: 15-20 min.

Learning Objectives



The students will be able to:

- Explain why conductors are important in electrical systems.
- Describe how insulators help keep electrical systems safe.
- Identify ways electricity is used in railway operations.
- Explain why engineers design safe and reliable electrical systems.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.8(A) – Identify and demonstrate that electrical energy travels through a complete circuit.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 4-PS3-2 – Make observations to provide evidence that energy can be transferred from place to place.

Materials Needed:

- Day 2 PowerPoint
- Images of railroad crossings, railway signals, and electrical wires (optional)
- Whiteboard or chart paper for discussion

Teacher Preparation

Review the "Why Conductors Matter" slides and prepare to facilitate a discussion about how electricity powers railway safety systems. Emphasize that conductors carry electricity to important equipment, while insulators help prevent electrical hazards by keeping electricity safely contained.

Facilitation Guide

1. Display the Why Conductors Matter slide.
2. Review how conductors and insulators function within an electrical circuit.
3. Discuss how railway systems depend on electricity to operate signals, crossing gates, and other safety equipment.
4. Explain why metal wires are commonly used as conductors and why protective coatings, such as rubber, are used as insulators.
5. Ask students to consider what could happen if electrical systems failed and discuss why engineers design reliable systems to keep trains and communities safe.



Reflection & Discussion

- Why are conductors important in railway systems?
- Why are insulators just as important as conductors?
- What might happen if electricity stopped flowing to a railroad crossing or signal?
- How do engineers help make railway systems safer?

Teacher Tips

Encourage students to connect this discussion to the circuit investigation they just completed. Help them recognize that the same scientific concepts they observed in a simple classroom circuit are used in much larger systems that operate trains and protect communities. Keep the conversation focused on how engineers use science to solve real-world safety challenges.

Differentiation

Support: Display photographs of railroad crossings, signal lights, and electrical wires while discussing how electricity is used in railway systems.

Extension: Ask students to identify other places in their community where conductors and insulators are important, such as traffic lights, streetlights, household wiring, or school technology, and compare their purpose to railway systems.

Activity #6: Electricity in Railway Systems

Activity Overview

Students explore how electricity is used throughout modern railway systems to power signals, crossing gates, communication systems, and other safety technologies. Through guided discussion and visual examples, students discover that electrical systems help trains operate safely by providing reliable communication, controlling railroad crossings, and alerting both train crews and the public. Students connect these technologies to the concepts of circuits, conductors, and insulators introduced earlier in the day.

Estimated Time: 15-20 min.

Learning Objectives

The students will be able to:

- Identify ways electricity is used in railway systems.
- Explain how electrical systems improve railway safety.



- Connect circuits, conductors, and insulators to real-world transportation systems.
- Recognize the role of engineers in designing and maintaining railway technologies.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.8(A) – Identify and demonstrate that electrical energy travels through a complete circuit.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 4-PS3-2 – Make observations to provide evidence that energy can be transferred from place to place.

Materials Needed:

- Day 2 PowerPoint
- Images or videos of railroad crossings, signal lights, and railway systems
- Whiteboard or chart paper (optional)

Teacher Preparation

Review the presentation slides that highlight the use of electricity in railway systems. Be prepared to discuss how electrical circuits power railroad signals, crossing gates, communication systems, and other technologies that help keep trains, passengers, and communities safe. Encourage students to make connections between the circuits they built and the much larger electrical systems used in transportation.

Facilitation Guide

1. Display the Electricity in Railway Systems slides.
2. Review examples of how electricity is used throughout modern railway operations.
3. Discuss how electrical circuits power railroad signals, crossing gates, and communication equipment.
4. Ask students to identify similarities between the simple circuits they built and the electrical systems used on railways.
5. Facilitate a discussion about how engineers design and maintain these systems to improve safety and reliability.

Reflection & Discussion

- Why is electricity important to railway systems?



- How do electrical systems help keep people and trains safe?
- What similarities do you see between your classroom circuit and the electrical systems used on railways?
- Why do engineers need to design reliable electrical systems?

Teacher Tips

Encourage students to think beyond the classroom by connecting today's investigation to the railroad crossings and signal lights they may have seen in their own communities. Reinforce that although railway electrical systems are much larger and more complex, they operate using the same basic concepts of circuits, conductors, and insulators that students explored during the hands-on investigation.

Differentiation

Support: Display photographs or short video clips of railroad crossings, signal lights, and train control systems while discussing how electricity is used in railway operations.

Extension: Ask students to identify other transportation systems that depend on electricity, such as traffic signals, airports, or electric buses, and compare how engineers use electrical systems to improve safety and efficiency.

Activity #7: Building an Electromagnet

Activity Overview

Students investigate the relationship between electricity and magnetism by constructing a simple electromagnet using a battery, insulated wire, and an iron nail. After assembling their electromagnets, students test whether they can attract metal objects and observe how electricity creates a temporary magnetic field. Through hands-on exploration, students apply the Engineering Design Process while making connections between electromagnets and the technologies used in modern railway systems.

Estimated Time: 30-40 min.

Learning Objectives

The students will be able to:

- Construct a simple electromagnet.
- Explain that electricity can create a magnetic field.
- Test and observe the strength of an electromagnet.
- Describe how engineers use electromagnets in everyday technology and railway systems.



Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.8(A) – Identify and demonstrate that electrical energy travels through a complete circuit.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 4-PS3-2 – Make observations to provide evidence that energy can be transferred from place to place.

Materials Needed:

- Battery (D-cell or battery pack)
- Insulated copper wire
- Iron nail
- Paper clips or other small metal objects
- Electrical tape (optional)
- Student recording sheet
- Day 2 PowerPoint

Teacher Preparation

Prepare one electromagnet kit for each student or small group. Verify that batteries and wires are functioning properly and review safe handling procedures for electrical materials. Demonstrate how to wrap the wire tightly around the nail and connect it to the battery before students begin building.

Facilitation Guide

1. Introduce the concept of an electromagnet and explain how electricity flowing through a wire creates a magnetic field.
2. Demonstrate how to wrap insulated wire around an iron nail and connect the wire to the battery.
3. Have students build their own electromagnets following the demonstration.
4. Test each electromagnet by attempting to pick up paper clips or other small metal objects.
5. Discuss how the electromagnet worked and how engineers use similar technology in real-world applications.

Reflection & Discussion

- What happened when electricity flowed through the wire?
- How was an electromagnet different from a regular magnet?



- What factors do you think affect the strength of an electromagnet?
- Where might engineers use electromagnets in transportation or other technologies?

Teacher Tips

Remind students that electromagnets only work while electricity is flowing through the circuit. Encourage them to make careful observations and compare the performance of different electromagnets. Reinforce that engineers often test prototypes, identify ways to improve them, and redesign their solutions based on evidence.

Differentiation

Support: Provide a step-by-step visual guide for wrapping the wire around the nail and assembling the electromagnet. Pair students who need additional support with a partner during construction.

Extension: Challenge students to predict how changing the number of wire wraps or using a different battery might affect the strength of the electromagnet. Encourage them to explain their reasoning before testing these ideas in the next engineering challenge.

Activity #8: Electromagnet Challenge

Activity Overview

Students apply the Engineering Design Process to improve the performance of the electromagnets they built during the previous activity. Working in teams, students modify one design variable at a time, such as the number of wire wraps or the tightness of the coils, and test how each change affects the electromagnet's ability to lift paper clips or other small metal objects. Students record their observations, compare results, and use evidence to identify the most effective design.

Estimated Time: 30-40 min.

Learning Objectives

The students will be able to:

- Apply the Engineering Design Process to improve an electromagnet.
- Test how design changes affect the strength of an electromagnet.
- Collect and compare data from multiple trials.
- Use evidence to explain why one design performed better than another.
- Collaborate with teammates to evaluate and improve a solution.

