University Transportation Center for Railway Safety (UTCRS)

MIDDLE SCHOOL STEM CURRICULUM
# Table of Contents

Learning Objectives.................................................................................................................. 3
Technology Standards.................................................................................................................. 6
Texas Essential Knowledge and Skills (TEKS)............................................................................ 10
  Science TEKS......................................................................................................................... 10
  Math TEKS............................................................................................................................. 12
NGSS Standards.......................................................................................................................... 13
Day 1: A Future in Engineering.................................................................................................. 15
  Activity #1: Introduction to Engineering.................................................................................. 15
  Activity #2: Ice Breaker........................................................................................................... 16
    Title: Ice Breaker– Ice Cup Challenge................................................................................... 16
  Activity #3: Railway Engineering............................................................................................ 17
  Activity #5: Hot Wheels Lab................................................................................................... 18
    Activity #6: Clean Up & Closing......................................................................................... 19
Day 2: Getting to Know Spike Prime.......................................................................................... 21
  Activity #1: Getting to Know Spike Prime............................................................................. 21
  Activity #2: Hopper Race....................................................................................................... 22
  Activity #3: Uphill................................................................................................................... 23
  Activity #4: Clean up and Discussion.................................................................................... 25
Day 3: Training Camp................................................................................................................ 26
  Activity #1 The Wheel and Axle............................................................................................ 26
  Activity #2: Training Camp 1................................................................................................ 27
  Activity #3: Training Camp 2................................................................................................ 28
  Activity #4: Training Camp 3................................................................................................ 29
  Activity #1: Visit to the High Bay......................................................................................... 31
  Activity #2: Build and Program a Robot with Ultrasonic Sensor......................................... 32
  Activity #3: The Claw............................................................................................................. 33
  Activity #4: Remove and Relocate an Obstruction............................................................... 33
    Activity #2: Clean Up and Closing Discussion.................................................................... 36
Appendices.................................................................................................................................... 38
  Appendix A:............................................................................................................................. 38
  Appendix B:............................................................................................................................. 38
  Appendix C:............................................................................................................................. 38
References....................................................................................................................................... 39
Learning Objectives

Day 1

Activity #1: Introductions
The students will be able to …
1. define engineering from their prior knowledge and videos.
2. describe the types of engineers and their jobs, engineering design process, and educational requirements that are needed to become a transportation engineer throughout the PowerPoint.

Activity #2: Ice Breaker – Ice Cup Challenge
The students will be able to …
1. discover how engineers work together to achieve a goal by stacking cups with few strings and a rubber band.
2. discuss their knowledge of how engineers work in teams to achieve goals.
3. identify the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
4. recognize to assign tasks based on the goals and needs of a team.

Activity #3: Railway Engineering
The students will be able to …
1. recognize what railway engineers and freight trains are and their importance from the PowerPoint.
2. state the importance of transportation engineers further along the PowerPoint.

Activity #4: Assign Team Roles
The students will be able to …
1. understand how engineers work in teams to achieve a goal in their activities.
2. determine their roles for their future activities/goals that are needed within their team.

Activity #5: Bridge Building/ Hot Wheels Challenge
The students will be able to …
1. analyze how potential and kinetic energy play a role in the increase or decrease of motion in their Hot Wheels cars by building tracks with ramps and loops.
2. use problem-solving skills to construct a track that is successful with or without loops.
3. explain Potential and Kinetic Energy from the experiment.
4. create the “best” track with a loop that will allow the car to go through the loop completely and still have the car travel the farthest distance off of the ramp.

Day 2

Activity #1: Getting to Know Spike Prime
The students will be able to …
1. recognize different parts that make spike prime run, such as the hub, ports, sensors, and Bluetooth connection.
2. use problem-solving skills to create, run, and test the different sensors by using the Spike app.

**Activity #2: Hopper Race**
The students will be able to …
1. adapt the engineering design process by testing, analyzing their problems, and then improving the robot.
2. construct a hopper to race and redesign to make the hopper better and faster.
3. use problem-solving skills to create, test, and run programs to command their robot.
4. apply their knowledge on how engineers work in teams to achieve a goal.
5. demonstrate the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
6. plan to assign tasks based on the goals and needs of a team.

**Activity #3: Uphill**
The students will be able to …
1. construct a bot that goes up and downhill with a ramp.
2. compare potential and kinetic energy by their observation of their bike.
3. describe how potential and kinetic energy are conserved through the transfers and transformations.
4. apply their knowledge on how engineers work in teams to achieve a goal.
5. demonstrate the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
6. express their roles to assign tasks based on the goals and needs of a team.

**Activity #4: Closure discussion**
The students will be able to …
1. summarize the engineering process based on their activists.
2. state what is Potential and Kinetic Energy from reviewing and applying throughout their activities.

---

**Day 3**

**Activity #1: The Wheel and Axle**
The students will be able to …
1. develop the method and concept of Wheel and Axle Assembly, as well as the critical role of forklifts in performing maintenance on railways and train wheels.
2. listen to the safety procedures in preparation for the high bay tour.
3. compare the difference between the two wheels and the significance of the shape using the cups.

**Activity #2: Training Camp 1**
The students will be able to …
1. create a practice Driving Base, making precise, and controlled movements using the Spike Prime Kit.
2. construct a code that programs the robot to move it to a designated spot with the Spike Prime Kit.

Activity 3: Training Camp 2
The students will be able to …
1. apply the Engineering Design Process through a Robotic Challenge.
2. create a Driving Base with sensors to control motors and interact with objects on the competition field.
3. invent a code that challenges the student’s bot to maneuver itself and the object throughout the Robotic challenge.
4. create a practice Driving Base and make precise and controlled movements.
5. operate on their knowledge of how engineers work in teams to achieve goals.
6. show the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
7. choose their assigned tasks based on the goals and needs of a team.

Activity 4: Training Camp 3
The students will be able to …
1. apply the engineering design process by creating a Driving Base and writing programs using the color sensor to make the driving base autonomous.
2. use the Engineering Design Process through A Robotic Challenge.
3. operate on their knowledge of how engineers work in teams to achieve goals.
4. show the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
5. choose to assign tasks based on the goals and needs of a team.

