UNIVERSITY TRANSPORTATION CENTER FOR

RAILWAY SAFETY

Day 1

WELCOME ABOARD!

UTRio Grande Valley

Housekeeping Rules

Safety and **respect** is our priority, please adhere to the following rules so that we can have a fun and engaging experience.

Must wear designated shirt every day.

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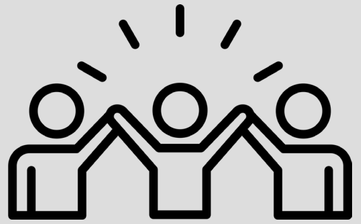
Use of electronic devices is only for instructional purposes.



Be active, engaged, and participate in your group.

- 30 second silent observation
- What do you see?
- What do you think the focus of this camp is?
- What do you wonder about what is in store for the week?

I see... I think... I wonder...

Goals and Objectives

- Understand how engineers work in teams to achieve a common goal
- Learn about the different containers on trains
- Explore and practice the engineering design process

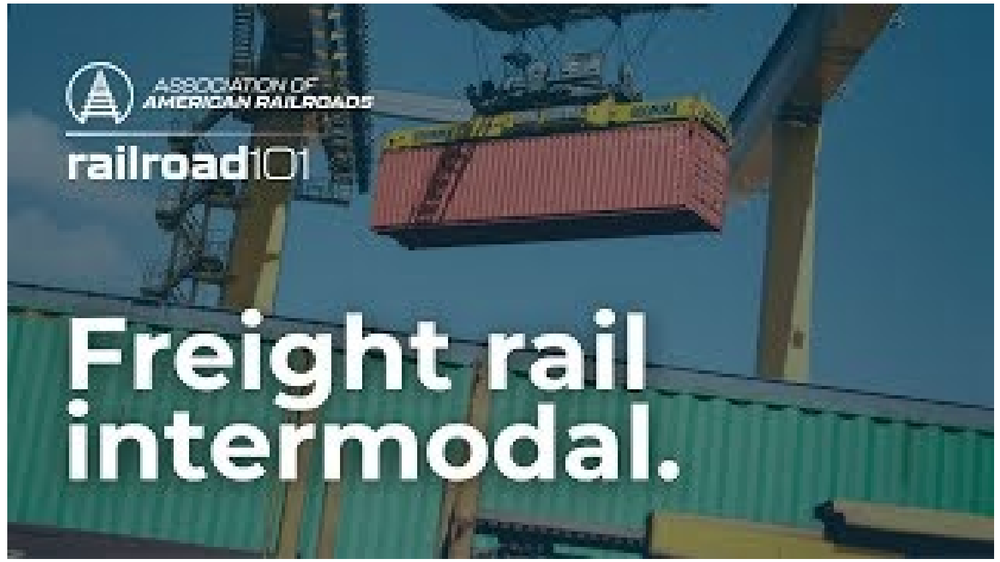
Railway Systems 101

Intro to Locomotive Science

01 How do trains help move freight?

02 Why use trains instead of just trucks?

03 What are some innovative tools that enhance train operations?



https://youtu.be/qU-_otA075A

Cargo Containers Types

Dry Container

(Box Containers)
Carry clothes, toys, books, tools and things that don't need to be cold.

Refrigerated

(Reefers) Carry food like fruits, veggies, meat or medicine that must stay cold.

Tank

Carry liquids like milk, oil or chemicals, think of it like a soda on wheels!

Conductors in Training

Team Huddle & Collaboration Lab

Team Building Activity

https://www.windsorcharteracademy.org/cup-stacking-tournament

01 10-15 cups

02 1 Rubber band

03 4-6 yarn strings

Let's Reflect...

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 does this activity demonstrate how to work in a team?

What is Engineering?

Think, Pair, Share

Engineering Is…

- **Engineering** is the application of science and mathematics to improve society.
- Engineers exist to **design** , **construct** , **operate** , or **maintain systems** and devices that drive our society, making them as effective and efficient as possible.
- **Bottom line:** Engineering is problem solving.

Characteristics of Engineering:

- Strong STEM background
- Effective communication
- Effective Listening Skills
- Creativity
- Team Player
- Problem Solver

Trackside Theory 121

Engineering Principles in Action

Engineering Design

https://yes.mos.org/impact/engineering-design-process/

Signals and Systems 131

Robotics and Code Lab

Engineering Roles

- Lead Engineer (communicates with teacher)
- Systems Engineer (iPad)
- Mechanical Engineer (keeps parts organized)
- Mechatronics Engineer (builder)

Please find this icon on your iPad.

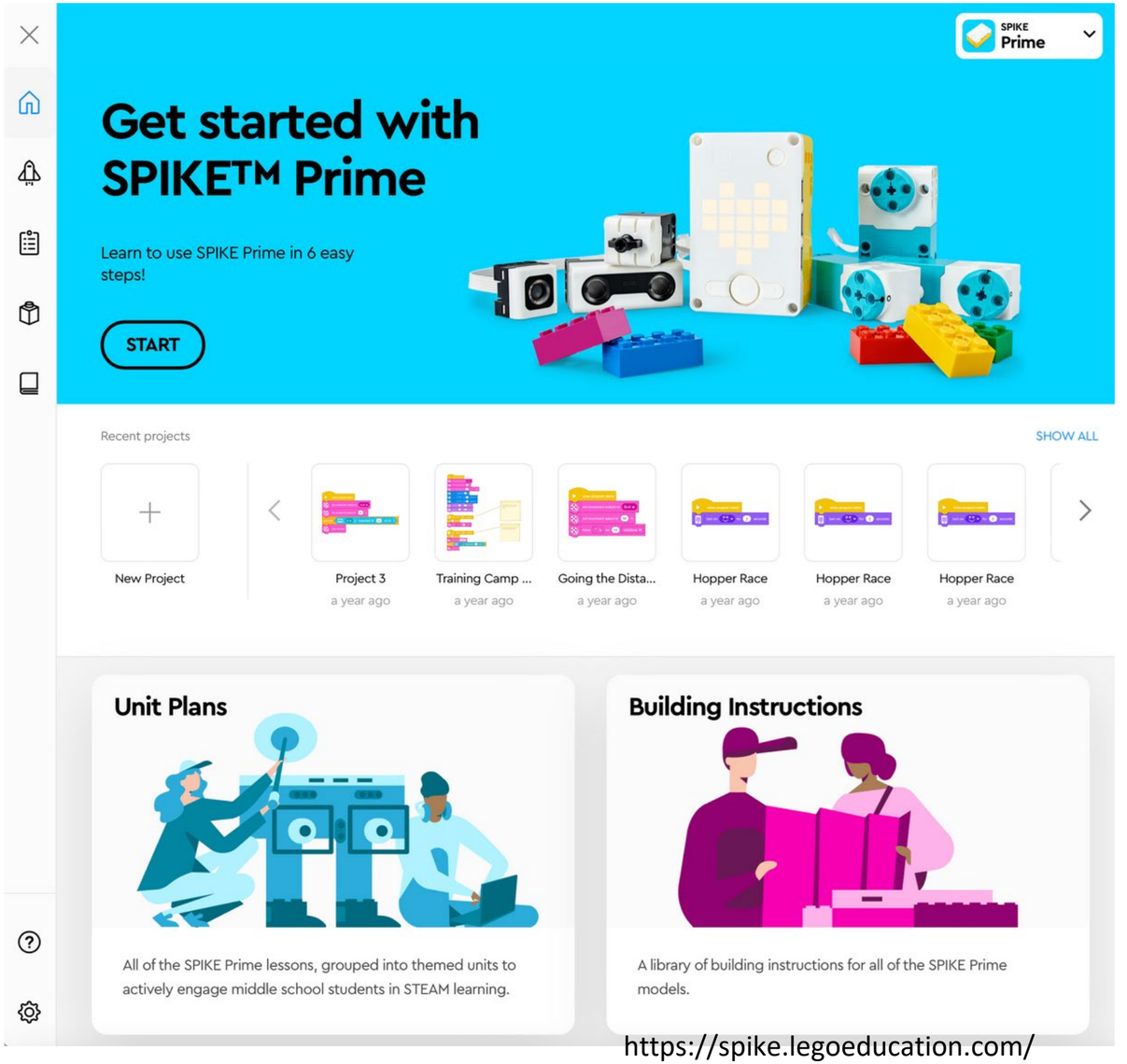
https://spike.legoeducation.com/

Select your SPIKE™ solution

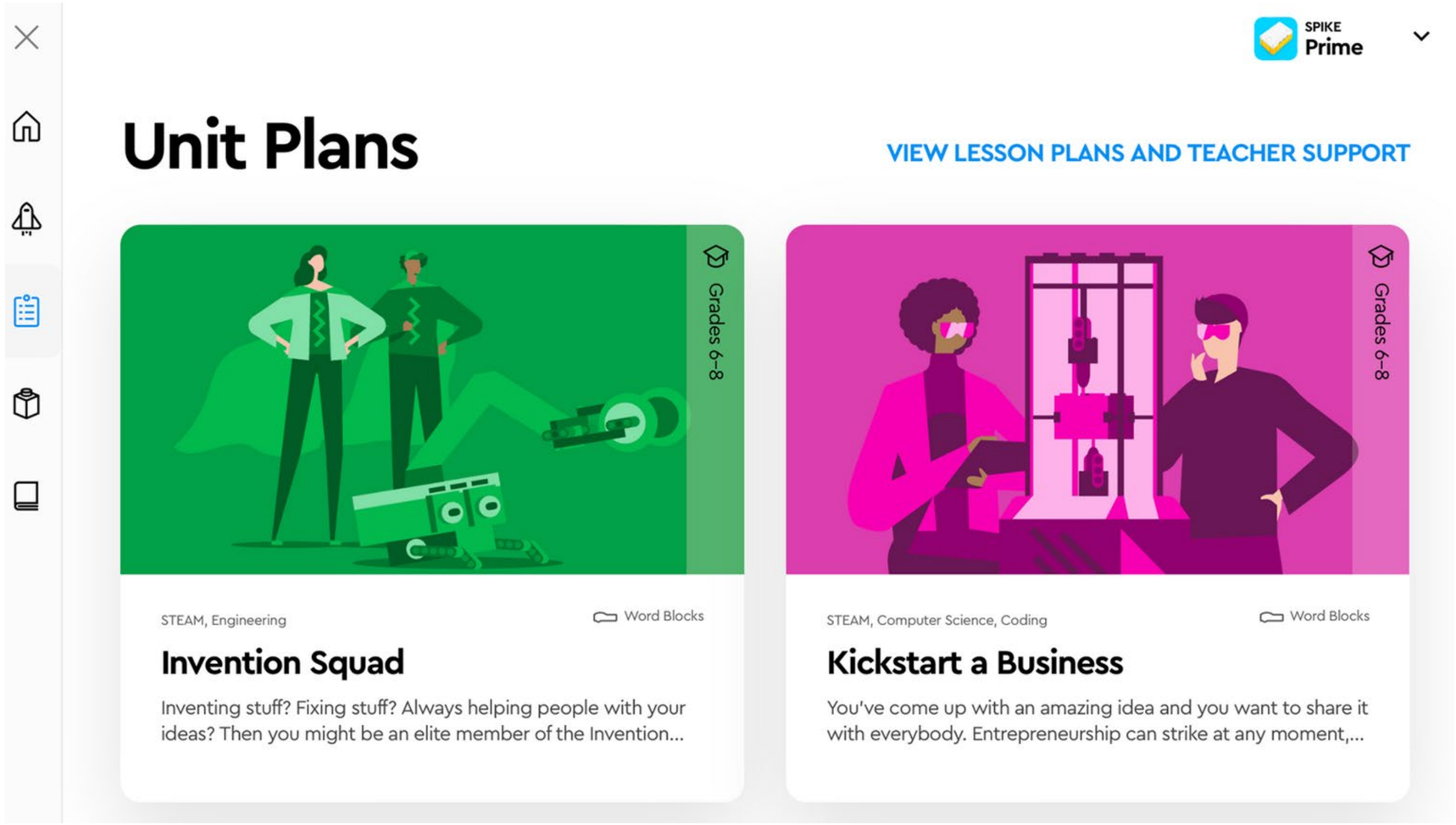
SPIKE Essential ›

SPIKE Prime ›

LEGO education https://spike.legoeducation.com/



https://spike.legoeducation.com/



https://spike.legoeducation.com/

Hopper Race

Creating prototypes

START

30–45 min.