Science TEKS:



- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.1(C) – Collect observations and measurements using appropriate tools to support scientific explanations.
- S.4.8(A) – Identify and demonstrate that electrical energy travels through a complete circuit.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-3 – Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.

Materials Needed:

- Student-built electromagnets
- Batteries
- Insulated copper wire
- Iron nails
- Paper clips or other small metal objects
- Student recording sheet
- Day 2 PowerPoint

Teacher Preparation

Ensure each group has a working electromagnet from the previous activity and sufficient materials for redesign. Encourage students to change only one variable at a time so they can observe how each modification affects the electromagnet's performance. Prepare a recording sheet for students to document each trial and its results.

Facilitation Guide

1. Review the Engineering Design Process and explain that engineers improve designs by testing one change at a time.
2. Have each team identify one modification they would like to make to their electromagnet.
3. Students rebuild or adjust their electromagnet and test its ability to lift paper clips or other metal objects.
4. Record the results of each trial and compare performance with previous designs.
5. Facilitate a class discussion in which teams share the changes they made, the evidence they collected, and the improvements they observed.



Reflection & Discussion

- What change improved your electromagnet the most?
- Which design collected the greatest number of paper clips? Why do you think it performed better?
- Why is it important to test only one variable at a time?
- How did your team use evidence to improve your design?
- How does this activity reflect the work of engineers?

Teacher Tips

Emphasize that engineering is an iterative process and that not every design change will improve performance. Encourage students to make careful observations, record accurate data, and use evidence to justify their design decisions. Celebrate thoughtful testing and persistence rather than simply identifying the strongest electromagnet.

Differentiation

Support: Provide students with a planning sheet to help them identify one variable to change and predict how it might affect the electromagnet before testing.

Extension: Challenge teams to optimize their design within a set time limit and explain which engineering decisions contributed to their final results. Encourage students to discuss how similar testing and redesign processes are used by engineers developing railway technologies and other electrical systems.



Day 3: Freight Transportation Engineers **Wheel and Axle Design, Maintenance, and Cargo Movement**

Day Overview

Day 3 introduces students to the important role engineers play in designing and maintaining freight transportation systems. Students begin by strengthening their teamwork skills through a collaborative activity before investigating how engineers keep trains operating safely through regular maintenance and careful inspection of railway equipment. They learn that engineers continuously monitor train components, such as wheels, axles, bearings, and tracks, to help prevent derailments and improve the safety of rail transportation.

Throughout the day, students explore how simple machines, including wheels and axles, make it easier to move heavy loads efficiently. They discover how freight trains transport goods across the country and examine the role of forklifts in loading and unloading cargo. By connecting engineering concepts to real-world transportation systems, students gain a deeper understanding of how freight moves safely from one location to another.

Students then apply these concepts by building and programming a LEGO® Education SPIKE™ Prime forklift. Working collaboratively, they use the Engineering Design Process to design, test, and improve a robotic vehicle capable of moving cargo. Through hands-on engineering challenges, students strengthen their problem-solving, communication, and computational thinking skills while experiencing how engineers design technologies that improve transportation safety and efficiency.

By the end of Day 3, students will understand how engineering, maintenance, simple machines, and robotics work together to keep freight transportation systems operating safely and efficiently.

Lesson Objectives:

By the end of Day 3, students will be able to:

- Explain the importance of teamwork during engineering projects.
- Describe how maintenance helps keep railway systems safe.
- Define a derailment and identify common causes of train derailments.
- Identify the functions of wheels, axles, and bearings in railway systems.
- Explain how wheels and axles make moving heavy objects easier.
- Describe how freight trains transport goods safely and efficiently.
- Build and program a LEGO® Education SPIKE™ Prime forklift.
- Apply the Engineering Design Process to complete a freight transportation challenge.
- Collaborate with teammates to design, test, and improve an engineering solution.



Essential Questions

- Why is teamwork important in engineering?
- How does maintenance help prevent train derailments?
- How do wheels, axles, and bearings help trains move safely?
- How do engineers transport heavy freight efficiently?
- How can robotics improve freight transportation?
- How does the Engineering Design Process help engineers solve transportation challenges?

Day 3 at a Glance

Time Frame	Activity	Focus / Goal
10–15 min	Welcome & Day 3 Introduction	Review camp expectations, introduce the day's focus on freight transportation engineering, and prepare students for the High Bay Tour.
15–20 min	Team Building Activity (Rock, Paper, Scissors War)	Strengthen teamwork, communication, encouragement, and collaboration while connecting these skills to engineering.
20–25 min	Maintenance and Derailments	Explore what derailments are, investigate common causes, and discuss how maintenance helps keep trains operating safely.
15–20 min	Wheel and Axle Design	Learn how wheels, axles, and bearings work together to reduce friction and safely support the weight of a train.
20–25 min	Freight Transportation Systems	Explore how freight trains transport goods and examine the role of containers, cargo handling, and forklifts in the transportation industry.
20–25 min	Simple Machines: Wheels and Axles	Investigate how wheels and axles make moving heavy loads easier and connect these concepts to railway engineering.
45–60 min	Building a LEGO® SPIKE™ Prime Forklift	Build and program a robotic forklift while applying the Engineering Design Process and computational thinking skills.



Time Frame	Activity	Focus / Goal
30–40 min	Freight Transportation Challenge	Test, evaluate, and improve the LEGO® forklift by completing a cargo transportation challenge using teamwork and iterative design.
5–10 min	Day 3 Reflection	Reflect on teamwork, maintenance, freight transportation, simple machines, and robotics while preparing for Day 4.

Day 3 Vocabulary

Students should review the following vocabulary before beginning the Day 3 activities. These terms will be used throughout the day during discussions about electricity, magnets, railway systems, crossings, and robotics.

Term	Student-Friendly Definition	Day 3 Connection
Derailment	When a train comes off its track.	Students investigate what can cause derailments and how engineers help prevent them.
Maintenance	The work people do to keep trains, tracks, and railway systems safe and working correctly.	Students connect maintenance to inspections, safety, and preventing problems before they happen.
Wheel	A round part that helps an object move smoothly.	Students test wheel designs and connect wheels to how trains move heavy cargo.
Axle	A rod that connects wheels and helps them turn together.	Students explore how axles keep wheels aligned and support smooth movement.
Bearing	A part that helps wheels and axles rotate smoothly while reducing friction and heat.	Students learn that bearings help wheel-and-axle assemblies move safely and efficiently.
Cargo Container	A container or railcar used to carry goods such as food, clothing, fuel, grain, or packages.	Students sort cargo and match products to dry containers, hopper cars, and tank cars.



Term	Student-Friendly Definition	Day 3 Connection
Forklift	A machine used to lift, carry, and move heavy cargo.	Students build and program a LEGO® SPIKE™ Prime forklift to transport cargo during the freight transportation challenge.
Simple Machine	A basic tool that makes work easier by changing the direction or amount of force needed to move an object.	Students investigate how wheels and axles are examples of simple machines that help engineers move heavy freight more efficiently.

Activity #1: Team Building Activity (Rock, Paper, Scissors War)

Activity Overview

Students participate in a high-energy team-building activity that encourages collaboration, encouragement, communication, and good sportsmanship. As students compete in a large-group version of Rock, Paper, Scissors, they learn that successful engineers support one another, celebrate team successes, and continue working toward a common goal even when their own ideas are not selected. This activity establishes a positive learning environment while reinforcing the teamwork skills needed for the engineering challenges throughout Day 3.

Estimated Time: 15-20 min.