Day 4
Activity #1: Visit to the High Bay
The students will be able to …
1. identify what Engineering High Bay is before heading to the tour.
2. analyze the various machinery and equipment associated with Engineering High Bay.
3. apply their understanding of engineering fields as they relate to other career fields.

Activity #2: Build and Program a Robot with Ultrasonic Sensor
The students will be able to …
1. apply problem-solving skills to create, test, and run programs created to control a robot.
2. judge their build by identifying errors and implementing the engineering design process to correct them.

Activity #3: The Claw
The students will be able to …
1. create a robot and apply a specific code to complete a specific task.
2. analyze the values for each piece of code that will allow the robot to traverse through a small course with an obstruction successfully.

**Activity #4: Remove and Relocate an Obstruction**
The students will be able to …
1. modify the code for their robot to allow for traversing of a track and movement of an obstacle.

**Day 5**

**Activity #1: Railway Safety Cargo Races**
The students will be able to …
1. examine Cargo and Freight Trains from their final challenge.
2. review the Final Challenge Rules and Expectations.
3. plan to begin the Final Challenge by editing and making final changes to the robot and the code.

**Activity #2: Clean Up and Closing Discussion**
The students will be able to …
1. review learning and applying practices to real life.

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

**Note that some objectives may be repeated across activities, as they are building upon each other to help students develop a deeper understanding of engineering concepts and principles.**
### Texas Essential Knowledge and Skills (TEKS)

#### Science TEKS

**2021 Texas Education Agency Science Standards**

<table>
<thead>
<tr>
<th>S5.7(A)</th>
<th>Investigate and explain how equal and unequal forces acting on an object cause patterns of motion and transfer of energy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S5.7(B)</td>
<td>Design a simple experimental investigation that tests the effect of force on an object in a system such as a car on a ramp or a balloon rocket on a string.</td>
</tr>
<tr>
<td>S5.8(A)</td>
<td>Investigate and describe the transformation of energy in systems such as energy in a flashlight battery that changes from chemical energy to electrical energy to light energy.</td>
</tr>
<tr>
<td>S5.8(C)</td>
<td>Demonstrate and explain how light travels in a straight line and can be reflected, refracted, or absorbed.</td>
</tr>
<tr>
<td>S6.7(A)</td>
<td>Identify and explain how forces act on objects, including gravity, friction, magnetism, applied forces, and normal forces, using real-world applications.</td>
</tr>
<tr>
<td>S6.7(B)</td>
<td>Calculate the net force on an object in a horizontal or vertical direction using diagrams and determine if the forces are balanced or unbalanced.</td>
</tr>
<tr>
<td>S6.7(C)</td>
<td>Identify simultaneous force pairs that are equal in magnitude and opposite in direction that result from the interactions between objects.</td>
</tr>
<tr>
<td>S6.8(B)</td>
<td>Describe how energy is conserved through transfers and transformations in systems such as electrical circuits, food webs, amusement park rides, or photosynthesis.</td>
</tr>
<tr>
<td>S6.2(A)</td>
<td>Identify advantages and limitations of models such as their size, scale, properties, and materials.</td>
</tr>
<tr>
<td>S6.1(B)</td>
<td>Use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems.</td>
</tr>
<tr>
<td>S6.2(D)</td>
<td>Evaluate experimental and engineering designs.</td>
</tr>
<tr>
<td>S6.1(G)</td>
<td>Develop and use models to represent phenomena, systems, processes, or solutions to engineering problems.</td>
</tr>
<tr>
<td>S6.8(A)</td>
<td>Compare and contrast gravitational, elastic, and chemical potential energies with kinetic energy</td>
</tr>
<tr>
<td>S7.7(A)</td>
<td>Calculate average speed using distance and time measurements from investigations.</td>
</tr>
<tr>
<td>S7.7(B)</td>
<td>Distinguish between speed and velocity in linear motion in terms of distance, displacement, and direction.</td>
</tr>
<tr>
<td>S7.7(C)</td>
<td>Measure, record, and interpret an object's motion using distance-time graphs.</td>
</tr>
<tr>
<td>S7.7(D)</td>
<td>Analyze the effect of balanced and unbalanced forces on the state of motion of an object using Newton's First Law of Motion.</td>
</tr>
<tr>
<td>S7.8(A)</td>
<td>Investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation.</td>
</tr>
<tr>
<td>S7.8(C)</td>
<td>Explain the relationship between temperature and the kinetic energy of the particles within a substance.</td>
</tr>
<tr>
<td>S7.9(B)</td>
<td>Describe how gravity governs motion within Earth’s solar system.</td>
</tr>
<tr>
<td>S8.7(A)</td>
<td>Calculate and analyze how the acceleration of an object is dependent upon the net force acting on the object and the mass of the object.</td>
</tr>
<tr>
<td>S8.7(B)</td>
<td>Investigate and describe how Newton's three laws of motion act simultaneously within systems such as in vehicle restraints, sports activities, amusement park rides, Earth's tectonic activities, and rocket launches.</td>
</tr>
</tbody>
</table>
### Math TEKS