> MORE

https://spike.legoeducation.com/

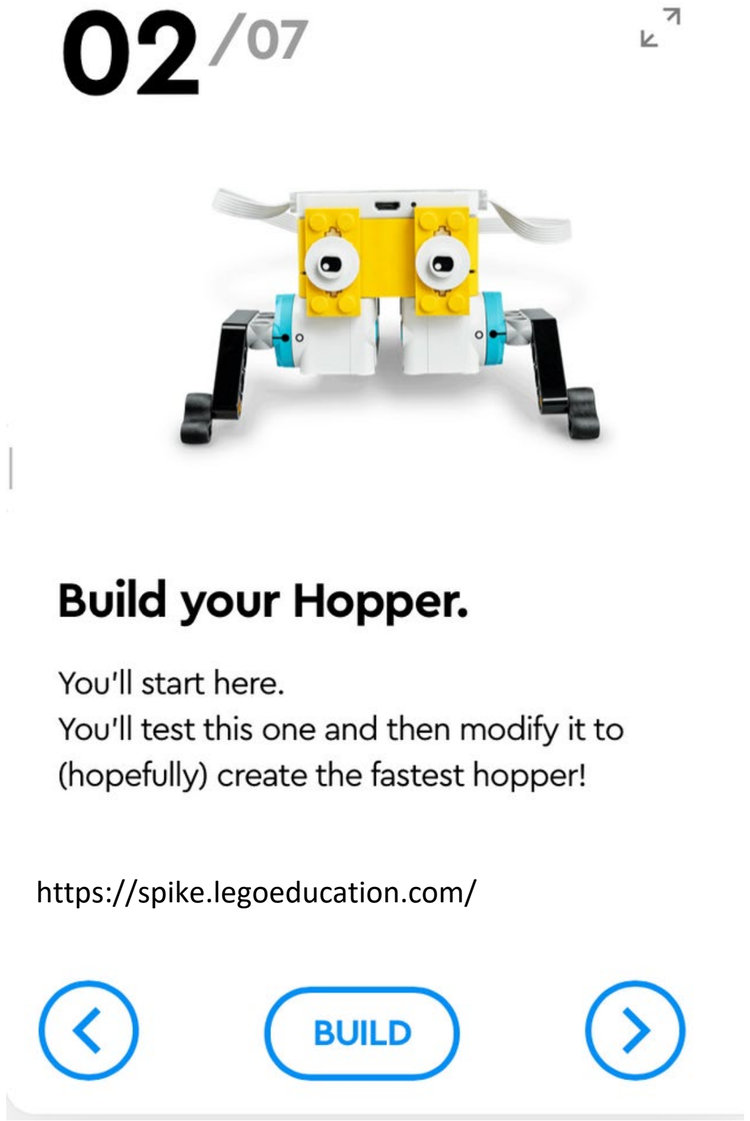
Based on the video, what do you think we are going to be doing?

A Hopper Race!

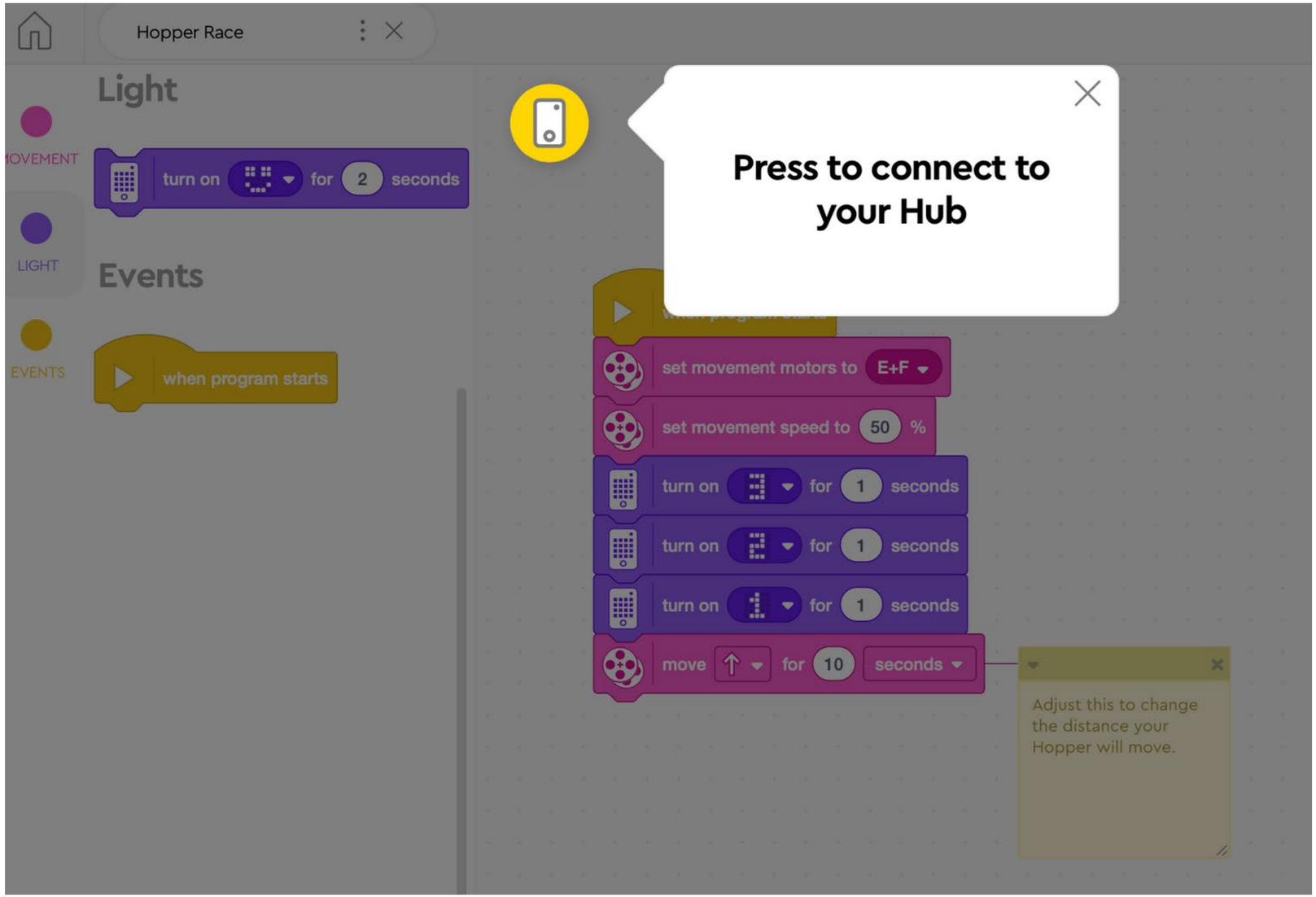
https://spike.legoeducation.com/

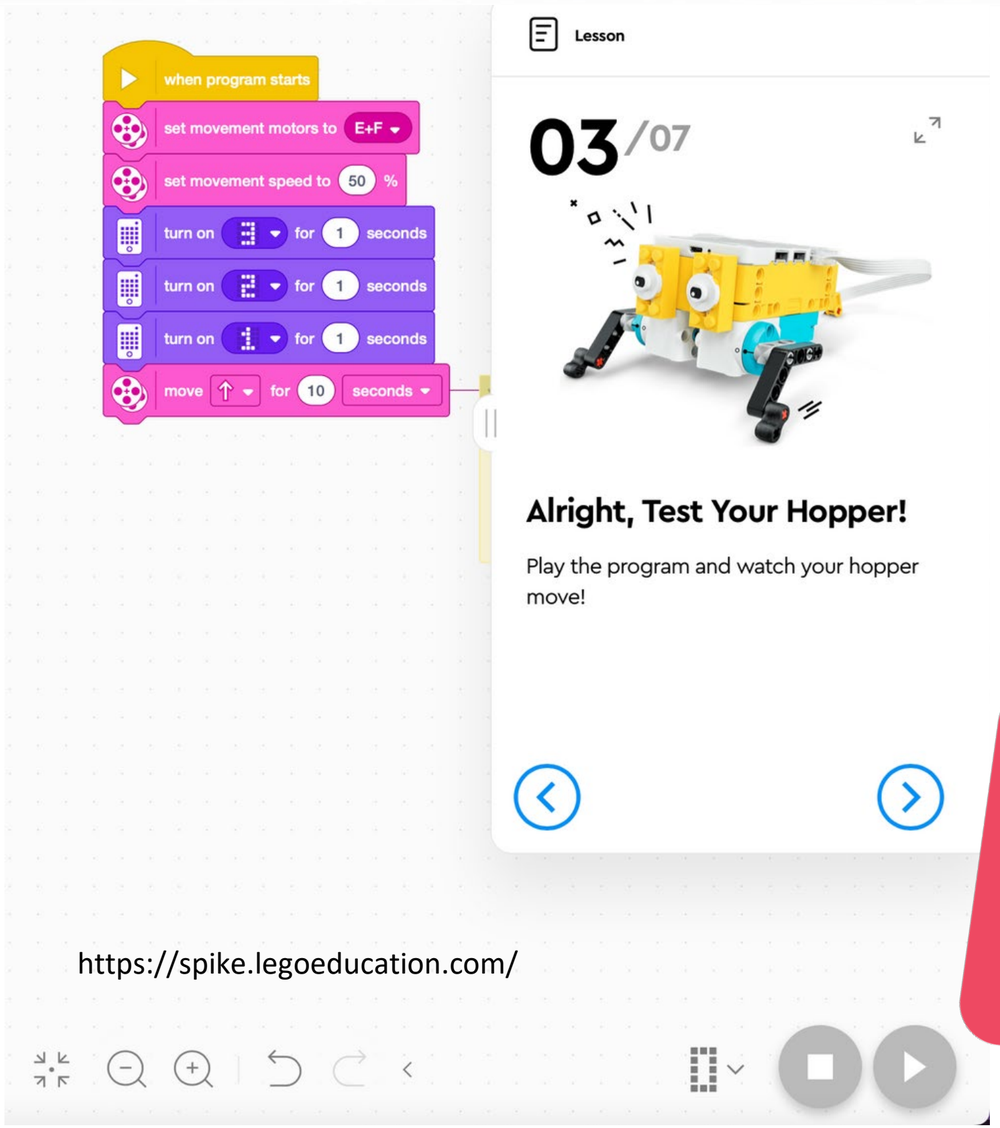
Click Build and follow the instructions!