Learning Objectives

The students will be able to:

- Demonstrate teamwork and collaboration during a group activity.
- Practice effective communication and encouragement.
- Explain why teamwork is an important part of engineering.
- Demonstrate good sportsmanship while participating in friendly competition.
- Connect teamwork skills to real-world engineering careers.

Science TEKS:

- S.4.1(A) Ask questions and define problems based on observations or information.
- S.4.1(B) Use scientific and engineering practices to investigate questions and design solutions.
- S.4.1(G) Develop and use models, communicate ideas, and collaborate during scientific and engineering investigations.



Math TEKS:

- M.3.1(A) Apply mathematics to solve problems arising in everyday life.
- M.3.1(B) Use a problem-solving model that incorporates communication and collaboration.

NGSS:

- 3–5 ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints.
- Science and Engineering Practice: Engaging in Argument from Evidence and Obtaining, Evaluating, and Communicating Information through collaboration and discussion.

Materials Needed:

- Open space for students to move safely
- Day 3 PowerPoint
- Projector or interactive display
- Timer (optional)

Teacher Preparation

Review the activity procedures before class and ensure there is adequate space for students to move safely. Explain that the purpose of the activity is not simply to win, but to demonstrate teamwork, encouragement, and collaboration. Emphasize that engineers rely on these same skills when solving complex problems together.

Facilitation Guide

1. Introduce the importance of teamwork in engineering and explain that students will participate in a collaborative team-building activity.
2. Have students find a partner within their group.
3. Students play one round of Rock, Paper, Scissors.
4. Winners continue playing against winners from other groups.
5. Students who lose become their champion's biggest fan and cheerleader, encouraging them throughout the competition.
6. Continue until one champion remains.
7. Lead a class discussion connecting teamwork, encouragement, and collaboration to the work of railway engineers.

Reflection & Discussion

- How did it feel to encourage someone else during the activity?
- Why is working together important when solving problems?
- How can engineers contribute to a team even if their idea is not selected?
- What does it mean to demonstrate good sportsmanship?



- Why is teamwork important when engineers design and build solutions?

Teacher Tips

Remind students that the goal is to build a supportive team culture rather than focus on winning. Encourage enthusiastic cheering and positive interactions while ensuring all students feel included. After the activity, connect students' experiences to the way engineers collaborate, share ideas, learn from mistakes, and work together to solve transportation challenges.

Differentiation

Support: Pair students who may be hesitant with encouraging classmates and model positive cheering behaviors before beginning the activity.

Extension: Challenge students to identify additional careers in railway transportation that depend on teamwork and explain how communication and collaboration contribute to safety and successful freight operations.

Activity #2: Maintenance and Derailments

Activity Overview

Students investigate the importance of railway maintenance and learn how engineers help prevent train derailments. Through class discussion, visual examples, data analysis, and a short video, students explore what derailments are, examine common causes, and identify warning signs that engineers monitor to keep railway systems operating safely. Students discover that routine maintenance, careful inspections, and engineering design all contribute to safer freight transportation.

Estimated Time: 25-30 min.

Learning Objectives

The students will be able to:

- Define the term **derailment**.
- Explain why routine maintenance is essential for railway safety.
- Identify common causes of train derailments.
- Describe warning signs engineers look for before equipment fails.
- Explain how engineers use inspections and maintenance to improve transportation safety.

Science TEKS:

- S.4.1(A) Ask questions and define problems based on observations and information.



- S.4.1(B) Use scientific and engineering practices to investigate problems and design solutions.
- S.4.1(C) Collect observations and analyze information to support explanations.

Math TEKS:

- M.3.1(A) Apply mathematics to solve problems arising in everyday life.
- M.3.1(B) Use a problem-solving model that incorporates communication and collaboration.

NGSS:

- 3–5 ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints.
- 3–5 ETS1-2 Generate and compare possible solutions to a problem based on evidence.

Materials Needed:

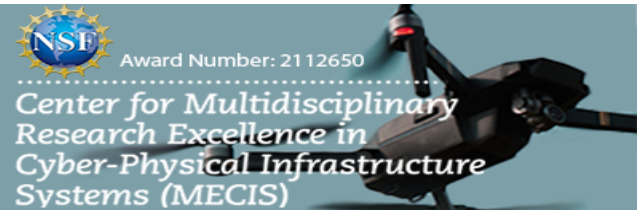
- Day 3 PowerPoint
- Projector or interactive display
- Chart showing common causes of derailments
- Derailment video
- Student science journal or recording sheet
- Pencils

Teacher Preparation

Review the presentation slides and prepare the derailment video before class. Remind students that engineers work continuously to prevent accidents through inspections, maintenance, testing, and improved designs. Emphasize that this lesson focuses on understanding how engineering helps keep trains safe, not on accidents themselves.

Facilitation Guide

1. Introduce the terms derailment and maintenance, discussing why keeping trains and tracks in good condition is important.
2. Display the chart showing common causes of derailments and ask students to identify the leading cause shown in the data. Facilitate a discussion about why maintenance is necessary to reduce these risks.
3. Show the derailment video and ask students to observe possible causes and discuss how engineers could prevent similar situations.
4. Explain that trains often show warning signs before equipment fails, such as unusual noises, sparks, or shaking. Discuss why engineers regularly inspect trains to identify these signs before they become serious problems.
5. Conclude with a class discussion about how maintenance, inspections, and engineering work together to improve railway safety.



Reflection & Discussion

- What is a derailment?
- Why is maintenance important for keeping trains safe?
- According to the chart, what is one common cause of derailments?
- What warning signs might tell engineers that something is wrong with a train?
- How do engineers help prevent accidents before they happen?

Teacher Tips

Keep the discussion focused on engineering and problem solving rather than the accident itself. Encourage students to think like engineers by asking, "How could we prevent this?" Reinforce that engineers use data, observations, inspections, and teamwork to improve transportation safety every day.

Differentiation

Support: Provide students with picture cards illustrating derailments, maintenance activities, train inspections, and warning signs to reinforce key vocabulary and concepts.

Extension: Have students work in small groups to create a simple maintenance checklist for a freight train. Ask them to explain why each inspection item would help improve railway safety before a train begins its journey

Activity #3: Wheel and Axle Design

Activity Overview

Students investigate the essential components of a train's wheel and axle system and discover how engineers design these parts to keep trains moving safely and efficiently. Through class discussion, diagrams, demonstrations, and guided exploration, students learn how wheels, axles, and bearings work together to support the weight of a train, reduce friction, and keep the train aligned on the tracks. Students connect these concepts to the importance of regular maintenance and engineering design in preventing derailments.

Estimated Time: 20-25 min.

Learning Objectives

The students will be able to:

- Identify the three main components of a train's wheel and axle system.
- Describe the function of wheels, axles, and bearings.
- Explain how bearings reduce friction and heat.



- Explain how proper wheel and axle design contributes to railway safety.
- Connect engineering design and maintenance to preventing derailments.

Science TEKS:

- S.4.1(A) Ask questions and define problems based on observations and information.
- S.4.1(B) Use scientific and engineering practices to investigate questions and design solutions.
- S.4.6(A) Identify and describe how forces affect the motion of objects.
- S.4.6(B) Explain how friction affects the movement of objects.

Math TEKS:

- M.3.1(A) Apply mathematics to solve problems arising in everyday life.
- M.3.1(B) Use a problem-solving model to analyze information and communicate conclusions.

NGSS:

- 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.
- 3–5 ETS1-2 Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints.