#### 2012 Texas Education Agency Math Standards

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

#### 2017 Next Generation Science Standards 6-8

<p>| MS-PS2-1 | Apply Newton’s Third Law to design a solution to a problem involving the motion of two bodies.                  |
| MS-PS2-2 | Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. |
| MS-PS2-3 | Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. |
| MS-PS2-4 | Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. |
| MS-PS2-5 | Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. |
| MS-PS3-1 | Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. |
| MS-PS3-2 | Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. |
| MS-PS3-3 | Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* |
| MS-PS3-4 | Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. |
| MS-PS3-5 | Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. |
| MS-ETS1-1 | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| MS-ETS1-2 | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| MS-ETS1-3 | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |
| MS-ETS1-4 | Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. |
| STEL-1 | Develop innovative products and systems that solve problems and extend capabilities based on individual or collective needs and wants. |
| STEL-1K | Compare and contrast the contributions of science, engineering, mathematics, and technology in the development of technological systems. |
| STEL-1L | Explain how technology and engineering are closely linked to creativity, which can result in both intended and unintended innovations. |
| STEL-1M | Apply creative problem-solving strategies to the improvement of existing devices or processes or the development of new approaches. |
| STEL-2M | Differentiate between inputs, processes, outputs, and feedback in technological systems. |
| STEL-2N | Illustrate how systems thinking involves considering relationships between every part, as well as how the system interacts with the environment in which it is used. |
| STEL-2O | Create an open-loop system that has no feedback path and requires human intervention. |
| STEL-2P | Create a closed-loop system that has a feedback path and requires no human intervention. |
| STEL-2Q | Predict outcomes of a future product or system at the beginning of the design process. |
| STEL-2R | Compare how different technologies involve different sets of processes. |
| STEL-2S | Defend decisions related to a design problem. |
| STEL-3E | Analyze how different technological systems often interact with economic, environmental, and social systems. |
| STEL-3F | Apply a product, system, or process developed for one setting to another setting. |
| STEL-3G | Explain how knowledge gained from other content areas affects the development of technological products and systems. |
| STEL-4K | Examine the ways that technology can have both positive and negative effects at the same time. |
| STEL-4L | Analyze how the creation and use of technologies consumes renewable and non-renewable resources and creates waste. |
| STEL-4M | Devise strategies for reducing, reusing, and recycling waste caused from the creation and use of technology. |
| STEL-4N | Analyze examples of technologies that have changed the way people think, interact, and communicate. |
| STEL-4O | Hypothesize what alternative outcomes (individual, cultural, and/or environmental) might have resulted had a different technological solution been selected. |</p>
<table>
<thead>
<tr>
<th>STEL-5F</th>
<th>Analyze how an invention or innovation was influenced by its historical context.</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEL-5G</td>
<td>Evaluate trade-offs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors.</td>
</tr>
<tr>
<td>STEL-6C</td>
<td>Compare various technologies and how they have contributed to human progress.</td>
</tr>
<tr>
<td>STEL-6D</td>
<td>Engage in a research and development process to simulate how inventions and innovations have evolved through systematic tests and refinements.</td>
</tr>
<tr>
<td>STEL-6E</td>
<td>Verify how specialization of function has been at the heart of many technological improvements.</td>
</tr>
<tr>
<td>STEL-7P</td>
<td>Illustrate the benefits and opportunities associated with different approaches to design.</td>
</tr>
<tr>
<td>STEL-7Q</td>
<td>Apply the technology and engineering design process.</td>
</tr>
<tr>
<td>STEL-7R</td>
<td>Refine design solutions to address criteria and constraints.</td>
</tr>
<tr>
<td>STEL-7S</td>
<td>Create solutions to problems by identifying and applying human factors in design.</td>
</tr>
<tr>
<td>STEL-7T</td>
<td>Assess design quality based upon established principles and elements of design.</td>
</tr>
<tr>
<td>STEL-7U</td>
<td>Evaluate the strengths and weaknesses of different design solutions.</td>
</tr>
<tr>
<td>STEL-7V</td>
<td>Improve essential skills necessary to successfully design.</td>
</tr>
<tr>
<td>STEL-8H</td>
<td>Research information from various sources to use and maintain technological products or systems.</td>
</tr>
<tr>
<td>STEL-8I</td>
<td>Use tools, materials, and machines to safely diagnose, adjust, and repair systems.</td>
</tr>
<tr>
<td>STEL-8J</td>
<td>Use devices to control technological systems.</td>
</tr>
<tr>
<td>STEL-8K</td>
<td>Design methods to gather data about technological systems.</td>
</tr>
<tr>
<td>STEL-8L</td>
<td>Interpret the accuracy of information collected.</td>
</tr>
<tr>
<td>STEL-8M</td>
<td>Use instruments to gather data on the performance of everyday products.</td>
</tr>
</tbody>
</table>
Day 1: A Future in Engineering

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

**Activity #1 : Introduction to Engineering**

**Title:** Introductions and Assign Students to Groups

**Estimated Time:** 10 min

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

**Learning Objectives:**
The students will be able to …

1. define engineering from their prior knowledge and videos.
2. describe the types of engineers and their jobs, engineering design process, and educational requirements that are needed to become a transportation engineer throughout the PowerPoint.

**TEKS:**
1. S5.7(A)

**NGSS:**
1. MS-ETS1-1

**Technology Standards:**
1. STEL-1K
2. STEL-2P

**Materials needed:**
1. PowerPoint Lesson

**Lesson Flow:**
1. Welcome: During the introduction you want to get kids excited about the curriculum lessons and what they are about to learn. Mention some of the projects students will be building, the daily challenges and the “Grand Challenge”. Introduce yourself and tell students a little about yourself.
2. Show video of different types of Engineers: [What's an Engineer? Crash Course Kids #12.1](https://www.youtube.com/watch?v=dQw4w9WgXcQ)
3. Have students identify what type of engineer they would want to be and discuss in groups
4. Agenda: Go over the agenda for the day so students know what is going to happen.
Activity #2: Ice Breaker

Title: Ice Breaker– Ice Cup Challenge

Estimated Time: 50-60 min

Lesson Overview: Students will engage in an icebreaker.

Learning Objectives:
The student will be able to …
1. discover how engineers work together to achieve a goal by stacking cups with few strings and a rubber band.
2. discuss their knowledge of how engineers work in teams to achieve goals.
3. identify the importance of each member's role and functions, given the student assigns/ Follows their role throughout their challenge.
4. recognize to assign tasks based on the goals and needs of a team.

TEKS:
1. S5.8(A)

NGSS:
1. MS-EST-1

Technology Standards:
1. STEL-8H

Materials needed: (per group)
1. 15 Red Cups
2. A Rubber band
3. 5 Strings

Lesson Flow:
1. In this game, our challenge is to build a pyramid of cups (as shown) by working TOGETHER. Tie your string to the rubber band. All team members will NOT TOUCH CUPS, stretch the rubber band to grab a cup.
2. Give students directions for the game and materials. Start the game and monitor students to make sure they are working together and not touching the cups with their hands.
3. Do 3 rounds. The goal for the 1st round is to stack 10 cups in pyramid formation.
4. The 2nd round is to stack 15 cups in pyramid formation.
5. The 3rd round is to add a time factor and challenge the teams. Fastest team wins.