(No modifications, only Hopper.)



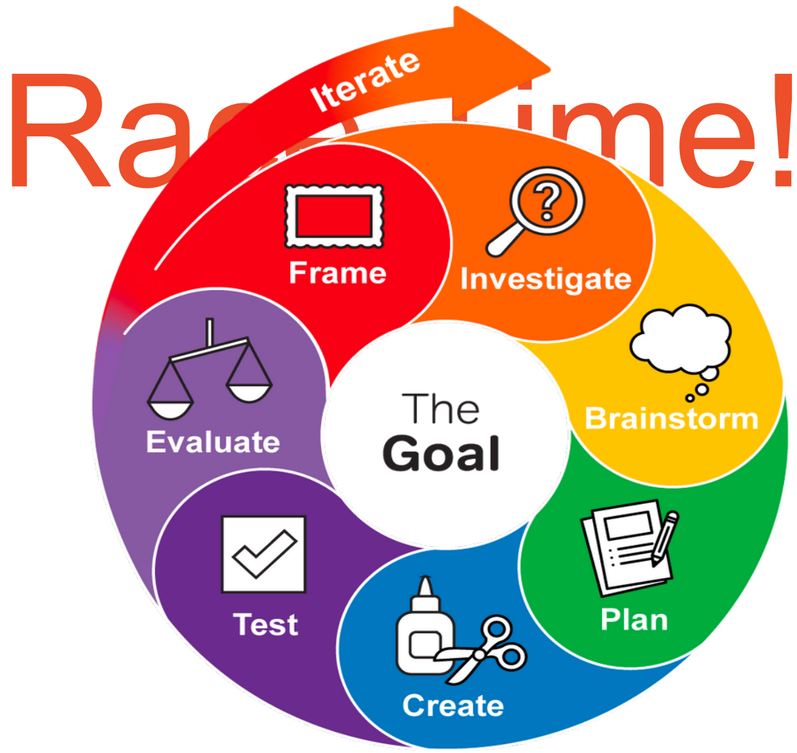
Follow on screen directions.





https://spike.legoeducation.com/

Ra[illegible]me!



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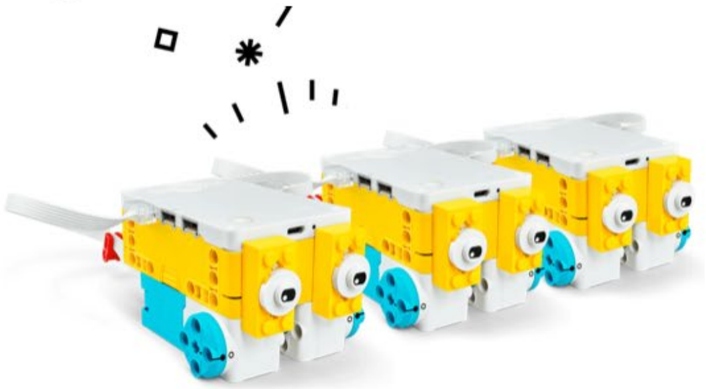
06/07



On your mark, get set, go!

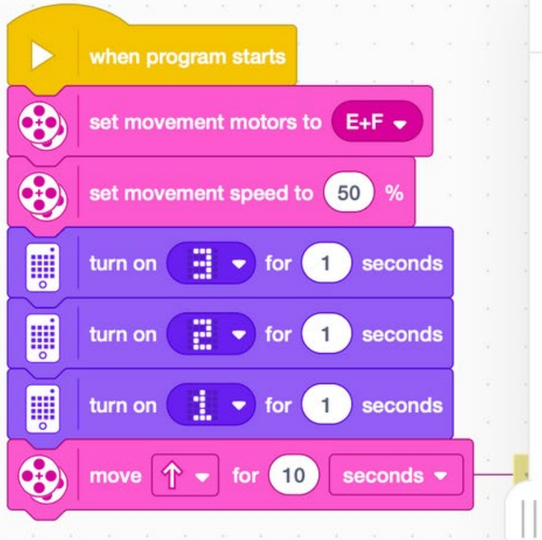
Which team built the fastest legs? Explain the mechanics of your prototype.

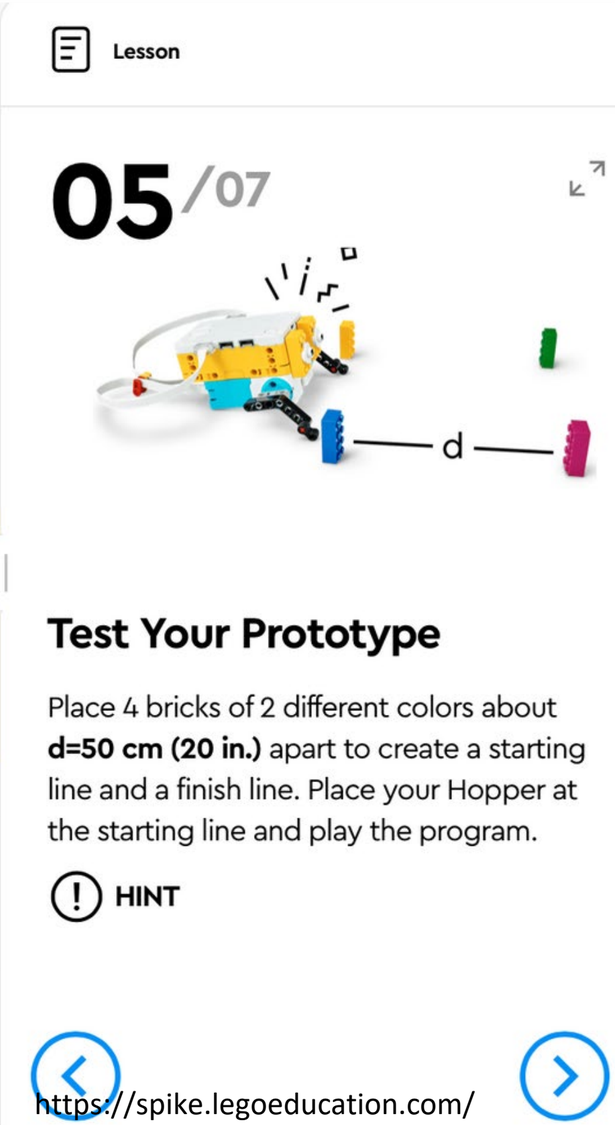
HINT

https://spike.legoeducation.com/

https://yes.mos.org/impact/engineering-design-process/

Iterate





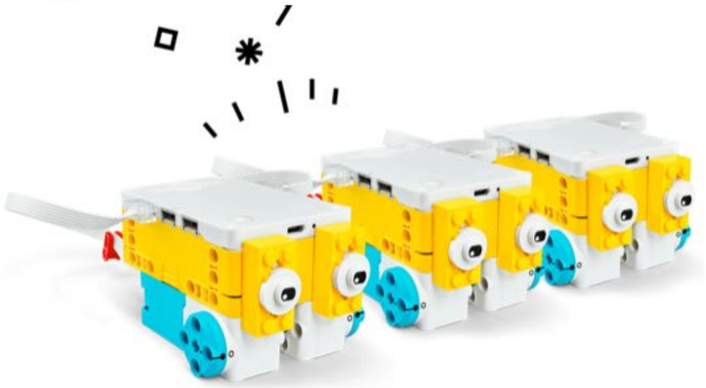
https://spike.legoeducation.com/

Test out your design, document your observations, and as a team, decide if you would like to make any improvements. **(without wheels.)**

Race Time!

https://yes.mos.org/impact/engineering-design-process/

06/07



On your mark, get set, go!

Which team built the fastest legs? Explain the mechanics of your prototype.

HINT

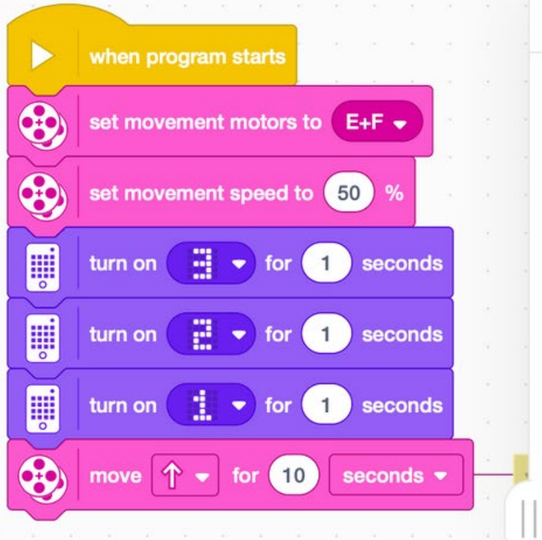
https://spike.legoeducation.com/

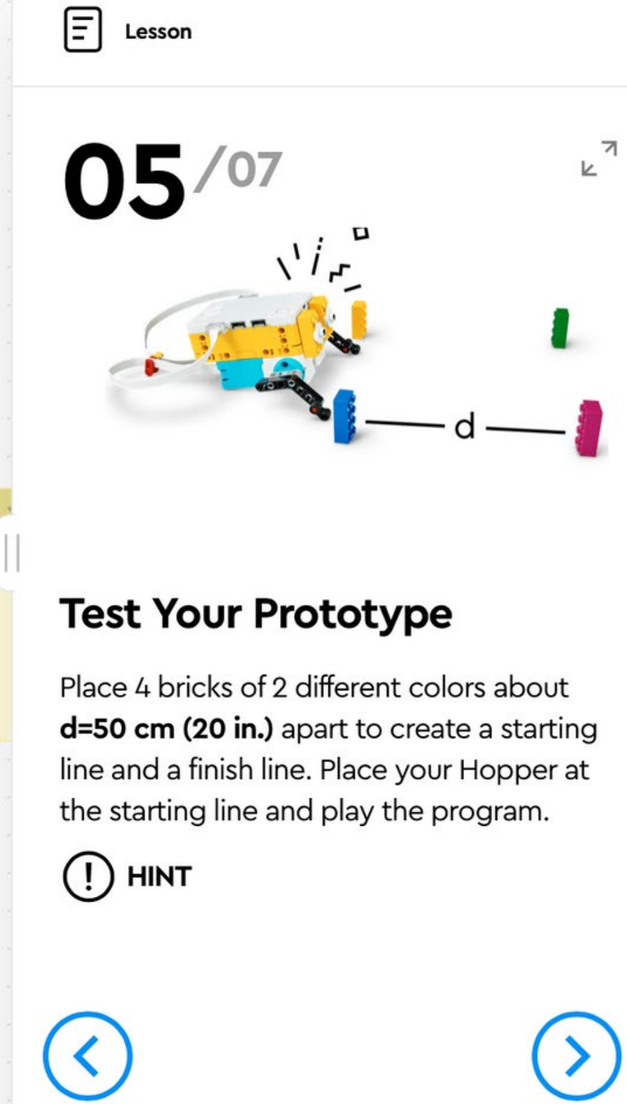
Observations

- Did your robot navigate effectively?
- What improvements would you consider incorporating into your design?