Materials Needed:

- Day 3 PowerPoint
- Projector or interactive display
- Images or diagrams of a train wheel, axle, and bearing
- Wheel and axle demonstration model (if available)
- Student science journal or recording sheet
- Pencils

Teacher Preparation

Review the presentation slides and become familiar with the function of each wheel and axle component. If available, prepare a physical wheel-and-axle model or images that allow students to closely observe how the parts fit together. Emphasize that engineers continually inspect these components because even small problems can affect the safety and performance of an entire train.

Facilitation Guide

1. Display the diagram of a train wheel, axle, and bearing, and introduce each component. Explain that the wheel supports the weight of the train, the axle connects the wheels and keeps them aligned, and the bearing allows the wheels and axle to rotate smoothly by reducing friction and heat.



2. Discuss how these components work together to help trains move safely and efficiently along the tracks.
3. Connect the lesson to the previous activity by discussing how worn or damaged wheels, axles, or bearings can contribute to derailments if they are not properly maintained.
4. If available, demonstrate a wheel-and-axle model or allow students to examine diagrams and identify each component.
5. Facilitate a class discussion about how engineers inspect, maintain, and improve these systems to keep freight trains operating safely.

Reflection & Discussion

- What job does each part of the wheel and axle system perform?
- Why are bearings important for train safety?
- How does reducing friction help trains operate more efficiently?
- Why do engineers regularly inspect wheels, axles, and bearings?
- How does proper engineering design help prevent derailments?

Teacher Tips

Encourage students to think of the wheel, axle, and bearing as a team, where each part has an important role. Reinforce that engineers focus not only on designing these components but also on maintaining them throughout the life of the train. Connecting this lesson to the previous discussion on derailments helps students understand that good engineering and routine maintenance work together to improve railway safety.

Differentiation

Support: Provide labeled diagrams of the wheel, axle, and bearing, allowing students to identify and describe the function of each component with teacher guidance.

Extension: Challenge students to compare the wheel-and-axle system on a train with another familiar object, such as a bicycle, skateboard, or shopping cart. Ask them to explain how reducing friction helps each object move more efficiently and why engineers design these systems to withstand repeated use.

Activity #4: Wheel and Axle Engineering Challenge: Designing a Train That Stays on Track

Activity Overview

Students apply their understanding of wheel and axle design by constructing a simple model train using Styrofoam cups and a wooden dowel or pencil as the axle. Working in engineering teams, students



investigate how wheel spacing, alignment, and axle placement affect a train's ability to stay on the track. Using the Engineering Design Process, teams build, test, evaluate, and improve their designs through multiple trials before completing a final class demonstration. Throughout the activity, students discover how engineers use testing and redesign to improve railway safety and reduce the risk of derailments.

Estimated Time: 30-40 min.

Learning Objectives

The students will be able to:

- Construct a simple wheel-and-axle model using everyday materials.
- Investigate how wheel spacing and alignment affect train stability.
- Explain how improper wheel and axle design can contribute to derailments.
- Apply the Engineering Design Process to test and improve a design.
- Work collaboratively to solve an engineering problem using evidence from testing.

Science TEKS:

- S.4.1(B) Use scientific and engineering practices to investigate questions and design solutions.
- S.4.1(C) Collect observations and measurements to support scientific explanations.
- S.4.6(A) Investigate how forces affect the motion of objects.
- S.4.6(B) Explain how friction and design influence movement.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.
- M.3.7(A) Collect and organize data from multiple trials.

NGSS:

- 3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on motion.
- 3–5 ETS1-3 – Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.

Materials Needed:

- 2 Styrofoam cups
- 1 wooden dowel or pencil (axle)
- Tape
- 2 meter sticks (track)
- Chairs or tables to support the track
- Student recording sheet
- Pencil



Teacher Preparation

Before class, assemble a simple track by securing two meter sticks parallel to one another between chairs or tables. Ensure each team has a complete set of materials. Review the challenge procedures and encourage students to focus on changing only one design variable at a time so they can observe how each modification affects the performance of their model train.

Facilitation Guide

1. Introduce the engineering challenge by explaining that each team will design a model train that rolls smoothly along the track without derailing.
2. Ask students to make predictions about how wheel spacing, wheel angle, or axle alignment might affect the model's performance.
3. Have students slide the Styrofoam cups onto the axle to create the train wheels.
4. Students complete an initial test run by rolling their model along the meter-stick track.
5. Teams observe whether the model stays on track and record what happened.
6. Students modify one aspect of their design, such as wheel spacing or alignment, and test the model again.
7. After completing two or three trials, each team performs a final run for the class and shares the improvements they made.

Reflection & Discussion

- Which design changes helped your model stay on the track?
- What caused some models to derail?
- Why is it important for engineers to test more than once?
- How did your team use evidence to improve your design?
- How does this challenge relate to the work of railway engineers?

Teacher Tips

Encourage students to change only one variable between trials so they can clearly identify which modification improved their design. Reinforce that engineers rarely achieve the perfect solution on the first attempt. Instead, they test, collect data, analyze results, and continue improving their designs. Celebrate thoughtful redesigns and evidence-based decision making rather than simply identifying the fastest or most successful model.

Differentiation

Support: Provide a partially assembled model or demonstrate how to position the Styrofoam cups on the axle before students begin building. Guide students in recording observations after each trial.

Extension: Challenge teams to design the most stable model by experimenting with different wheel spacing or axle positions. Have students explain how their findings relate to the design and maintenance



of real freight train wheel-and-axle systems and how engineers use similar testing methods to improve railway safety.

Activity #5: Railway Cargo Sorting: Matching Freight to the Railcar

Activity Overview

Students investigate how freight trains transport goods by exploring the different types of railcars used throughout the railroad industry. Working collaboratively, students examine a variety of cargo items and determine which type of railcar is best suited to transport each material. Through discussion and hands-on sorting, students learn that engineers carefully match cargo to the appropriate railcar to maximize safety, efficiency, and product protection during transportation.

Estimated Time: 25-30 min.

Learning Objectives

The students will be able to:

- Identify common types of freight railcars.
- Describe the materials transported by different railcars.
- Match cargo items to the appropriate freight railcar.
- Explain why engineers select different railcars for different types of freight.
- Recognize the role freight transportation plays in everyday life.

Science TEKS:

- S.4.1(A) Ask questions and define problems based on observations and information.
- S.4.1(B) Use scientific and engineering practices to investigate questions and design solutions.
- S.4.1(G) Develop and communicate explanations using evidence from observations.

Math TEKS:

- M.3.1(B) Apply a problem-solving process to organize, classify, and communicate information.
- M.3.7(A) Represent and interpret categorical data to solve problems.

NGSS:

- 3–5 ETS1-3 – Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.
- Science and Engineering Practice: Obtaining, Evaluating, and Communicating Information.

Materials Needed:



- Day 3 PowerPoint
- Projector or interactive display
- Freight railcar picture cards
- Cargo picture cards
- Cargo sorting mat or chart (optional)
- Student recording sheet
- Pencils

Teacher Preparation

Print and organize the cargo and railcar cards before class. Review the freight railcar examples presented in the PowerPoint and prepare to discuss why engineers select specific railcars based on the characteristics of the cargo being transported. Encourage students to think like logistics engineers as they justify each of their choices.

Facilitation Guide

1. Introduce the purpose of freight transportation and explain that trains carry many different types of cargo throughout the country.
2. Present the three freight railcar types:
 - a. Box Containers (Boxcars/Shipping Containers): Carry items such as clothing, toys, books, tools, electronics, and packaged food.
 - b. Hopper Cars: Carry bulk materials such as grain, wheat, gravel, or sand using a bottom hatch for unloading.
 - c. Tank Cars: Carry liquids such as milk, oil, or certain chemicals in sealed tanks.
3. Divide students into teams and provide each group with pictures or cards showing different cargo items.
4. Students work together to match each cargo item with the appropriate freight railcar or container.
5. Review each match as a class and discuss why each type of cargo requires a specific railcar.
6. Conclude by explaining that engineers carefully plan how freight is loaded and transported to improve safety, efficiency, and product protection.