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

Activity #3: Railway Engineering

Estimated Time: 10 min  
Lesson Overview: Teacher will lecture on engineers and trains  
Learning Objectives:  
The students will be able to …
   1. recognize what railway engineers and freight trains are and their importance from the PowerPoint.
   2. state the importance of transportation engineers further along the PowerPoint.

TEKS:  
   1. S7.7(A)

NGSS:  
   1. MS-ETS1

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

Materials needed: Powerpoint

Lesson Flow:  
Explain: The Infinity Train  
   1. Watch Video: The Infinity Train Can Run Forever Using Only Gravity
   2. Ask the following questions:
      a. What type of energy is used to charge the battery?
      b. Why is it called the infinity train?
      c. Name at least one energy transformation that occurs.
      d. How is gravitational potential energy increased?
      e. What does a transportation engineer do?
      f. What are the specialties within transportation engineering?

Activity #4: Assign Team Roles

Estimated Time: 5 minutes  
Lesson Overview: Students will be assigned to groups and roles within groups to create teams of engineers.  
Learning Objectives:  
The students will be able to …  
   1. understand how engineers work in teams to achieve a goal in their activities.
2. determine their roles for their future activities/goals that are needed within their team.

**Materials Needed:** N/A

**Lesson Flow:**
1. Make sure that students are in groups of 4-5.
2. Have students discuss and decide who will serve in each of the roles. Roles include:
   a. One lead engineer
   b. 2-3 assistant engineers.
   c. 1-2 programmers (programmers will not be needed until Activity #6).
3. Assure students that everyone will get the chance to be in each of the roles at least once.

**Activity #5: Hot Wheels Lab**

**Estimated Time:** 40 minutes

**Lesson Overview:** As an engineer, how would you build a track to get your Hot Wheels car to move through a loop and go as far as it can?

**Learning Objectives:**
The student will be able to …
1. analyze how potential and kinetic energy play a role in the increase or decrease of motion in their Hot Wheels cars by building tracks with ramps and loops.
2. use problem-solving skills to construct a track that is successful with or without loops.
3. explain Potential and Kinetic Energy from the experiment.
4. create the “best” track with a loop that will allow the car to go through the loop completely and still have the car travel the farthest distance off of the ramp.

**TEKS:**
1. S5.7(A)
2. S5.7(b)
3. S5.8 (A)
4. M6.12(A)
5. M7.3(A)
6. M7.4(A)

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

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

**Materials Needed:** (per group)
1. 15 hot wheels long track pieces
Lesson Flow:

1. **Engage:** Mini-lab
   a. Connect 6 ramp pieces.
   b. Place the car on the flat ramp. Does it move?
   c. Elevate one side of the ramp about two inches and place the car on the ramp. Does it move?
   d. Continue this process until the ramp reaches 10 inches in height.
   e. What are you changing?
   f. How does this change in Potential Energy affect Kinetic Energy (motion)?
   g. Watch: [The Yellow Driver's World Record Jump (Tanner Foust) | Team Ho…]

2. **Pre-Lab Questions:**
   a. What did you notice about the design of the ramp?
   b. How do you think the engineers got the car to do the jump?
   c. What did you notice about the track and the car?
   d. How was the car different from cars you usually see people drive?
   e. How were the tracks different from the streets in your neighborhood?

3. **Lab:**
   a. Use the Hot Wheels cars, tracks, and other available materials. Work as a group to create the “best” track with a loop that will allow the car to go through the loop completely and still have the car travel the farthest distance off of the ramp.
   b. With your group create at least 4 different track designs.
   c. Record the design changes that you make to your track and loop after each new set of trials. (Draw/sketch, time and Measure).
   d. Look at the data and decide what track design allowed the car to go through the loop completely and still have the car travel the farthest distance off of the ramp.
   e. Calculate Speed with Distance/time.

4. **Evaluate-Post Lab Questions:**
   a. What do you think caused the car to go farther?
   b. What are some of the factors that could have affected your results?
   c. Do you think the type of car your group used affected your results?
   d. How would you improve your ramp design?

**Activity #6: Clean Up & Closing**

**Estimated Time:** 15 minutes

**Title:** Clean-up and Closing Discussion
Lesson Overview: Have students reflect on the challenge at hand and other challenges real transportation engineers face on a daily basis.

Learning Objectives:
The student will be able to …

1. summarize the transportation engineering real-life challenges from the activities.

Materials Needed:
1. No materials necessary.

Lesson Flow:
1. Have a discussion about the challenges real engineers would face if they encountered a situation as in the last activity. What possible solutions do they suggest to solve this situation?
2. Make sure students count and put all materials back in the box and that no Lego parts are missing, misplaced, or left behind
Day 2: Getting to Know Spike Prime

**Day Overview:** The students will get to see the Spike Prime Kit and explore the different parts that make it work such as motors, sensors, hub, ports, and Ipad. Once students familiarize themselves with the different components of the kit they will incorporate the engineering design process to complete the first lesson which is the Hopper Race. The students will then disassemble and work on the Uphill build for the second part of the day where they will describe the energy transformation happening in their specific build. The students will end the day with an exit ticket based on the engineering design process and the energy transformation that happened in the uphill build.

**Activity #1: Getting to Know Spike Prime**

![Spike Prime components](image)

**Estimated Time:** 30-45 minutes

**Title:** Getting to Know Spike Prime.

**Lesson Overview:** Teams will become familiar with all parts of the Spike Prime kit.

**Learning Objectives:**
The students will be able to …

1. recognize different parts that make spike prime run, such as the hub, ports, sensors, and Bluetooth connection.
2. use problem-solving skills to create, run, and test the different sensors by using the Spike app.