Iterate

Test out your design, document your observations, and as a team, decide if you would like to make any improvements. **(You can now add wheels.)**





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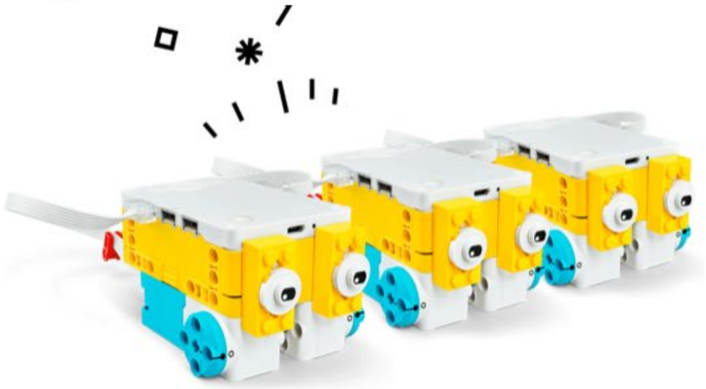

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Which team built the fastest legs? Explain the mechanics of your prototype.

HINT

https://spike.legoeducation.com/

Innovation Depot 141

Engineering Design Challenge

Scenario

Challenge: Transporting Cargo

Apple is tasked with transporting 1,000 new iPhones and watches over 1,000 miles. They are seeking to hire a new transportation company and are currently conducting live trials. Will your company secure the contract?

Task

Challenger Transport Cargo

- To gauge the distance you will be traveling, we will utilize a meter stick.
- A meter stick measures 1000 millimeters (mm).

Conversion Facts:

- 1 meter = 1000 mm
- For today's activity, 1 mm will represent 1 mile.

Equivalents:

- 1 mm = 1 mi
- 1000 mm = 1,000 mi

Task

Develop a “train” designed to transport this technology securely and efficiently.

Final Stop

Debrief, Clean Up, and Departure

Clean up and take apart Spikes.

Closing Discussion

1. How was today‘s challenge applicable to Railway Engineering?

2. What are some challenges engineers face?

3. What are some of your team’s strengths and weaknesses?

UNIVERSITY TRANSPORTATION CENTER FOR

RAILWAY SAFETY

Day 2

NEXT STOP: VAQUERO STATION

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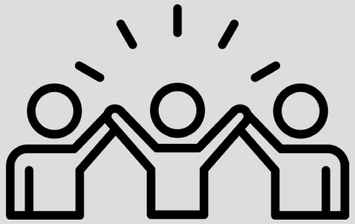


Be active, engaged, and participate in your group.

Goals and Objectives

- Understand how engineers work in teams to achieve a common goal.
- Learn about the different railroad classes
- Explore and practice the engineering design process.

Railway Systems 101

Intro to Locomotive Science

https://youtu.be/9poImReDFeY

01 What kinds of goods do freight trains commonly transport, and why are trains an efficient method for moving these items?

02 How do different railroads work together when cargo travels across the country or internationally?

03 What role do freight trains play in connecting ports, warehouses, and consumers across the world?

Business Classifications

(Class 1, 2, 3 Railroads)

These classifications are based on annual operating revenue, not on infrastructure or train speed.

Freight Rail Overview. (n.d.). FRA. https://railroads.dot.gov/rail-network-development/freight-rail-overview

Conductors in Training

Team Huddle &Collaboration Lab

Railroad FREIGHT Classes

Class 1: Are the largest, national railroad companies that move freight or passengers across long distances at a faster speed than Class 2 and Class 3. Ex: Union Pacific

Class 2: Are medium-sized regional railroads that connect towns or cities across one or more states. Ex: Florida East Coast Railway

Class 3: Also called short-line railroad, are small, local railroads that connect factories or towns to bigger railroad networks.
Ex: Hondo Railway in Texas

Class 1 Railroads

- BNSF Railway: Western and Central U.S
- Union Pacific Railroad: 23 states west of Chicago/New Orleans
- CSX Transportation: Eastern U.S Ontario, Quebec
- Norfolk Southern Railway: Eastern/Midwestern U.S
- Canadian National Railway (CN): Canada/Plus north-south U.S Routes
- Canadian Pacific Kansas City (CPKC): Canada-U.S-Mexico

Class 2 Railroads

21 active Class 2 Railroads

Alabama & Gulf Coast Railway (AGR) in the South,

- Transports forest products and industrial goods

Buffalo & Pittsburgh Railroad (BPRR) in Northeast,

- Specializes in coal and chemicals

Florida East Coast Railway (FEC) in Florida

- Transports intermodal containers and aggregates

Wisconsin & Southern Railroad (WSOR) in the Midwest

- Moves agricultural products like paper, and chemicals

Class 3 Railroads

- Nearly 500 Class 3 Railroads across the U.S
- Local connectors, where class 1 and 2 can’t reach.

Check Point

Class 1

01

- Major national freight railroads
- Operate across multiple states and even internationally
- Move massive volumes of cargo

Class 2

02

- Regional railroads
- Operate within a specific region
- Connect rural or mid-sized areas to Class 1
- Handle medium-distance freight

Class 3

03

- Short line & local railroads
- Often within cities or short rural stretches
- Serve vital role moving goods to and from Class 1 or Class 2 railroads

Check for Understanding

1. What is a key characteristic of a Class 1 Railroad?
2. Class 2 railroads are also known as what type of railroad?
3. Class 3 railroads are also known as?
4. Which type of railroads would you commonly find here in the RGV?

Trackside Theory 121

Engineering Principles in Action

Ramp Railways

Modeling Train Speed by Class

Track maintenance, signaling systems, and infrastructure determine what class I section qualifies for.

(note: this is different from the business classification of railroads like Class 1, 2, and 3 based on revenue).

https://rstrackinc.com/rail-maintenance/

Let's Reflect...

1. Which track class allowed for the fastest/smoothest trip?
2. Why do you think trains on Class 3 tracks move more slowly in real life?
3. What might be the risks of traveling too fast on lower-quality tracks?
4. How does infrastructure investment affect shipping times and safety?

Energies

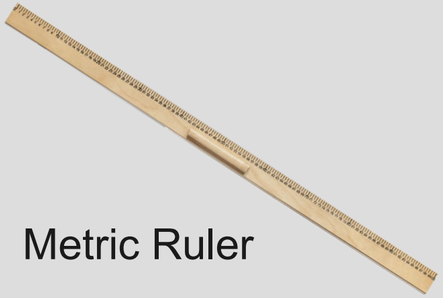
- **Potential energy** is stored energy due to position.
  - **Example:** The higher an object is, the more potential energy it has.

- **Kinetic energy** is energy in motion.
  - **Example:** The faster it moves and the heavier the object, the more kinetic energy it has.

Materials
Per Group

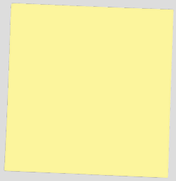
Hot Wheels Car

Ramps and Connectors



Metric Ruler

Stopwatch or timer



Sticky Notes label Class 1, 2, and 3

Recording sheet

Ramp Setup

Three ramp setups of different lengths and angles, labeled as:

Class 1

Smoothest, steepest, longest ramp (fastest/highest quality)

Class 2

Medium quality ramp

Class 3

Short, bumpy, or less inclined ramp (slowest/roughest track)

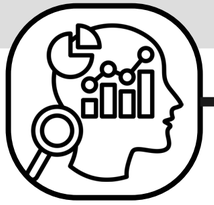
You will create a “Cargo Delivery Station” at the end of each ramp indicating how far the car travels.

Procedures

1. Create a model of a Class 3 railroad using only 5 tracks.
2. Create a model of a Class 2 railroad using 10 tracks.
3. Create a model of a Class 1 railroad using all tracks.

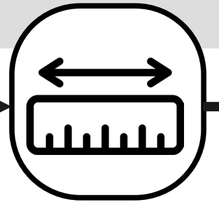
Challenge 1 - Model the 3 classes

Prediction
predict how far each car will travel on different “track classes.”



Launch
rolls their Hot Wheels car from the top of each ramp.

Measure
Record the distance traveled and/or time taken to reach the end.



Repeat
Test multiple times for each class and average the results.

Data Analysis
Compare how ramp angle/smoothness (infrastructure quality) influences speed/distance

Challenge 2 - Loop

Prediction

Can a hot wheel car travel through a loop?

Launch

Rolls their Hot Wheels car from a ramp with a loop included.

Measure

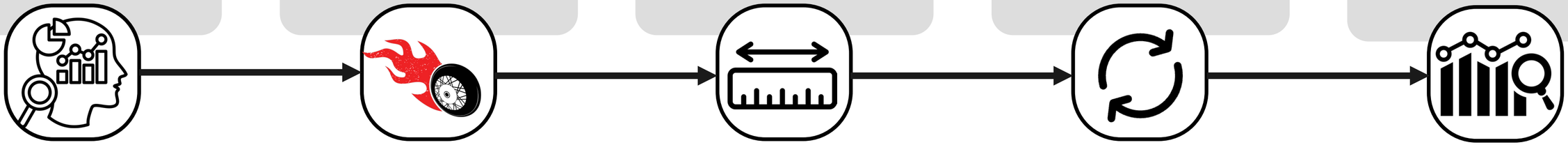
Record the distance traveled and/or time taken to reach the end.

Repeat

Test multiple times for each class and average the results.

Data Analysis

Compare how ramp angle/smoothness (infrastructure quality) influences speed/distance



Things to think about...

- What should be your starting point, and why?
- Ensure your car makes it through the loop.

https://www.istockphoto.com/vector/roller-coaster-in-flat-design-extreme-attraction-at-amusement-park-vector-gm2153923237-574829090?irclickid=yq7W86RfoxycRRiUK3Q6hQbnUkp31Q2K0Urf0o0&irgwc=1&cid=IS&utm_medium=affiliate_SP&utm_source=FreeImages&clickid=yq7W86RfoxycRRiUK3Q6hQbnUkp31Q2K0Urf0o0&utm_term=roller%20coaster&utm_campaign=srp_freeillustrations_top-thumbs&utm_content=270498&irpid=246195

Let's Reflect...

1. Where does the car experience the most potential energy?
2. What type of energy increases as the car goes down the ramp?
3. Why does the car need enough potential energy before it enters the loop?
4. What happens to the car's energy as it goes up the loop?