Reflection & Discussion

- Why can't every product be shipped in the same type of railcar?
- Which freight car would be best for transporting grain? Why?
- Why are tank cars used to carry liquids?
- How do shipping containers help move products around the world?
- How do engineers make freight transportation safer and more efficient?

Teacher Tips



Encourage students to explain *why* they selected each railcar rather than simply identifying the correct answer. Reinforce that engineers think carefully about the properties of each material: whether it is a liquid, loose bulk material, or packaged product, when selecting the safest transportation method. Connecting cargo choices to real-world examples helps students recognize the complexity of freight transportation.

Differentiation

Support: Provide labeled pictures of each railcar along with picture cards of common cargo items. Allow students to work with a partner to discuss each match before sharing with the class.

Extension: Challenge students to think like logistics engineers by introducing unusual cargo items and asking them to justify which railcar they would use. Students can also explain how freight may travel using multiple forms of transportation, such as ships, trains, and trucks, before reaching its final destination. This reinforces the concept of intermodal transportation introduced in the presentation.

Activity #6: Build and Program a LEGO SPIKE Prime Forklift

Activity Overview

Students become freight transportation engineers by building and programming a LEGO® Education SPIKE™ Prime Forklift. Working in collaborative teams, students follow engineering instructions to assemble the forklift, identify its major components, and create a program that allows it to move, lift, and transport cargo. Throughout the activity, students use the Engineering Design Process to build, test, troubleshoot, and improve both their robot and program while developing computational thinking and problem-solving skills.

Estimated Time: 60-75 min.

Learning Objectives

The students will be able to:

- Build a LEGO® Education SPIKE™ Prime Forklift using engineering instructions.
- Identify the motors, sensors, and structural components of the robot.
- Develop a program that controls the forklift's movement.
- Test and troubleshoot their code to improve robot performance.
- Apply the Engineering Design Process to improve a robotic solution.
- Explain how robotics supports freight transportation and warehouse operations.

Science TEKS:



- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.1(C) – Collect observations and measurements using appropriate tools to support scientific explanations.
- S.4.1(G) Develop and use models to communicate engineering ideas.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each meets the criteria and constraints.
- 3–5 ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.

Materials Needed:

- LEGO® Education SPIKE™ Prime Kit (1 per team)
- iPad or compatible device with the SPIKE™ app installed
- Day 3 PowerPoint
- LEGO® SPIKE™ Prime building instructions
- Challenge mat or designated work area
- Cargo blocks or small objects for testing
- Student engineering journal (optional)

Teacher Preparation

Ensure each team has a complete LEGO® SPIKE™ Prime kit and a charged device with the SPIKE™ app installed. Verify that students can access the forklift building instructions and that all motors and sensors are functioning properly. Prepare a testing area where teams can safely operate their forklifts before completing the engineering challenge.

Facilitation Guide

1. Introduce the engineering task and explain that students will build a robotic forklift similar to those used in freight terminals and distribution centers.
2. Divide students into engineering teams and distribute the LEGO® SPIKE™ Prime kits.
3. Guide students through the construction of the forklift using the provided building instructions.
4. Once construction is complete, introduce the SPIKE™ programming environment.
5. Students create a basic program that allows the forklift to move forward, backward, turn, and operate the lifting mechanism.



6. Teams test their forklifts and identify any mechanical or programming issues.
7. Students revise their designs or code as needed until the forklift performs consistently and is ready for the final engineering challenge.

Reflection & Discussion

- What was the most challenging part of building your forklift?
- How did your team solve problems during construction or programming?
- Why is testing an important part of the Engineering Design Process?
- How do forklifts make freight transportation more efficient?
- If you could redesign your forklift, what improvements would you make?

Teacher Tips

Encourage students to assign roles within their engineering teams, such as builder, programmer, parts manager, and tester, so everyone contributes to the project. Remind students that debugging and redesign are expected parts of engineering. Celebrate persistence and collaboration just as much as successful robot performance.

Differentiation

Support: Provide students with a completed example of the forklift or offer guided checkpoints during the build. Pair students strategically so those with more robotics experience can support teammates during construction and programming.

Extension: Challenge teams to enhance their forklift by improving the efficiency of their code or modifying the design to transport cargo more accurately or with fewer movements. Encourage students to explain how engineers continually improve robotic systems used in modern freight terminals and warehouses.

Activity #7: Freight Transportation Challenge

Activity Overview

Students put their LEGO® Education SPIKE™ Prime forklifts to the test by completing a freight transportation challenge. Working in engineering teams, students program their forklifts to safely pick up, transport, and deliver cargo from one location to another. Teams evaluate the performance of their robot, identify areas for improvement, and refine their design or code as needed. Through multiple rounds of testing, students experience how engineers use collaboration, problem solving, and iterative design to improve transportation systems.

Estimated Time: 30-40 min.



Learning Objectives

The students will be able to:

- Operate a LEGO® SPIKE™ Prime forklift to complete a cargo transportation task.
- Apply coding and engineering skills to solve a real-world transportation challenge.
- Evaluate the effectiveness of their robot's design and program.
- Improve their solution through testing and redesign.
- Demonstrate teamwork and communication throughout the engineering process.

Science TEKS:

- S.4.1.B – Use scientific practices to plan and conduct investigations and use engineering practices to design solutions to problems.
- S.4.1(C) – Collect observations and measurements using appropriate tools to support scientific explanations.
- S.4.1(G) Develop, test, and communicate engineering solutions.

Math TEKS:

- M.3.1.B – Apply a problem-solving model by analyzing information, developing a strategy, and evaluating solutions.

NGSS:

- 3–5 ETS1-2 Generate and compare multiple solutions to a problem.
- 3–5 ETS1-3 – Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.

Materials Needed:

- LEGO® Education SPIKE™ Prime Forklift
- iPad with the SPIKE™ app
- Cargo blocks or small freight items
- Delivery station or designated loading and unloading zones
- Challenge course
- Student engineering journal or recording sheet
- Stopwatch (optional)

Teacher Preparation

Set up the challenge course with clearly marked loading and unloading areas. Place cargo at the designated starting location and ensure each team's forklift is fully assembled and programmed. Review the challenge expectations with students and remind them that engineers focus on accuracy, safety, and continuous improvement rather than simply finishing first.



Facilitation Guide

1. Introduce the Freight Transportation Challenge and explain the mission: safely transport cargo from the loading station to the delivery station using the LEGO® SPIKE™ Prime forklift.
2. Review the challenge rules and success criteria with the class.
3. Allow each engineering team time to test their forklift before beginning the official challenge.
4. Teams complete the challenge by lifting, transporting, and placing the cargo at the designated destination.
5. After the first attempt, students evaluate their robot's performance and identify improvements to their design or program.
6. Teams revise their code or mechanical design and complete a second challenge attempt.
7. Conclude with a class discussion highlighting how engineers continually improve technology through testing, collaboration, and redesign.

Reflection & Discussion

- What worked well during your freight transportation challenge?
- What obstacles did your team encounter, and how did you overcome them?
- How did testing help improve your robot's performance?
- Why is redesign an important part of engineering?
- How did teamwork contribute to your success?
- How do robotic forklifts improve safety and efficiency in real freight transportation systems?

Teacher Tips

Encourage students to focus on the engineering process rather than speed. Reinforce that every test provides valuable information that helps engineers improve a design. Give students opportunities to discuss their ideas, share successful strategies, and learn from other teams' solutions. Recognize persistence, collaboration, and thoughtful problem solving throughout the challenge.