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

**NGSS:**
1. MS-PS3-3
2. MS-ETS1-2
3. MS-ETS1-3
Materials Needed: (per group)
1. One LEGO® Spike Prime robotics kit
2. One LEGO® Spike Prime robotics kit Manual
3. One iPad
4. LEGO® Spike Prime software installed on the iPad

Lesson Flow:
1. Explore the Lego Spike Prime kit and take out major parts such as the hub, color sensor, touch sensor, distance sensor, and motors.
2. Use problem solving skills to create, run, and test the different sensors.
3. Compare the different tutorials of the hub, sensors, and motors.

Activity #2: Hopper Race

Estimated Time: 60-90 minutes

Title: Hopper Race

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

Learning Objectives:
The students will be able to …
1. adapt the engineering design process by testing, analyzing their problems, and then improving the robot.
2. construct a hopper to race and redesign to make the hopper better and faster.
3. use problem-solving skills to create, test, and run programs to command their robot.
4. apply their knowledge on how engineers work in teams to achieve a goal.
5. demonstrate the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
6. plan to assign tasks based on the goals and needs of a team.
1. **TEKS:**
   1. S6.1(B)
   2. S6.1(G)
   3. S6.2(A)
   4. S6.2(D)

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

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

4. **Materials Needed:** (per group)
   1. One LEGO® Spike Prime robotics kit
   2. One iPad

5. **Lesson Flow:**

   1. **Prepare**
      a. Read through the student material in the LEGO® Education SPIKE™ App.
      b. Have each build the initial bot using the spike prime app and race.
      c. Students will implement the engineering design process and use problem-solving skills to create, test, and run programs to do a second build that will make the bot better and faster. (x2)

   2. **Engage**
      a. Use the ideas in the *Ignite a Discussion* section below to engage your students in a discussion related to this lesson.
      b. Use the video to explain the lesson.

   3. **Explore**
      a. Have your students in pairs to build the hopper model.
      b. Ask them to play the program to see how the hopper moves.
      c. Have them prototype new legs to move the hopper's body forward faster.
         Highlight that they cannot use wheels for locomotion.

   4. **Explain**
      a. Facilitate a discussion by asking the students to describe the methods they've used to improve their hopper's movement.
5. **Elaborate**
   a. Prepare the test track by setting up start and finish lines using LEGO bricks.
   b. Give the teams 15 minutes to test and improve(2) their models before the final race.
   c. If time allows, encourage them to give their hoppers some character by adding bricks and other materials from around the classroom. They can also place bricks on the test track, creating an uneven surface that's more difficult to walk over.
   d. Don't forget to leave some time for cleanup.

6. **Evaluate**
   a. Give feedback on each student's performance.
   b. You can use the assessment rubrics provided to simplify the process.

Activity #3: Uphill

Estimated Time: 60-90 min

Title: Build and Program the Uphill lesson

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

Learning Objectives:
The student will be able to …

1. construct a bot that goes up and downhill with a ramp.
2. compare potential and kinetic energy by their observation of their bike.
3. describe how potential and kinetic energy are conserved through the transfers and transformations.
4. apply their knowledge on how engineers work in teams to achieve a goal.
5. demonstrate the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
6. express their roles to assign tasks based on the goals and needs of a team.

TEKS:

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

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

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

**Materials Needed:** (per group)
1. One LEGO® Spike Prime robotics kit
2. One iPad

**Lesson Flow:**

1. **Engage**
   a. The topic of this lesson is energy transfer. Your students will learn that in order for a biker to maintain a constant speed (i.e., constant kinetic energy) when going uphill (i.e., to gain potential energy), he or she needs to input energy. This lesson uses a model of an electric bike. Its energy will come from an increase in its motor's power consumption. In a real-life situation, this energy would come from extra effort from the bicyclist.
   b. Use various materials to engage your students on the topic of energy transfer.

2. **Ignite a Discussion**

   Start a discussion by asking questions related to the lesson. Here are a few suggestions:
   a. What will happen to your speed when you go up a hill?
   b. What type of energy do you gain as you go up?
   c. What do you need to do to maintain a consistent energy level of you on your bike (your system)?
   d. Why do you think that's the case?
   e. Have your students write down their thoughts as a hypothesis.

3. **Explore**
   a. Have your students build a smart bike that can record its motor's power consumption and the angle of a slope. They can create their own models, or follow the building instructions in the app to build the Smart Bike model.
   b. Ask your students to try out their models on a flat surface using the suggested program in the SPIKE App.
c. Tell them to look at the graph and document what they see: Why do the two plotted lines look like they do?

4. **Explain**
   a. Have your students repeat the experiment using a slope, which they can create using the SPIKE Prime box and a plank.
   b. Ask your students to explain how the smart bike's motor is adding energy to maintain a constant speed.
   c. Have them explain the relationship between the motor's power consumption and the angle of the slope.
   d. Tell them to export their data as a CSV file, so they can manipulate it in other software if they wish.

5. **Elaborate**
   a. If your students still have access to their SPIKE Prime Sets, have them complete the tasks from the SPIKE App, to elaborate with hands-on learning, for example:
   b. Challenge your students to create their own paths. Ask them to create paths that include a flat surface, and upward and downward slopes.
   c. Have them trace what they think the graph of the motor's power consumption will look like. Then ask them to run their bike along the path to see if they were right.
   d. If your students don't have access to their sets, have them complete their Student Inventor Notebook, or assign one of the extension activities suggested below. Most of the extension activities can be done using the data collected during the hands-on session.
   e. Facilitate a sharing session in which your students exchange their thoughts and results of this experiment. This can be done using whichever method/tool is most efficient (i.e., in-person or online).

6. **Evaluate**
   a. Give feedback on each student's performance.

**Activity #4: Cleanup and Discussion**

**Estimated Time:** 15 minutes

**Title:** Clean-up and Closing Discussion

**Lesson Overview:** Have students reflect on the challenges real transportation engineers face on a daily basis.

**Learning Objectives:**
The students will be able to …
1. summarize the engineering process based on their activists.
2. state what is Potential and Kinetic Energy from reviewing and applying throughout their activities.