Signals and Systems 131

Robotics and Code Lab

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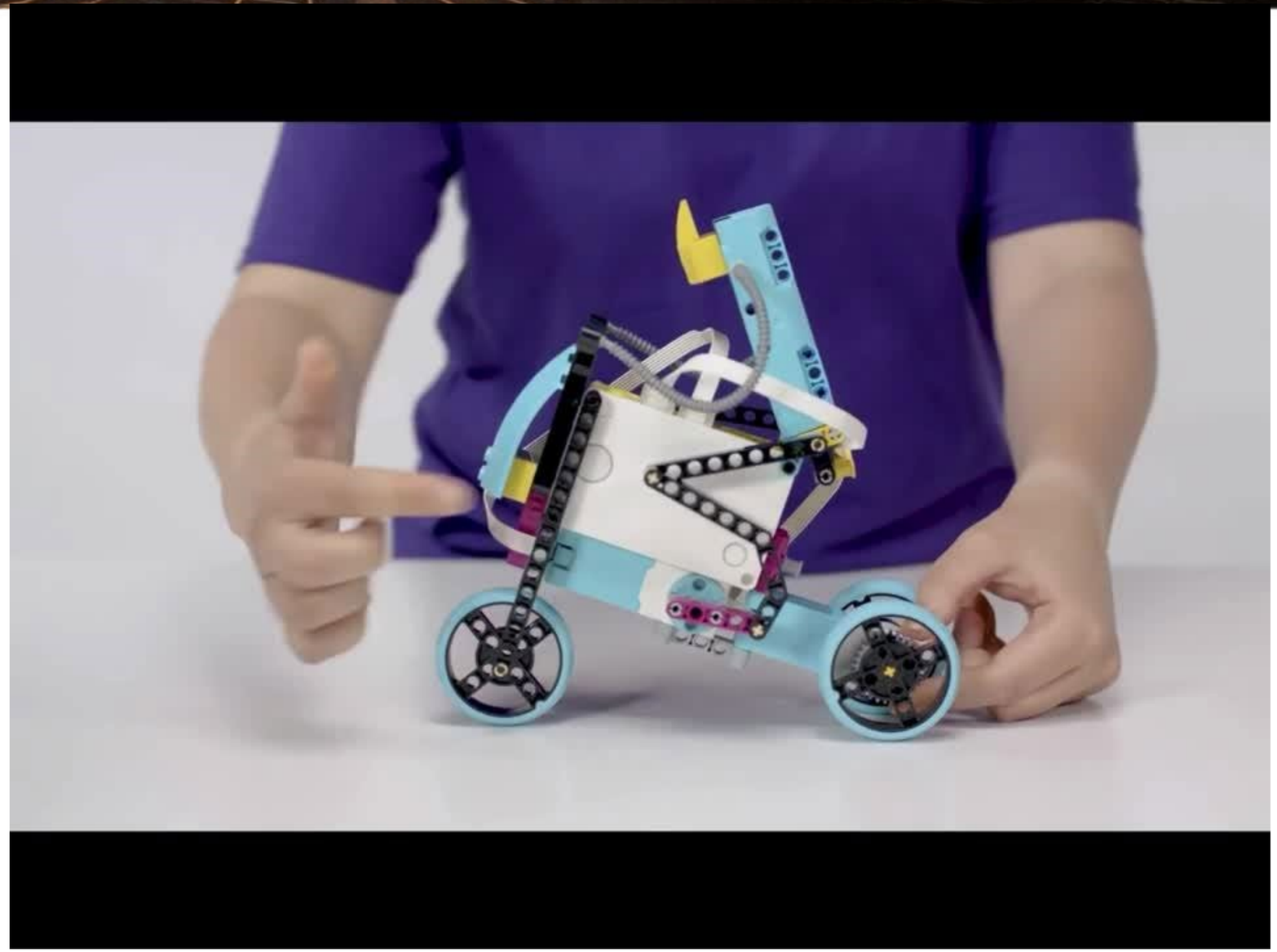

Engineering Roles

- Lead Engineer (communicates with teacher)
- Systems Engineer (iPad)
- Mechanical Engineer (keeps parts organized)
- Mechatronics Engineer (builder)

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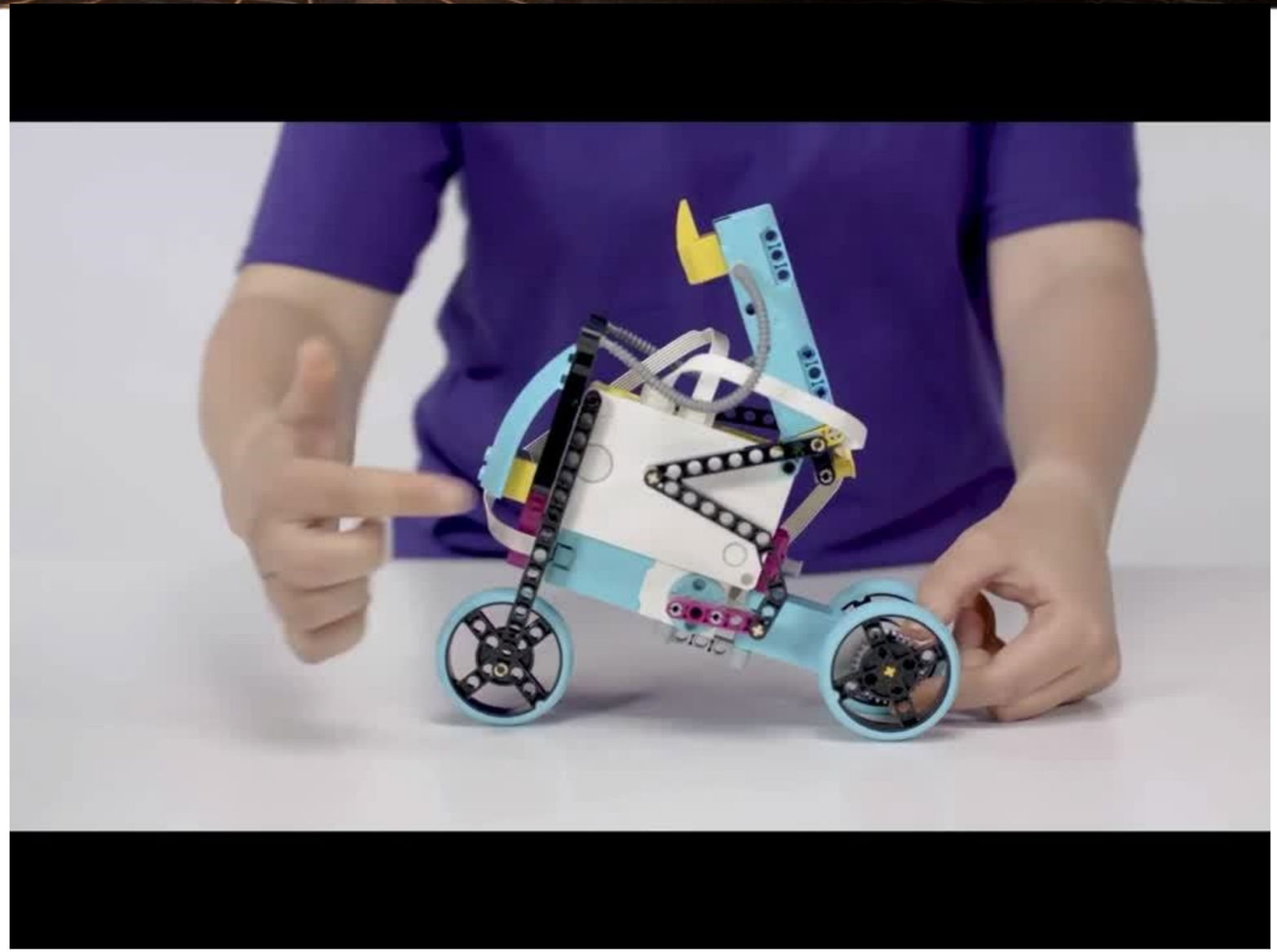

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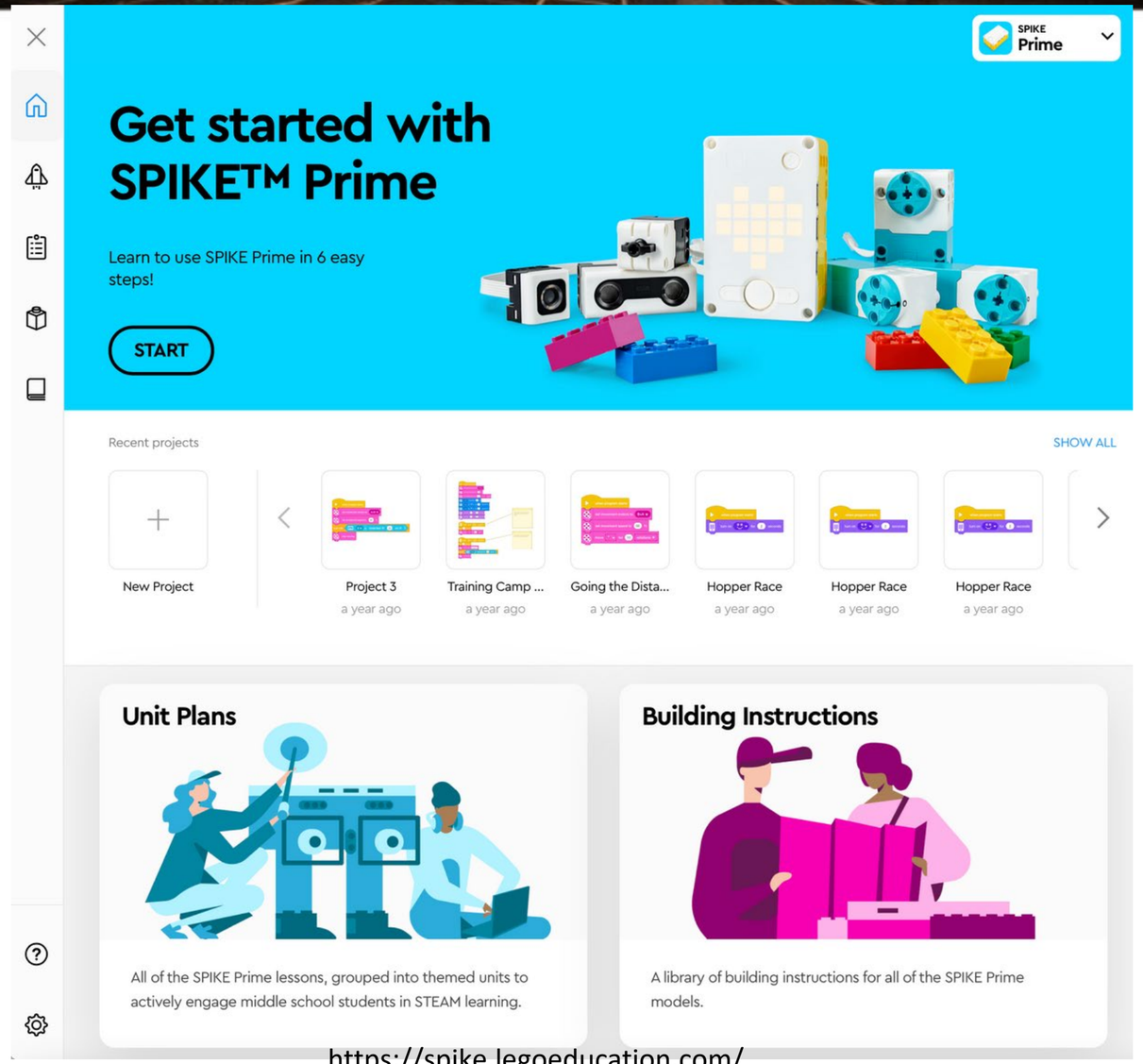
SPIKE Essential

SPIKE Prime

https://spike.legoeducation.com/



https://spike.legoeducation.com/

STEAM, Computer Science, Coding

Word Blocks

Life Hacks

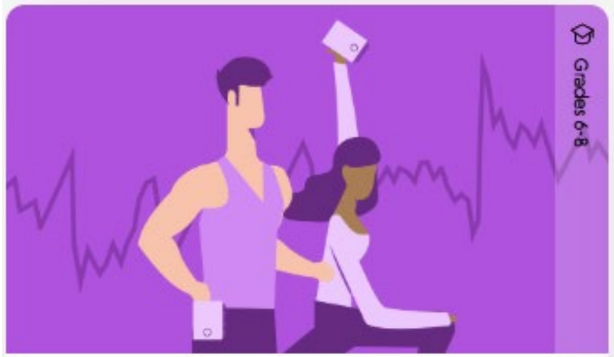
Is there anything in your life that could benefit from a hack? What if that hack could help you see data? Or train your body, plan yo...