Differentiation

Support: Simplify the challenge by reducing the distance the forklift must travel or limiting the task to transporting a single cargo item. Provide students with a sample program or additional teacher guidance during testing.

Extension: Challenge teams to complete multiple deliveries, transport different sizes of cargo, or modify their code to improve efficiency and accuracy. Encourage students to justify their programming and design decisions using evidence gathered during testing.



Day 4: Full Steam Ahead: The Final Freight Challenge

Day Overview

On the final day of camp, students bring together everything they have learned throughout the week as they take on the role of railway engineers. The day begins with a High Bay tour, where students observe real railway research equipment and explore engineering careers that support safe and efficient freight transportation. Students then strengthen their teamwork and communication skills through a collaborative challenge before reviewing key railway science concepts, including freight transportation, derailment prevention, signals and sensors, and Newton's Third Law of Motion. To conclude the week, students apply the Engineering Design Process to complete a final wheel-and-axle assembly challenge using their LEGO® Education SPIKE™ Prime forklifts, demonstrating their understanding of engineering, robotics, and railway safety.

Lesson Objectives:

By the end of Day 4, students will be able to:

- Apply teamwork and communication skills during collaborative engineering activities.
- Describe how engineers use inspections, sensors, signals, and maintenance to improve railway safety.
- Explain Newton's Third Law of Motion and how it relates to train movement.
- Investigate how action and reaction forces influence motion through hands-on activities.
- Apply the Engineering Design Process to solve a wheel-and-axle engineering challenge.
- Demonstrate safe and effective operation of a LEGO® Education SPIKE™ Prime forklift.
- Connect the engineering concepts learned throughout the week to real-world railway careers and freight transportation.

Essential Questions

- How do engineers work together to solve transportation challenges?
- How do inspections, sensors, and maintenance improve railway safety?
- How does Newton's Third Law help explain how trains move?
- Why is testing and redesign an important part of engineering?
- How do engineers use robotics and technology to improve freight transportation?
- How can the Engineering Design Process help solve real-world railway problems?

Day 4 at a Glance

Time Frame	Activity	Focus / Goal
20–30 min	High Bay Tour: Exploring Railway Engineering	Tour the UTRGV High Bay facility, observe railway research equipment, and explore engineering careers that support railway safety and freight transportation.
15–20 min	Team Building Challenge: Good Listener	Strengthen communication, active listening, teamwork, and collaboration while preparing students for the day's engineering challenges.
20–25 min	Railway Systems Review	Review key concepts from the week, including freight transportation, railroad classifications, derailment prevention, inspections, signals, sensors, and railway safety.
20–25 min	Newton's Third Law in Action	Investigate action and reaction forces through a Balloon Racer activity and connect Newton's Third Law to train movement, braking systems, and railway engineering.
60–75 min	Final Engineering Challenge: Wheel and Axle Assembly	Build, program, and operate a LEGO® Education SPIKE™ Prime forklift to transport and assemble a wheel-and-axle system while applying the Engineering Design Process, robotics, teamwork, and problem-solving skills.
10–15 min	Camp Reflection and Closing Celebration	Reflect on the week's learning, celebrate accomplishments, discuss engineering careers, and recognize students' growth as young engineers.

Day 4 Vocabulary

Students should review the following vocabulary before beginning the Day 4 activities. These terms will be used throughout the day during discussions about listening, motion, rural crossings, sensors, signals, and the final freight mission.



Term	Student-Friendly Definition	Day 4 Connection
High Bay	A large engineering laboratory where researchers test equipment, machines, and transportation systems.	Students will tour the UTRGV High Bay to observe real railway engineering and research.
Inspection	Carefully checking equipment to make sure it is working safely and correctly.	Engineers inspect trains and tracks to identify problems before they become dangerous.
Sensor	A device that detects changes, movement, or objects and sends information to a computer or machine.	Sensors help trains and robots detect obstacles and improve safety.
Signal	A visual or electronic system that tells trains when it is safe to move, slow down, or stop.	Railway signals help prevent collisions and keep trains operating safely.
Action Force	The force that pushes on an object to make something happen.	In the balloon activity, air rushing out of the balloon creates the action force.
Reaction Force	The force that pushes back in the opposite direction after an action force occurs.	The reaction force causes the balloon racer to move forward, just as forces help move trains.
Newton's Third Law	For every action, there is an equal and opposite reaction.	Students investigate how this law explains train movement and complete the Balloon Racer activity.
Propulsion	The force that moves an object forward.	Trains, robots, and balloon racers all rely on propulsion to move.
Derailment Prevention	The methods engineers use to keep trains safely on the tracks.	Students review inspections, maintenance, sensors, and signals that help prevent derailments.



Engineering Design Process	A series of steps engineers use to solve problems by asking questions, creating solutions, testing, and improving designs.	Students apply the Engineering Design Process one final time during the Wheel and Axle Assembly Challenge.
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Activity #1: High Bay Tour

Activity Overview

Students will visit the UTRGV High Bay research facility to observe railway engineering equipment and learn how engineers design, test, and improve transportation systems. During the tour, students will explore real-world engineering careers, observe large-scale railway research, and connect the concepts they have learned throughout the week, including forces and motion, electricity, electromagnets, robotics, sensors, maintenance, and freight transportation, to authentic engineering applications. Students are encouraged to ask questions, make observations, and think about how engineers solve problems to improve railway safety and efficiency.

Estimated Time: 20-30 min.

Learning Objectives

The students will be able to:

- Observe how engineers apply science, technology, engineering, and mathematics to solve real-world transportation problems.
- Identify examples of engineering concepts studied throughout the week within a professional research environment.
- Describe how teamwork and collaboration contribute to successful engineering projects.
- Ask questions and make observations about railway engineering careers and research.
- Connect classroom learning to real-world applications in railway safety and transportation.

Science TEKS:

- S.4.1(A) Ask questions and define problems based on observations.
- S.4.1(B) Use scientific and engineering practices to investigate questions and design solutions.
- S.4.1(G) Develop explanations and communicate observations using evidence.

Math TEKS:

- M.4.1(A) Apply mathematics to solve problems arising in everyday experiences.
- M.4.1(B) Use a problem-solving model that includes analyzing information, making decisions, and communicating reasoning.



NGSS:

- 3–5 ETS1-1 Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints.
- 3–5 ETS1-2 Generate and compare multiple possible solutions to a problem.

Materials Needed:

- Student engineering journals or observation sheets
- Pencil
- Personal protective equipment (if required by the facility)
- Closed-toe shoes
- Safety glasses (if provided by the facility)

Teacher Preparation

Coordinate with High Bay personnel before the visit to confirm the tour schedule and safety procedures. Review expectations with students, including appropriate behavior, staying with the group, asking respectful questions, and following all safety instructions. Encourage students to think about how the engineering concepts explored throughout the week are applied in the research facility.

Facilitation Guide

1. Review safety expectations and facility guidelines before entering the High Bay.
2. Introduce the purpose of the tour and explain that students will observe how engineers use science, technology, and teamwork to improve railway safety.
3. As students move through the facility, encourage them to identify examples of concepts learned throughout the week, such as forces and motion, electromagnets, sensors, robotics, wheel and axle systems, and freight transportation.
4. Invite students to ask questions about the equipment, research projects, and engineering careers they observe.
5. Have students record interesting observations or questions in their engineering journals during or immediately after the tour.
6. Conclude the visit by discussing how engineering research helps improve railway safety, efficiency, and transportation systems.

Reflection & Discussion

- What was the most interesting piece of equipment or technology you observed?
- How did the work being done in the High Bay connect to something we learned this week?
- What surprised you about the work of railway engineers?
- Why do engineers need to test their ideas before they are used in the real world?
- Would you be interested in a career related to engineering or transportation? Why or why not?