**TEKS:**
1. **S6.2(D)**

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

**Technology Standards:**
1. STEL-8J
2. STEL-2M
3. STEL-8L

**Lesson Flow:**
1. What's a prototype?
2. What's the benefit of having multiple options for a solution?
3. How do you usually generate ideas before prototyping them?
4. Have you ever prototyped an idea? How did you do it?
5. Have a discussion about the challenges real engineers would face if they encountered a situation as in the last activity, and other possible solutions they might come up with to solve this situation.
6. Make sure students count and put all materials back in the box and Lego parts are not misplaced, left behind, or missing.
Day 3: Training Camp

Day Overview: The students will be able to explore the history of trains and the wheel and axle. The students will use the Spike Prime Kit and explore the parts that make it work such as motors, sensors, hubs, ports, and iPads—incorporating the engineering design process, to complete the first lesson, the Training Camp 1. Then, the students will work on Training Camp 2 for the second part of the day where they will implement sensors to control motors and interact with objects. The students will end the day by applying the Engineering Design Process through A Robotic Challenge, Students will build a Driving Base and write programs using the color sensor to make the driving base autonomous.

Activity #1 The Wheel and Axle

Title: History of Trains and exploring the wheel and axle
Estimated Time: 30-45 minutes
Lesson Overview: The Students will analyze the history of trains and explore the function of the wheel and axle on a train
Learning Objectives:
The students will be able to …
1. develop the method and concept of Wheel and Axle Assembly, as well as the critical role of forklifts in performing maintenance on railways and train wheels.
2. listen to the safety procedures in preparation for the high bay tour.
3. compare the difference between the two wheels and the significance of the shape using the cups.

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

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

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

Materials needed:
1. 4 cups
2. tape
3. 2 meter sticks

Lesson Flow:
1. Tape 2 cups together to form the 2 sets of wheels.
2. Set up the two yard sticks into an inclined plane and tape them in place.

![Image of cups taped together]

3. Place your cups (wheels) at the top and let it drop.

**Discussion Questions:**

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

---

**Activity #2: Training Camp 1**

**Title:** Training Camp 1  
**Estimated Time:** 60-90 minutes  
**Lesson Overview:** Students will build a Practice Driving Base and make precise and controlled movements.

**Learning Objectives:**
The student will be able to …
1. create a practice Driving Base, making precise, and controlled movements using the Spike Prime Kit.
2. construct a code that programs the robot to move it to a designated spot with the Spike Prime Kit.

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

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

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

**Materials needed:** (per group)
1. LEGO® Spike Prime Robotics kit manual
2. LEGO® Spike Prime Robotics kit
3. iPad
4. LEGO® Spike Prime software installed on the iPad
5. Journal (per group)

**Lesson Flow:**
1. **Prepare:** Read through the student material in the LEGO® Education SPIKE™ Using Day 3 powerpoint, this will help familiarize your students with LEGO® Education SPIKE™ Prime.
2. **Engage:** Use the ideas in the Ignite a Discussion section below to engage your students in a discussion related to this lesson. Use the video to explain the lesson.
3. **Explore:** Have your students work in pairs to build the Practice Driving Base model. Give them some time to use the programming stacks provided to explore the movement of the Driving Base. Ask them to change the values and parameters of the blocks and to observe the effects.
4. **Explain:** Facilitate a discussion about the importance of planning each step of their program. Explain what pseudocode is and how it can help in their program planning.
5. **Elaborate:** Have your students find a way to move their Driving Base in a square. Set up a navigation challenge and encourage your students to test their skills. Don't forget to leave some time for cleanup.
6. **Evaluate:** Give feedback on each student's performance. You can use the assessment rubrics provided to simplify the process.
7. **Ignite a Discussion:** Navigating through obstacles in robotics competition fields is a key to success. Engage your students in a discussion by asking them to: Describe a field tactic associated with their favorite sport. List all the movements they think their Driving Base should be able to perform.
Activity #3: Training Camp 2

Title: Training Camp 2

Estimated Time: 60-90 minutes

Lesson Overview: Students will use sensors to control motors and interact with objects on the competition field.

Learning Objectives:
The students will be able to …

1. apply the Engineering Design Process through a Robotic Challenge.
2. create a Driving Base with sensors to control motors and interact with objects on the competition field.
3. invent a code that challenges the student’s bot to maneuver itself and the object throughout the Robotic challenge.
4. create a practice Driving Base and make precise and controlled movements.
5. operate on their knowledge of how engineers work in teams to achieve goals.
6. show the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
7. choose their assigned tasks based on the goals and needs of a team.

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

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

Technology Standards:
1. STEL-1J
2. STEL-7T
3. STEL-7U
4. STEL-8J
5. STEL-8L

Materials needed: (per group)
1. One spike Prime Robotic Kit Manual
2. LEGO® Spike Prime Robotics kit
3. iPad
4. Spike Prime software installed on the iPad

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

**Activity #4: Training Camp 3**

**Title:** Training Camp 3  
**Estimated Time:** 60-90 minutes  
**Lesson Overview:** Students will write programs using the Color Sensor to make the Driving Base autonomous.  
**Learning Objectives:**  
The students will be able to …  
1. apply the engineering design process by creating a Driving Base and writing programs using the color sensor to make the driving base autonomous.
2. use the Engineering Design Process through A Robotic Challenge.
3. operate on their knowledge of how engineers work in teams to achieve goals.
4. show the importance of each member's role and functions, given the student assigns/follows their role throughout their challenge.
5. choose to assign tasks based on the goals and needs of a team.