STEAM, Engineering, Computer Science

Word

Competition Ready

Ready to expand your robotics skills? This unit also includes a guided FIRST® LEGO® League mission!



Science, STEAM

Word Blocks

Training Trackers

You're active, in a smart way. You always want to track how many

STEAM, Engineering, Computer Science

Word

Supplementary Lessons

Get ready to start your exciting learning journey! You'll have t

Stretch with Data

Match graph values and explore margins of error qualitatively.

START

30-45 min.

MORE

This Is Uphill

Graph energy consumption to gain potential energy.

START

30-45 min.

MORE

Time for Squat Jumps

Graph potential energy at the maximum height of a jump.

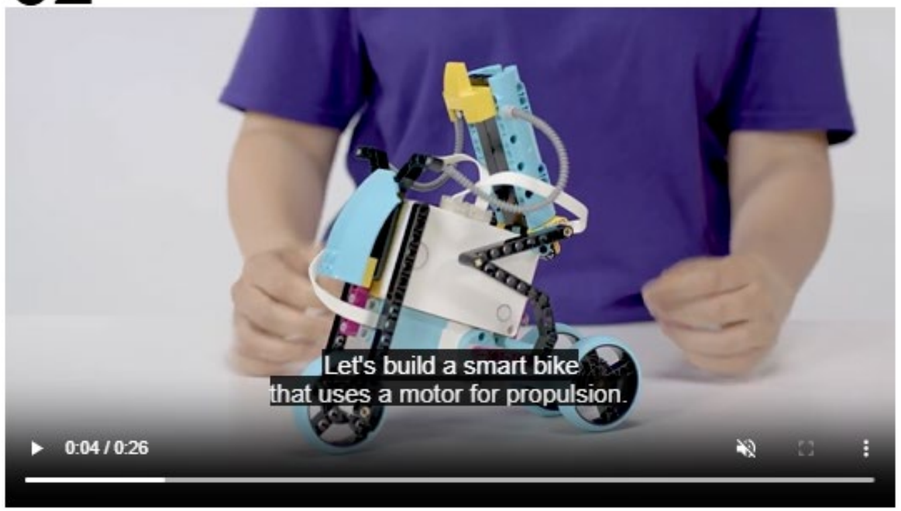
START

30-45 min.

MORE

https://spike.legoeducation.com/

02 /06



Lets build you, on a smart bike!

Done! I've built my bike.

BUILD

Building instructions

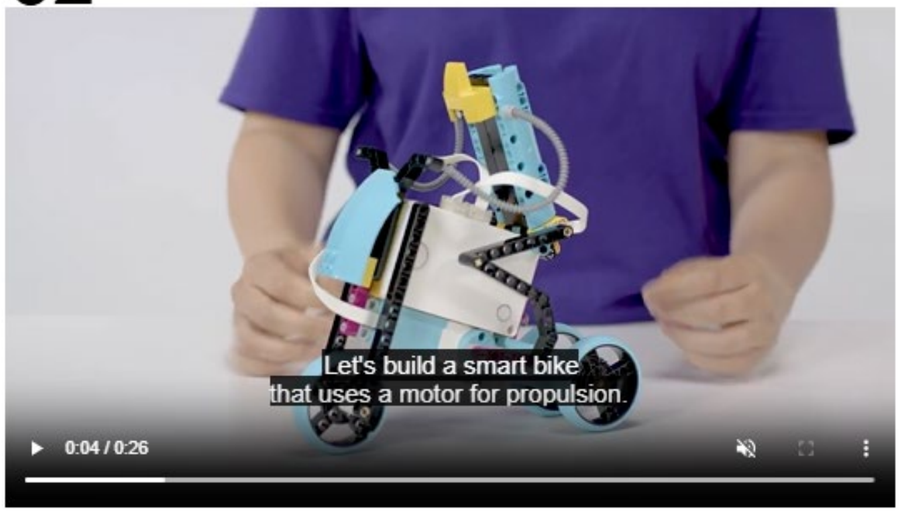
Smart Bike

Then

First

https://spike.legoeducation.com/

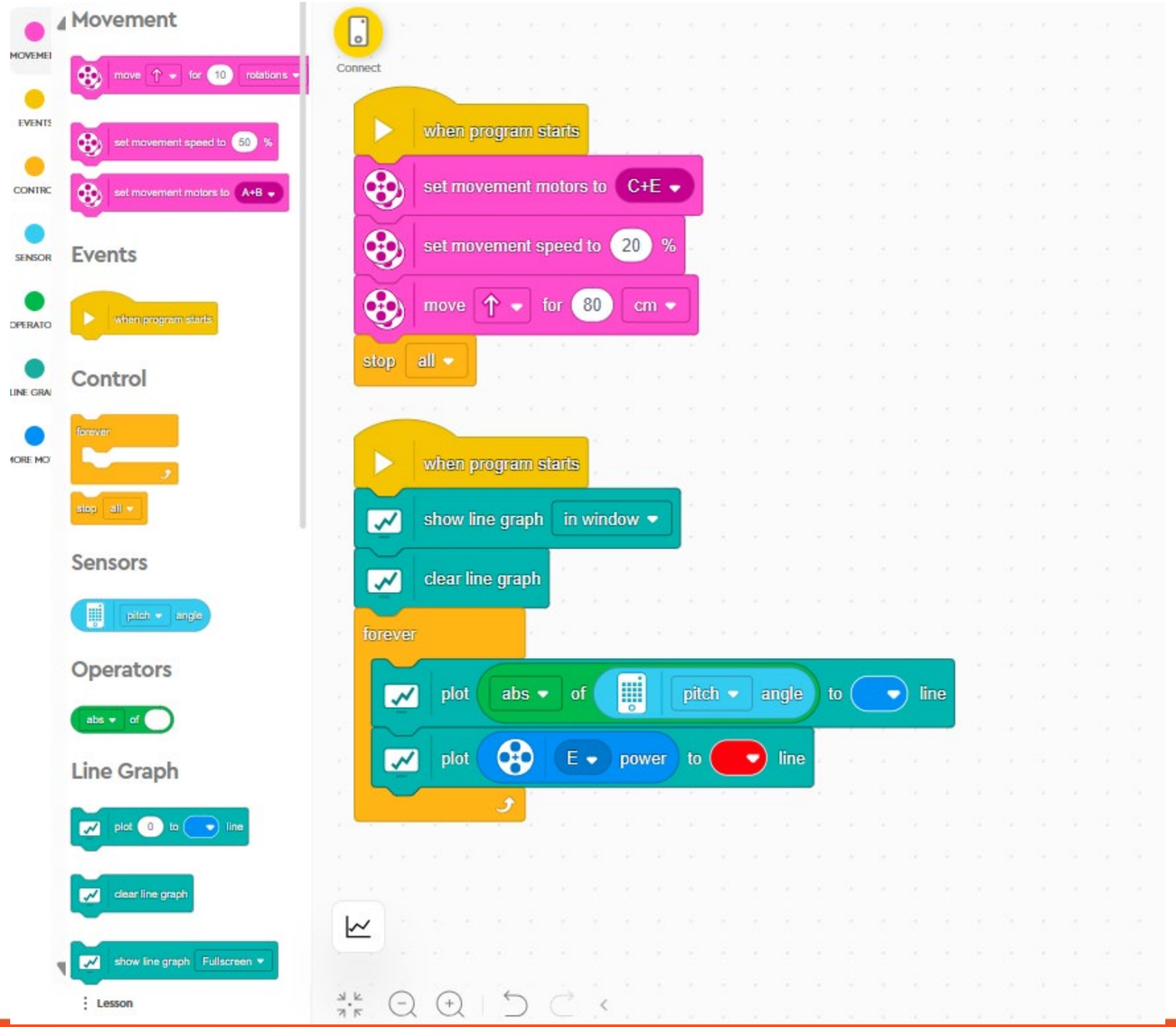
02 /06



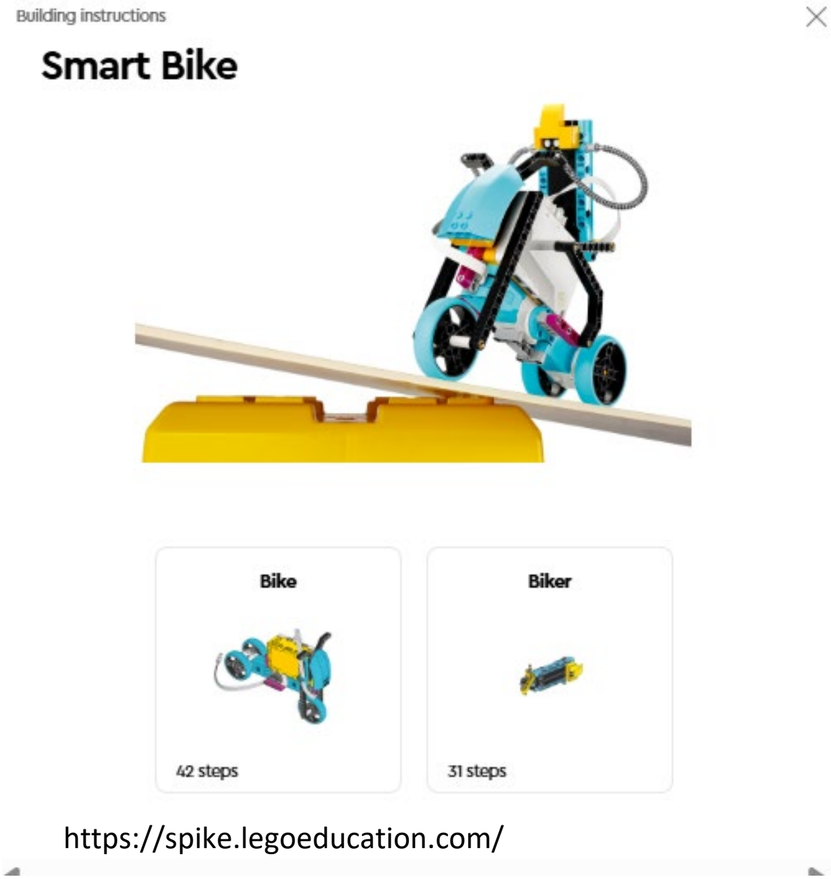
Lets build you, on a smart bike!