Teacher Tips

Encourage curiosity throughout the tour by allowing students time to observe carefully and ask thoughtful questions. Help students make connections between the research equipment they see and the classroom activities completed during the week. Reinforce that engineering is a collaborative profession that relies on creativity, testing, communication, and continuous improvement to solve real-world problems.

Differentiation

Support: Provide students with an observation checklist or a "scavenger hunt" that includes engineering concepts such as sensors, wheels, motors, safety equipment, and testing areas to help focus their observations.

Extension: Ask students to identify one engineering problem they observed during the tour and explain how they would use the Engineering Design Process to improve or solve it. Encourage students to share their ideas with the class during the closing discussion.

Activity #2: Team Building Challenge: “Good Listener” Cup Challenge

Activity Overview

Students will participate in a fast-paced listening and reaction game that emphasizes active listening, focus, teamwork, and sportsmanship. As the instructor calls out different body parts, students must respond by touching the correct body part. When the instructor calls "Cup!", students race to grab the cup before their partner. Following the activity, students discuss how listening, communication, and quick reactions contribute to safe and effective railway operations.

Estimated Time: 15-20 min.

Learning Objectives

The students will be able to:

- Demonstrate active listening and focus during a collaborative activity.
- Practice quick decision-making based on verbal instructions.
- Exhibit good sportsmanship while working with classmates.
- Explain why communication and teamwork are essential in engineering and railway careers.
- Connect listening skills to workplace safety and transportation operations.

Science TEKS:



- S.4.1(A) Ask questions and make observations during scientific and engineering activities.
- S.4.1(B) Use scientific and engineering practices to solve problems collaboratively.

Math TEKS:

- M.4.1(A) Apply problem-solving strategies while participating in collaborative activities.

NGSS:

- 3–5 ETS1-3 Plan and carry out tests in which variables are controlled and outcomes are observed to improve solutions.

Materials Needed:

- One plastic cup (or similar object) for every pair of students
- Open floor space or gymnasium
- Cones or floor markers (optional)

Teacher Preparation

Arrange students into two equal lines with partners facing one another. Place a plastic cup between each pair of students. Review the game rules and emphasize that students should respond only to the instructor's verbal directions while demonstrating respect and good sportsmanship. Remind students that engineers and railway professionals must carefully listen to instructions and communicate clearly to maintain safe operations.

Facilitation Guide

1. Pair students and have them stand facing one another with a cup placed on the floor between them.
2. Explain that students will listen carefully as the instructor calls out body parts such as "head," "shoulders," "knees," or "toes."
3. Each time a body part is called, students quickly touch the correct body part.
4. When the instructor calls "Cup!", students attempt to grab the cup before their partner.
5. Continue several rounds, allowing winners to advance if desired.
6. Conclude the activity with a class discussion about listening, communication, reaction time, and teamwork in engineering and railway careers.

Reflection & Discussion

- What happened when you lost focus or stopped listening carefully?
- How did paying close attention help you succeed?
- How did you demonstrate good sportsmanship during the activity?
- Why is listening an important skill for engineers and train operators?
- How can quick reactions help keep people safe around trains and railway crossings?



Teacher Tips

Keep the pace energetic while emphasizing that accuracy is more important than speed. Encourage students to cheer for one another and model positive sportsmanship throughout the activity. During the discussion, help students connect the game to real-world railway operations by explaining that engineers, conductors, dispatchers, and maintenance crews rely on clear communication and careful listening to prevent accidents and keep transportation systems operating safely.

Differentiation

Support: Slow the pace of the commands, reduce the number of body parts used, or allow students to practice several rounds before beginning the competition.

Extension: Increase the challenge by adding additional commands (such as "elbow," "ankle," or "waist"), incorporating movement between rounds, or asking students to explain how communication and teamwork contribute to safety in engineering professions.

Activity #3: Railway Systems Review

Activity Overview

Students will review the major engineering concepts explored throughout the week by examining how freight railroads safely transport goods across the country. Through interactive discussion, visual examples, and guided questioning, students will identify different types of freight railcars, compare railroad classifications, investigate common causes of derailments, and explain how inspections, maintenance, sensors, and signals help engineers keep trains operating safely. This activity prepares students for the engineering applications they will encounter during the remainder of the day.

Estimated Time: 20-25 min.

Learning Objectives

The students will be able to:

- Identify common types of freight railcars and the cargo they transport.
- Differentiate between Class I, Class II, and Class III railroads.
- Explain common causes of train derailments.
- Describe how inspections, maintenance, sensors, and signals improve railway safety.
- Connect engineering practices to the safe movement of freight across the railway system.

Science TEKS:



- S.4.1(A) Ask questions and define problems based on observations.
- S.4.1(B) Use scientific and engineering practices to investigate and solve problems.
- S.4.1(G) Communicate explanations using evidence from investigations.

Math TEKS:

- M.4.1(A) Apply mathematics to solve problems encountered in everyday experiences.
- M.4.1(B) Analyze information and communicate reasoning when solving problems.

NGSS:

- 3–5 ETS1-1 Define a design problem that reflects a real-world need.
- 3–5 ETS1-2 Generate and compare possible solutions to improve a design.

Materials Needed:

- Day 4 presentation
- Images of freight railcars
- Railroad classification chart
- Derailment causes graph
- Whiteboard or chart paper
- Student engineering journals (optional)

Teacher Preparation

Review the presentation slides and familiarize yourself with the freight railcar types, railroad classifications, derailment data, and railway safety systems. Prepare discussion questions that encourage students to connect these concepts to the engineering activities completed throughout the week. Emphasize that engineers continually analyze data and improve transportation systems to make rail travel safer and more efficient.

Facilitation Guide

1. Review the three primary freight railcar types—dry container (box container), hopper, and tank, and discuss the kinds of cargo each transports.
2. Introduce the three railroad classifications (Class I, II, and III) and explain how each serves a different role in moving freight.
3. Display the derailment chart and facilitate a discussion about the most common causes of train derailments.
4. Discuss how engineers reduce derailments through routine inspections, preventive maintenance, sensors, signals, and emergency systems.
5. Ask students to explain how these engineering practices improve railway safety and efficiency.
6. Conclude by connecting the review to the upcoming engineering activities, where students will apply these same concepts.



Reflection & Discussion

- Why are different types of railcars needed?
- How do Class I, Class II, and Class III railroads work together to move freight?
- What are some common causes of train derailments?
- Why are inspections and maintenance essential for railway safety?
- How do sensors and signals help engineers prevent accidents?
- Which railway safety system do you think is most important? Why?

Teacher Tips

Encourage students to explain their thinking rather than simply recall facts. Use the discussion to reinforce connections between science, engineering, and real-world transportation. When reviewing derailment prevention, emphasize that safe railway operations rely on many systems working together, including regular inspections, well-maintained equipment, advanced technology, and effective communication among railway professionals.

Differentiation

Support: Provide students with labeled images of freight railcars and a comparison chart of railroad classifications. Allow students to work with a partner when answering discussion questions.

Extension: Challenge students to analyze a real-world transportation scenario and recommend engineering solutions that could improve safety, reduce derailments, or increase the efficiency of freight movement. Encourage students to support their ideas using concepts learned throughout the week.

Activity #4: Newton's Third Law in Action: Balloon Racer Engineering

Activity Overview

Students will investigate Newton's Third Law of Motion by designing and testing a balloon-powered racer. As air escapes from the balloon, students observe how the action force of the escaping air produces an equal and opposite reaction force that propels the balloon forward. Through repeated testing and redesign, students will apply the Engineering Design Process while making connections between balloon propulsion, train movement, and robotic transportation systems.