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

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

Technology Standards:
1. STEL-1J
2. STEL-1M
3. STEL-2Q
4. STEL-8L

Materials needed: (per group)
1. LEGO® Spike Prime Robotics Kit Manual
2. LEGO® Spike Prime Robotics kit
3. iPad
4. LEGO® Spike Prime software installed on the iPad
5. Journal (per group)

Lesson Flow:
1. Prepare: Read through the student material in the LEGO® Education SPIKE™ App. You'll need a thick black line on a white or light surface for this lesson. Draw a black line on a sheet of white paper. Use electrical tape on a light surface Print out the "line ideas" PDF Use a spare black axle element from the LEGO SPIKE Core Set.
2. Engage: Use the ideas in the Ignite a Discussion section below to engage your students in a discussion related to this lesson. Use the video to explain the lesson.
3. Explore: Have your students work in pairs to build the Driving Base with a Color Sensor. Ask them to play the first programming stack to get their Practice Driving Base to move forward and stop perpendicular to a black line. Have them try the second programming stack and describe what happens.
4. Explain: Facilitate a discussion about how the Color Sensor detects the black line.
5. Elaborate: Have your students work through the next program to get their Driving Base to follow a black line. Ask them to optimize this code to create an even better line-follower program.
6. Evaluate: Give feedback on each student's performance.
7. **Ignite a Discussion:** Use these ideas to engage your students in a discussion about competition fields and the lines that are often part of them. Ask your students how they could use these lines to help make their Driving Base program more effective. Explain the different types of lines and intersections:
   a. Thin lines
   b. Right angles
   c. T-junction lines
   d. Non-continuous lines
   e. Black lines cut by a colored line
   f. Create a Maze

---

**Day 4: Rail Flaw Detection**

**Day Overview:** Today, students will be escorted to the University of Texas Rio Grande Valley High Bay where they will be able to walk through various different stations where they will learn about the various different pieces of machinery and equipment which students use for the testing of bearings on the wheel and axle of trains. When students finish their tour, they will return to their respective classrooms to finish working on their build from the previous instructional day. They will refine both the build and the coding to maximize their efficiency in moving an obstruction.

**Activity #1: Visit to the High Bay**

**Title:** Visit to the High Bay  
**Estimated Time:** 60 minutes

**Lesson Overview:**
1. Field Trip to University of Texas Rio Grande Valley - Center for Railway Safety and High Bay Manufacturing facility
2. Tour of facility, Interview of the Assistant Dean Mechanical Engineer Dr. Tarawneh who spearheads Center for Railway Safety, as well as student engineers who work in the facility

**Learning Objectives:**
The students will be able to …
1. Identify what Engineering High Bay is before heading to the tour.
2. Analyze the various machinery and equipment associated with Engineering High Bay.
3. Apply their understanding of engineering fields as they relate to other career fields.

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

**NGSS:**
Technology Standards:
1. STEL-1K
2. STEL-1L
3. STEL-2M
4. STEL-2N
5. STEL-2R
6. STEL-2S
7. STEL-3E
8. STEL-3G
9. STEL-5F

Materials needed: (per person)
1. Personal Protective Equipment (if instructed)
2. Proper lab attire (close toed shoes, jeans)

Lesson Flow:
1. Students will explore the High Bay and become acquainted with a lot of the equipment used at the University of Texas Rio Grande Valley by engineering students and staff
2. Students will tour several stations where they will get the opportunity to ask questions that pertain to engineering and railway safety to students and the appropriate staff
3. Ask students:
   a. How many of you know what you want to study in college?
   b. How many of you want to be an engineer?
   c. In what fields do you think engineers need to collaborate?
   d. How do you think engineering is important to other career fields?
4. Discuss why it is helpful to start exploring higher education and career options from a young age

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

Title: Build and Program a Robot with Ultrasonic Sensor
Estimated Time: 60 minutes
Lesson Overview: Students will build a robot with an ultrasonic sensor attachment as well as create, test, and run programs created to control their robot. Students will also watch a series of videos depicting incidents where the importance of Train Track Maintenance with Ultrasonic sensors was crucial as they are introduced to the sensors via a follow-up discussion

Learning Objectives:
The students will be able to …
   1. apply problem-solving skills to create, test, and run programs created to control a robot.
2. judge their build by identifying errors and implementing the engineering design process to correct them.

TEKS:
1. S5.7(A)
2. S6.7(C)
3. S7.7(A)
4. S7.7(D)
5. M7.3(A)
6. M7.3(B)
7. M7.4(B)
8. M7.4(E)

NGSS:
1. MS-ETS1-2
2. MS-ETS1-3

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

Materials needed: (per group)
- LEGO® Spike Prime Robotics kit manual
- LEGO® Spike Prime Robotics kit
- iPad
- LEGO® Spike Prime software installed on the iPad
- Journal (per group)
- Writing utensil (pen or pencil)

Lesson Flow:
1. Watch video on the importance of train track maintenance
2. Watch video on the importance of rail flaw detection using ultrasonic sensors
3. As a class, discuss the similarities between echolocation used in bats and the function of an
ultrasonic sensor
4. Discuss the importance of ultrasonic sensors as it relates to railway safety
5. Use the iPad with the Spike Prime tutorial to build a robot with the ultrasonic sensor attachment
6. Show the wall that students must program their robot to move to until it is 20 cm away from it
7. Have the students edit the code to alter variables like the movement speed, direction, and others that will determine the accuracy of their robot stopping 20 cm from the wall.
8. Students will place all of their bots in a central location and test them altogether to see if the robots avoid each other or collide.
9. Students will be calculating their average speed throughout the course of their programming

**Activity #3: The Claw**

**Title:** The Claw

**Estimated Time:** 30 minutes

**Lesson Overview:** Teams will build a robot with a claw and ultrasonic sensor that will serve to remove and relocate an obstruction

**Learning Objectives:**
- The students will be able to …
  1. create a robot and apply a specific code to complete a specific task.
  2. analyze the values for each piece of code that will allow the robot to traverse through a small course with an obstruction successfully.