Done! I've built my bike.

BUILD



This is Uphill



https://spike.legoeducation.com/

Disassemble

- Carefully disassemble your robot, do this on the lid, so that pieces will not fall to the ground.
- Work together to put the pieces back in their designated sections, as this will be critical upon building again.
- Take inventory of your parts

https://spike.legoeducation.com/

Let's Reflect...

1. Where does the bike experience the most potential energy?

2. What type of energy increases as the bike goes down the ramp?

Innovation Depot 141

Engineering Design Challenge

Scenario

Challenge: Transport Cargo From Coast to Country

You are the logistics engineer for a national shipping company. Your goal is to move a shipping container from:

- a major Class 1 National Hub,
- through a Class 2 Regional Center,
- and finally to a Class 3 Local Delivery Yard.

Task

Challenge: Transport Cargo From Coast to Country

At each stop, you must:

- Pause to simulate unloading/loading
- Switch carriers (class handoff)
- Adjust for track class speed differences

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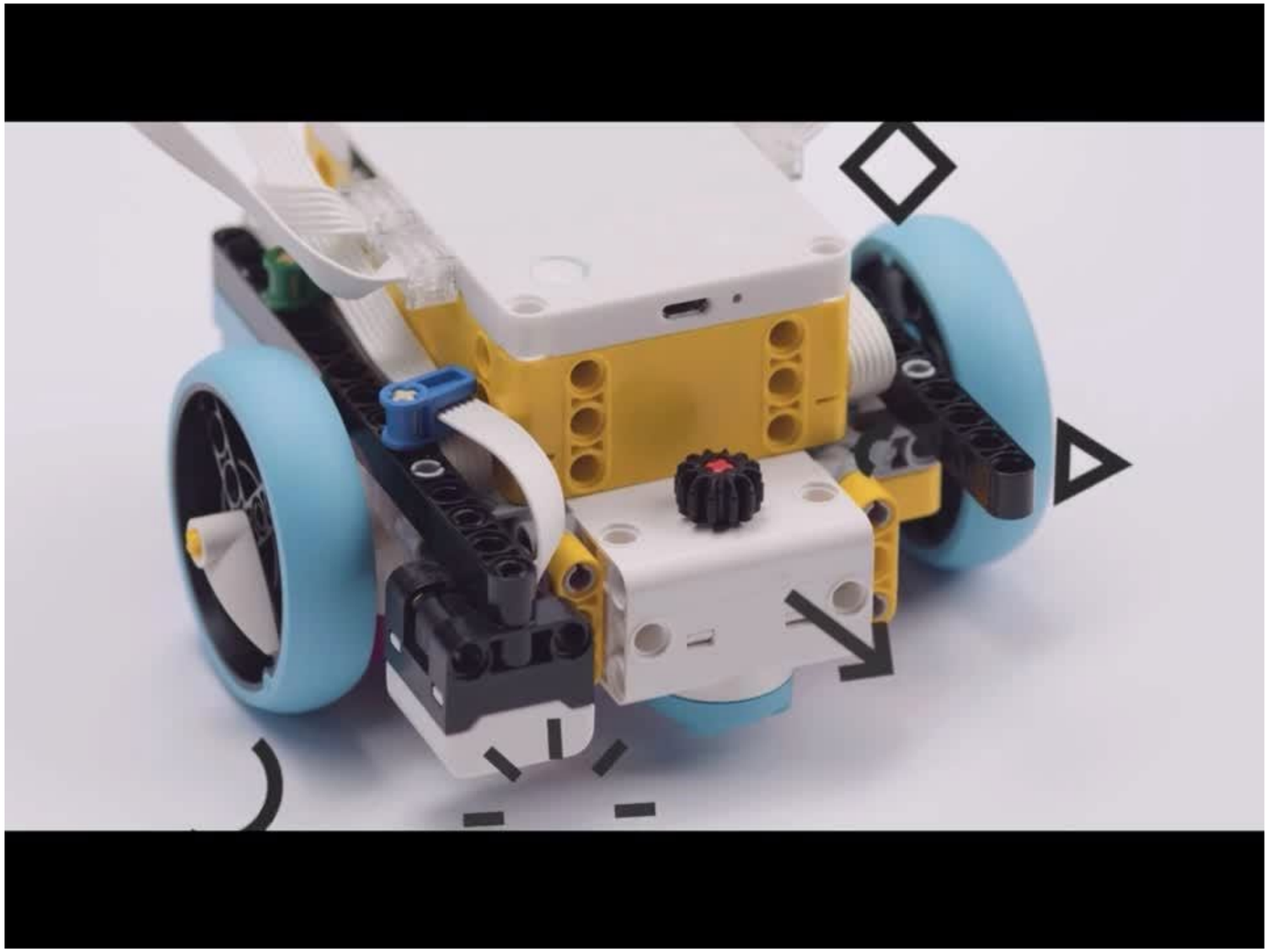

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Select your SPIKE™ solution

SPIKE Essential

SPIKE Prime

LEGO education

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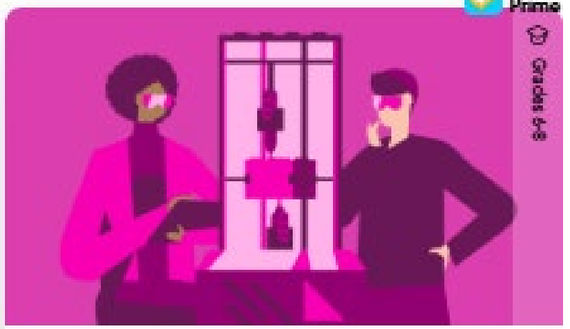
STEAM, Engineering

Word Blocks

Invention Squad

Inventing stuff? Fixing stuff? Always helping people with your ideas? Then you might be an elite member of the Invention...



STEAM, Computer Science, Coding

Word Blocks

Kickstart a Business

You've come up with an amazing idea and you want to share it with everybody. Entrepreneurship can strike at any moment, s...

STEAM, Computer Science, Coding

Word Blocks

Life Hacks

Is there anything in your life that could benefit from a hack? What if that hack could help you see data? Or train your body,...

STEAM, Engineering, Computer Science

Word Blocks

Competition Ready

Ready to expand your robotics skills? This unit also includes a guided FIRST® LEGO® League mission!

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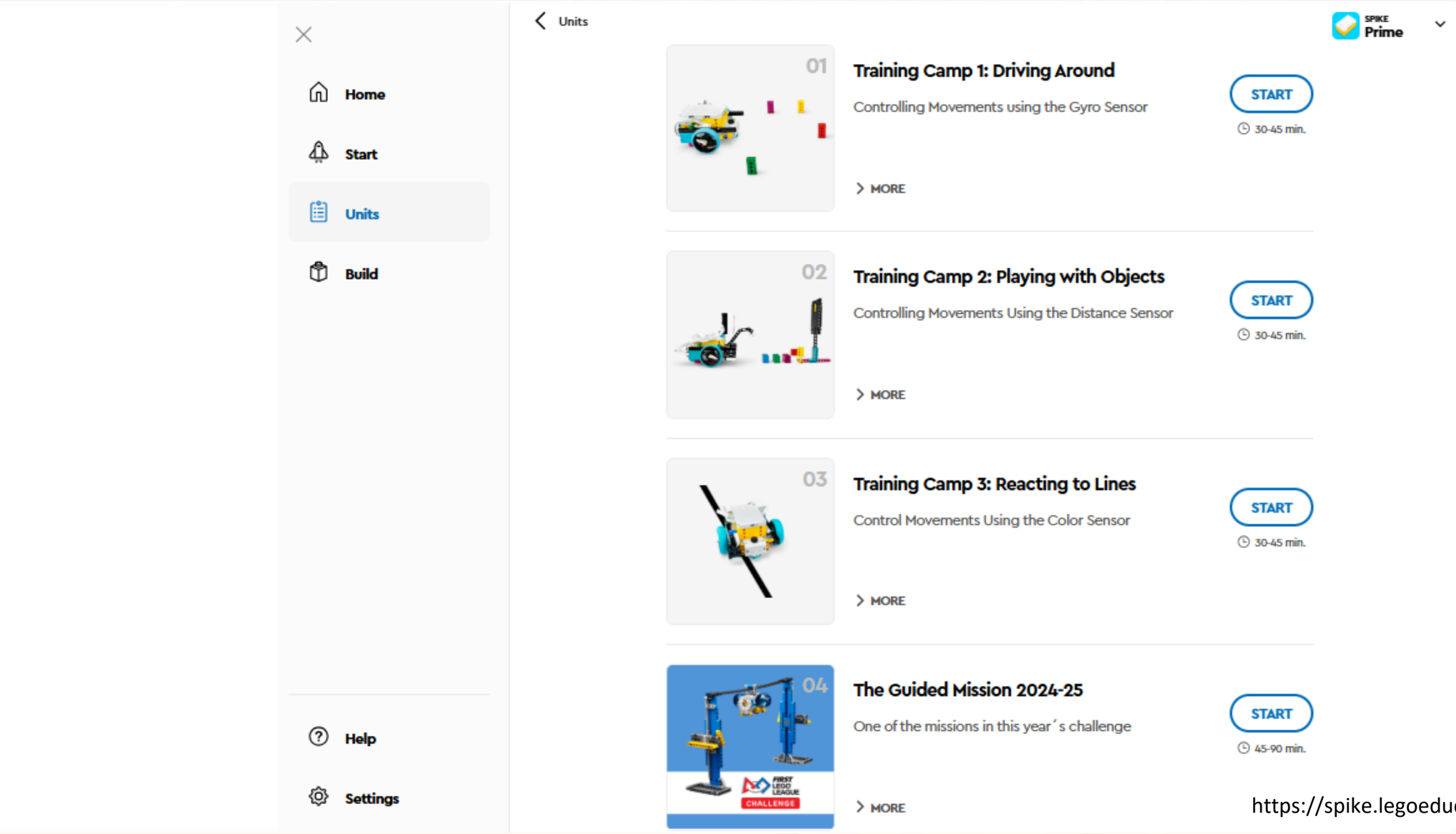