Estimated Time: 20-25 min.

Learning Objectives

The students will be able to:



- Explain Newton's Third Law of Motion using the concepts of action and reaction.
- Build and test a balloon-powered racer.
- Observe how forces create motion.
- Apply the Engineering Design Process by testing, evaluating, and improving their design.
- Connect action and reaction forces to train movement and robotic transportation systems.

Science TEKS:

- S.4.6(A) Investigate and describe how forces cause changes in motion.
- S.4.1(B) Use scientific and engineering practices to investigate and solve problems.
- S.4.1(C) Collect observations and use evidence to improve a design.
- S.4.1(G) Develop and communicate engineering solutions.

Math TEKS:

- M.4.1(A) Apply mathematics to solve problems arising from investigations.
- M.4.1(B) Analyze results and communicate conclusions.

NGSS:

- 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.
- 3–5 ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.

Materials Needed:

- Balloon (1 per team)
- Drinking straw
- String
- Tape
- Two chairs or other supports
- Scissors (teacher use as needed)
- Student observation sheet or engineering journal

Teacher Preparation

Secure a length of string between two chairs, making sure it is pulled tight. Thread a straw onto the string before students attach their balloons. Prepare enough stations for each team and review the Engineering Design Process, emphasizing that engineers learn by testing, making observations, and improving their designs. Introduce Newton's Third Law by explaining that every action force produces an equal and opposite reaction force.

Facilitation Guide



1. Introduce Newton's Third Law of Motion and discuss how trains move by applying forces.
2. Demonstrate how to build the balloon racer by threading the straw onto the string and taping the balloon securely to the straw.
3. Inflate the balloon without tying it and hold the opening closed.
4. Release the balloon and observe how it moves along the string.
5. Have teams complete two or three test runs while making observations about their racer's performance.
6. Encourage students to adjust their launch technique or balloon placement to improve performance.
7. Complete a final class demonstration and compare results among teams.
8. Discuss how the activity models the forces involved in train movement and robotic transportation.

Reflection & Discussion

- What action force caused the balloon to move?
- What was the reaction force?
- How is this similar to the way a train moves along the tracks?
- How do motors help robots move in a similar way?
- Why do engineers test their designs multiple times before deciding they are finished?
- What changes improved your balloon racer's performance?

Teacher Tips

Encourage students to focus on the science behind the activity rather than simply trying to make the balloon travel the farthest. Guide discussions toward identifying the action and reaction forces observed during each trial. Reinforce that engineers use repeated testing to gather evidence and improve designs. Help students recognize that while balloon propulsion differs from locomotive engines, both systems rely on forces to create motion.

Differentiation

Support: Provide a partially assembled balloon racer or model the construction process step-by-step. Pair students who need additional support with peers who can assist during assembly and testing.

Extension: Challenge students to investigate how changing one variable, such as balloon size, string length, or balloon inflation, affects the racer's performance. Have teams justify their conclusions using observations collected during testing and explain how engineers use similar investigations to improve transportation systems.



Activity #5: Final Engineering Challenge: Smart Railway Safety System

Activity Overview

Students will work in engineering teams to complete a simulated railway maintenance mission using their LEGO® Education SPIKE™ Prime forklifts. Teams will program their robot to travel along the railway, detect a railroad crossing, stop safely, activate a warning signal, retrieve a wheel-and-axle assembly from the tracks, transport it to a repair station, and continue safely to the depot. Throughout the challenge, students will apply the Engineering Design Process by testing, evaluating, and improving both their robot's design and programming to successfully complete the mission.

Estimated Time: 60-75 min.

Learning Objectives

The students will be able to:

- Apply the Engineering Design Process to solve a real-world railway engineering problem.
- Build, program, and operate a LEGO® SPIKE™ Prime forklift to complete a transportation mission.
- Demonstrate how sensors improve railway safety by detecting crossings and triggering appropriate responses.
- Explain the importance of removing damaged equipment from railway tracks following a derailment.
- Collaborate effectively with teammates to test, troubleshoot, and improve their engineering solution.

Science TEKS:

- S.4.1(B) Use scientific and engineering practices to investigate questions and design solutions.
- S.4.1(C) Collect observations and use evidence to improve a design.
- S.4.1(G) Develop, test, and communicate engineering solutions.
- S.4.6(A) Investigate how forces affect the motion of objects.

Math TEKS:

- M.4.1(A) Apply mathematics to solve problems arising in everyday experiences.
- M.4.1(B) Analyze results, evaluate solutions, and communicate reasoning.

NGSS:

- 3–5 ETS1-2 Generate and compare multiple solutions to a problem.
- 3–5 ETS1-3 – Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype.



Materials Needed:

- LEGO® Education SPIKE™ Prime forklift (one per team)
- SPIKE™ Prime hub and motors
- iPad with the SPIKE™ app
- Wheel-and-axle assembly
- Railway challenge mat or course
- Repair station and depot markers
- Railroad crossing marker
- Student engineering journal (optional)

Teacher Preparation

Prepare the challenge course before class by placing the railroad crossing, wheel-and-axle assembly, repair station, and depot in their designated locations. Confirm that each team's forklift is assembled and functioning properly. Review the mission objectives and remind students that engineers improve their designs through repeated testing and collaboration. Emphasize that success is measured not only by completing the mission, but also by safe operation, teamwork, and perseverance.

Facilitation Guide

1. Introduce the mission scenario: a wheel-and-axle assembly has been left on the tracks following a derailment and must be safely removed.
2. Review the Engineering Design Process and discuss how engineers solve transportation problems through planning, testing, and redesign.
3. Explain the mission objectives:
 - a. Travel safely along the railway.
 - b. Detect the railroad crossing.
 - c. Stop and activate a warning signal.
 - d. Pick up the wheel-and-axle assembly.
 - e. Deliver it to the repair station.
 - f. Continue to the depot and park safely.
4. Allow teams time to test their robot and make programming adjustments.
5. Teams complete the mission while the instructor observes teamwork, programming, and problem-solving.
6. If needed, students revise their code or robot design and attempt the mission again.
7. Conclude with a class discussion highlighting successful engineering strategies and lessons learned.

Reflection & Discussion

- What part of the mission was the most challenging?
- How did your robot use sensors or programming to improve safety?



- Why was it important to remove the wheel-and-axle assembly from the tracks?
- What changes did your team make after testing?
- How did teamwork contribute to your success?
- How is this challenge similar to the work performed by real railway engineers?

Teacher Tips

Encourage teams to approach the mission systematically by solving one task at a time before combining all of the programmed actions. Reinforce that engineers rarely succeed on the first attempt and that testing, troubleshooting, and redesign are expected parts of the engineering process. Recognize teams that demonstrate persistence, thoughtful problem-solving, and effective collaboration, even if they do not complete every portion of the mission.

Differentiation

Support: Break the mission into smaller tasks, allowing students to successfully complete each step before combining them into one continuous program. Provide sample code or additional teacher guidance as needed.

Extension: Challenge teams to complete the mission with greater efficiency by reducing travel time, improving code, or minimizing unnecessary movements. Students can also justify their programming decisions and explain how their robot models real-world railway maintenance operations.



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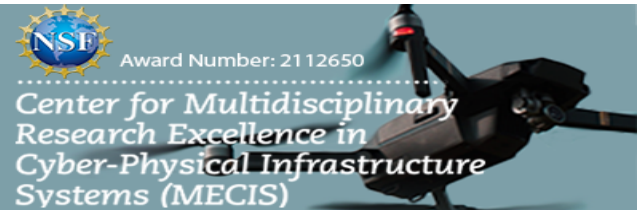
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This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.