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

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

**Technology Standards:**
1. STEL-1J
2. STEL-5G
3. STEL-7Q
4. STEL-7R
5. STEL-7T
6. STEL-7U
7. STEL-8J
Materials needed: (per group)

1. LEGO® Spike Prime Robotics kit manual
2. LEGO® Spike Prime Robotics kit
3. iPad
4. LEGO® Spike Prime software installed on the iPad
5. Journal (per group)
6. Writing utensil (pen or pencil)

Lesson Flow:
1. Direct students to the appropriate build on their iPads
2. Have students build their robot as well as the accompanying parts that will aid in a later challenge
3. Tape the track on the floor next to each group
4. Familiarize students with the correct coding sequence as to allow for a successful completion of the coming challenge

Activity #4: Remove and Relocate an Obstruction

Title: Remove and Relocate an Obstruction

Estimated Time: 45 minutes

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

Learning Objectives:
The students will be able to …
1. modify the code for their robot to allow for traversing of a track and movement of an obstacle.

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

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

Technology Standards:
1. STEL-1J
2. STEL-5G
Materials needed: (per group)

1. LEGO® Spike Prime Robotics kit manual
2. LEGO® Spike Prime Robotics kit
3. iPad
4. LEGO® Spike Prime software installed on the iPad
5. Journal (per group)
6. Writing utensil (pen or pencil)

Lesson Flow:

1. Guide students to correct any mistakes on their robot build
2. Mark the track on the floor for each group using masking tape
3. Provide examples on how to code for the robot’s movement, claw movement, and how to piece the code together to allow for successful relocation of the obstruction
4. Students may be guided to have their builds traverse a more difficult course if the simple one proves undemanding
5. Students will be calculating the average speed of their design as it traverses the course

Day 5: Railway Safety Cargo Delivery Race

Day Overview: Today's primary activity involved a hands-on engineering challenge where student teams used LEGO® Spike Prime Robotics kits to design and program a cargo delivery system. This system needed to pick up a wheel and axle, deliver them to a designated point, and return to the starting point without derailments. Following the Cargo Delivery Races, students engaged in a reflective discussion on the real-world challenges faced by transportation engineers. The session concluded with a review of key concepts and a clean-up activity.

Activity #1: Cargo Delivery Races

Estimated Time: 90 Min

Lesson Overview: Teams will use their creativity and the knowledge of engineering and programming in a freestyle design challenge to solve railway transportation issues.

Learning Objectives:
The students will be able to …

1. examine Cargo and Freight Trains from their final challenge.
2. review the Final Challenge Rules and Expectations.
3. plan to begin the Final Challenge by editing and making final changes to the robot and the code.

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

NGSS:
1. PS2-1
2. PS2-2

Technology Standards:
1. EST1-2
2. ETS1-3

Materials needed: (per group)
1. LEGO® Spike Prime Robotics kit robotics kit
2. LEGO® Spike Prime Robotics kit manual
3. Laptop or iPad
4. LEGO® Spike Prime software installed on the laptop
5. Meter stick
6. Black masking tape or vinyl electrical tape to delineate the challenge course
7. Journal (per group)

Lesson Flow:
1. Design a lift that will pick up a wheel and axle using the same driving base. (you may use building instructions from other lessons)
2. The objective is to pick up cargo, drop it off and return to the original starting point safely. No derailments.(stay on the path)
3. Use what you have learned throughout the week.
4. Remember to follow the Engineering Design Process.
5. Have students come up with
6. Begin Challenge: Remember, the Train that delivers the axle and returns to start the quickest win.

Activity #2: Clean Up and Closing Discussion

Title: Clean up & Closing
Estimated Time: 20 Min
Lesson Overview: Have students reflect on the challenges real transportation engineers face on a daily basis.

Learning Objectives:
The students will be able to …
1. review learning and applying practices to real life.

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

NGSS:
1. ETS1-1
2. ETSA-4

Technology Standards:
1. EST1-2
2. EST1-3

Materials needed: N/A

Lesson Flow:
1. Have a discussion about the challenges real engineers would face in the last activity, and the possible solutions they might have derived.
2. Concept review
   a. What are you measuring?
   b. Units for distance?
   c. Units for time?
   d. Units for speed?
   e. After the challenge, we will review the time each group took to get from one end to the other.
   f. What are some coding or other challenges you faced?
3. Closing Discussion
   a. How was today’s challenge applicable to Railway Engineering?
   b. What are some challenges real engineers face?
   c. What are some of your team’s strengths and weaknesses?
4. Make sure students count and put all materials back in the box and Lego parts are not misplaced, left behind, or missing
5. Announce the winning team, and let them know that they will be advancing to an overall competition (if there is an overall competition). Otherwise, announce the 1st, 2nd, and 3rd place winners.
6. Clean Up

Make sure students:
1. Look around the floor
2. Count, and put all materials back in the box
3. Ensure no Lego parts are missing, misplaced, or left behind.

End of Day 5
Appendices

Appendix A:

Calculating Speed
Hot Wheels

Formula: Speed(s) = Distance(d) / Time(t)

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

<table>
<thead>
<tr>
<th>Trial</th>
<th>Height</th>
<th>Distance (ft)</th>
<th>Time (s)</th>
<th>Speed (ft/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5 meter</td>
<td>13.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 meter</td>
<td>13.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.5 meter</td>
<td>13.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Try out your model
- Calculate the speed of your Hot Wheels
- Use the following:
  - Distance (measure your track).
  - Time (Use your phone to keep the time in seconds).
  - Speed (Use the provided formula to calculate the speed of the hot wheel).

Show your knowledge!!!
Identity in which trial is potential energy the highest? Explain why?
________________________________________________________________________
________________________________________________________________________
Calculating Speed Of a Balloon

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

\( d = \text{Distance (ft)} \)
\( t = \text{Time (seconds)} \)
\( s = \text{Speed (ft/s)} \)

<table>
<thead>
<tr>
<th>Distance (ft)</th>
<th>÷</th>
<th>Time (s)</th>
<th>=</th>
<th>Speed (ft/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>15 FEET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Try out your model
- Calculate Speed of your balloon
- Use the following:
  - Distance (15 feet).
  - Time (Use your phone to keep the time in seconds).
  - Speed (Use the provided formula to calculate the speed of the balloon).

Show your knowledge!!!

Identity which trial had the fastest speed? Explain why?

_________________________
_________________________
Appendix B:

Appendix C:
References


Resources. lead4ward. (2024, June). https://lead4ward.com/resources/