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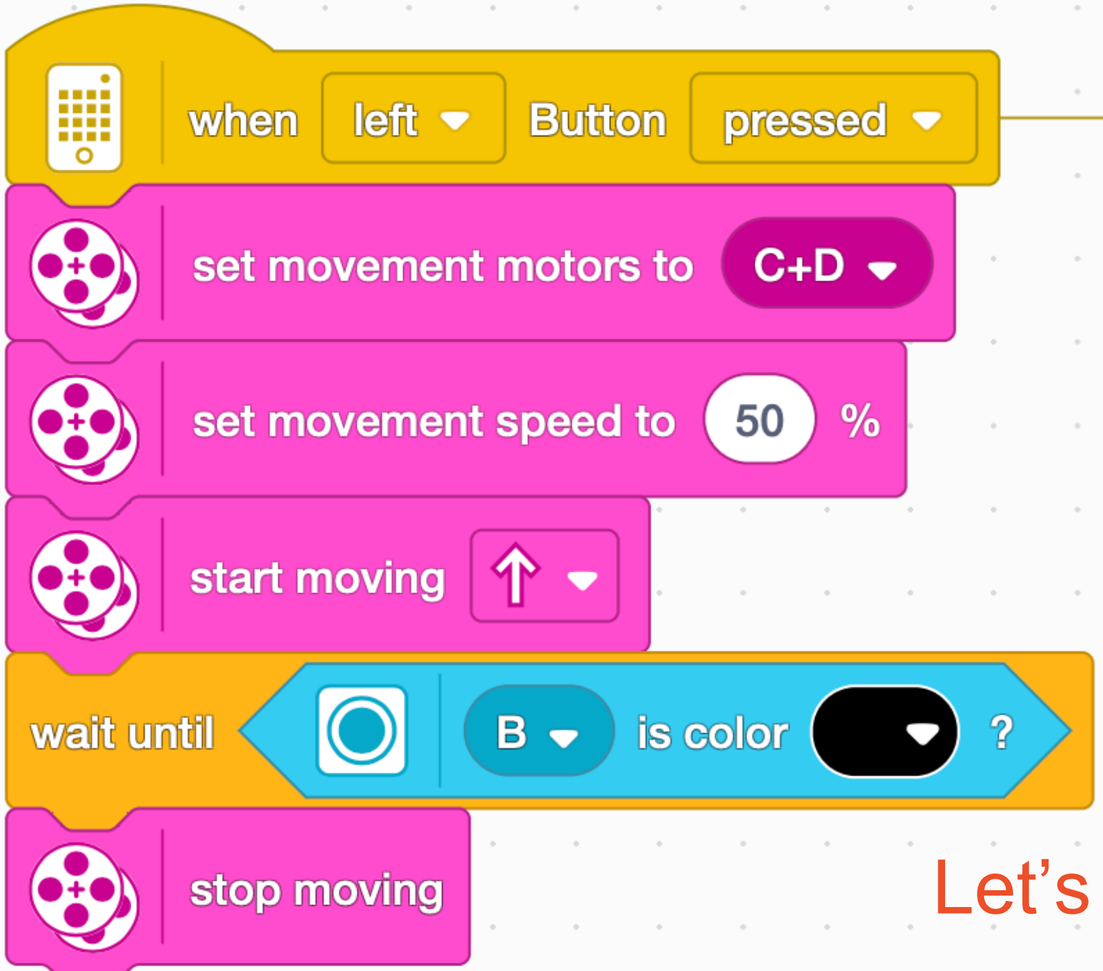
02/06

Build this Driving Base with a Color Sensor.

Let's do this!

https://spike.legoeducation.com/

BUILD



When the Left Button on the Hub is pressed, your Driving Base will move forward and stop when it detects a perpendicular line.

https://spike.legoeducation.com/

Let's read the code like we would read a paragraph.

Task

Students will code a robot train to simulate freight movement through three track classes making stops and handoffs at designated hubs using color sensors, loops, and delays.

Debrief Questions

1. How did the robot simulate real freight operations?

2. Why do speed and track quality matter in the real world

3. What challenges do rail companies face with coordination?

Final Stop

Debrief, Clean Up, and Departure

Disassemble

- Carefully disassemble your robot, do this on the lid, so that pieces will not fall to the ground.
- Work together to put the pieces back in their designated sections, as this will be critical upon building again.
- Take inventory of your parts

https://spike.legoeducation.com/

Ensure all pieces are accounted for.

UNIVERSITY TRANSPORTATION CENTER FOR

RAILWAY SAFETY

Day 4

Smart Sensors, Safe Crossings

UTRio Grande Valley

Housekeeping Rules

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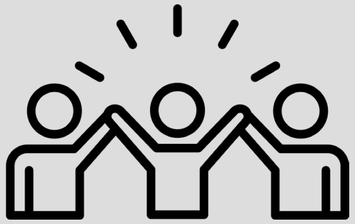


Be active, engaged, and participate in your group.

Railway Systems 101

Intro to Locomotive Science

Rural Grade Crossings

https://thetracksidephotographer.com/2018/01/11/grade-crossings-3/

https://railroads.dot.gov/sites/fra.dot.gov/files/inline-images/0274.jpg

https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQEa8R3KT5nLMbcFBo0kCo3U9OB8GrunNpJIQ&s

https://www.alamy.com/stock-photo/rural-railroad-crossing.html?sortBy=relevant

Based on these images, can you determine what rural grade crossings are?

https://www.yourdictionary.com/articles/rural-urban-suburban-difference

Stop and Think

01 What do you already know about railroad crossings in the country (rural areas)?

02 Have you ever crossed train tracks where there were no lights or gates? What did you do?

03 Why might people ignore warning signs at train tracks? What could go wrong?

Stop and Think

01 What clues in the video tell you something serious is about to happen?

02 How did the characters' choices impact the outcome?

03 What role does time and distance play in a train's ability to stop?

https://youtu.be/G35Qu7H92_U

Stop and Think

01 What message was the video trying to send?

02 How could sensors or better technology have helped prevent what happened?

03 How could you help others understand the dangers of rural grade crossings?

Conductors in Training

Team Huddle &Collaboration Lab

How do trains move forward?

https://www.shutterstock.com/shutterstock/videos/1028954141/preview/stock-footage-empty-train-track-camera-moving-backwards.webm

Newton’s 3rd Law

01 In the video, how did objects respond when a force was applied to them? How is this like how a train starts moving?

02 When a train pushes against the tracks what is the opposite reaction?

03 How might this law relate to safety systems like sensors or emergency braking?

How do trains move forward?

https://youtu.be/mO1qtmFee-k

Balloon Racer Activity

Students will observe and apply Newton's Third Law by building balloon-powered racers, then relate the action-reaction forces to how real trains move and stop, especially when using sensors.

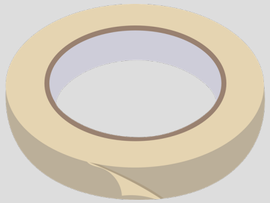
Materials

Per Group

1 balloon

1 straw

String



Tape

2 chairs to anchor string

https://www.spacecentre.nz/resources/learn/rockets/

Experiment Steps

Build

- Thread the straw onto the string.
- Tape the balloon to the straw
- Inflate the balloon (don’t tie it), hold it shut and get ready.

Test Run

Let go of the balloon and watch the racer fly forward.

Evaluate

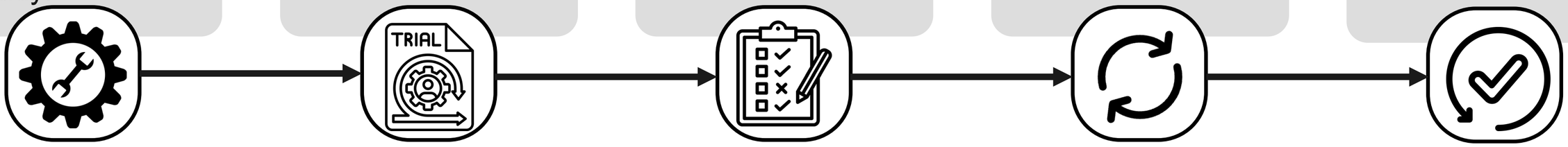
Make observations

Modify

Complete 2-3 runs, adjust your design or launch method.

Final Run

After 2-3 attempts, each team does a final run for the class.



Trackside Theory 121

Engineering Principles in Action

Let's Reflect...

1. What was the action?
2. What was the reaction?
3. How is this like a train using its wheels to push on the track?
4. If a sensor tells the train to stop, what is the reaction?

Signals and Systems 131

Robotics and Code Lab

Spike Prime Forklift

Robotics and Code Lab

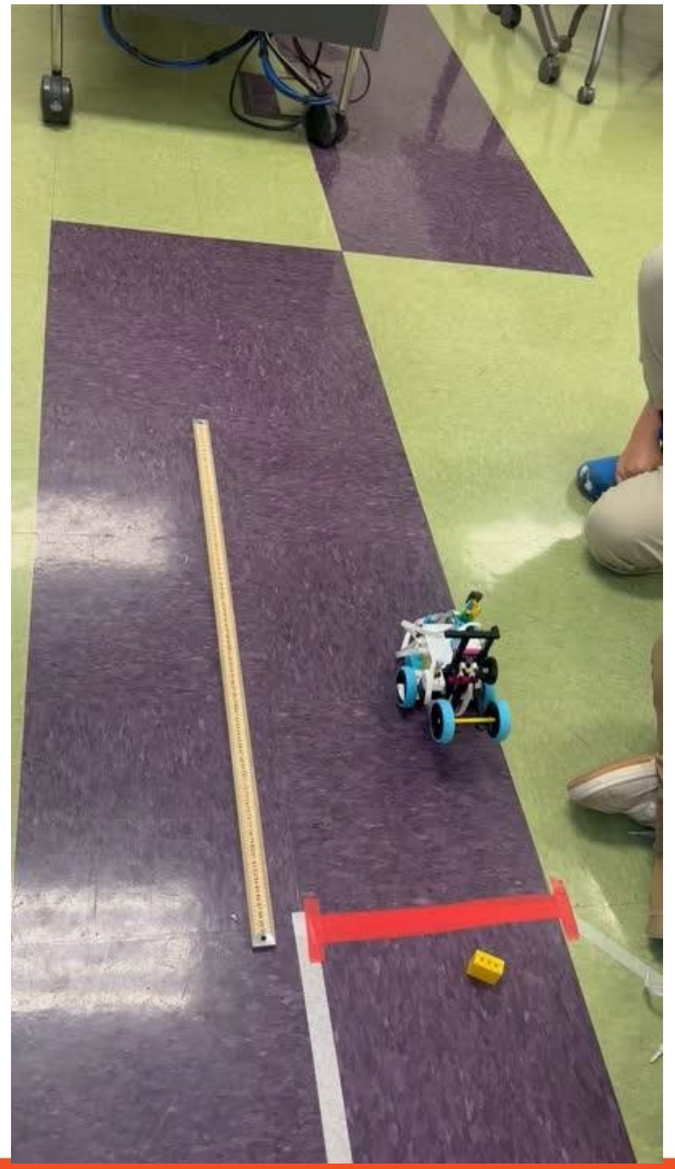


Photo Credits: UTRGV Railway Camp

Innovation Depot 141

Engineering Design Challenge

Engineering Roles

- Lead Engineer (communicates with teacher)
- Systems Engineer (iPad)
- Mechanical Engineer (keeps parts organized)
- Mechatronics Engineer (builder)

Spike Prime Forklift

Forklift Schematics

Please find this icon on your iPad.

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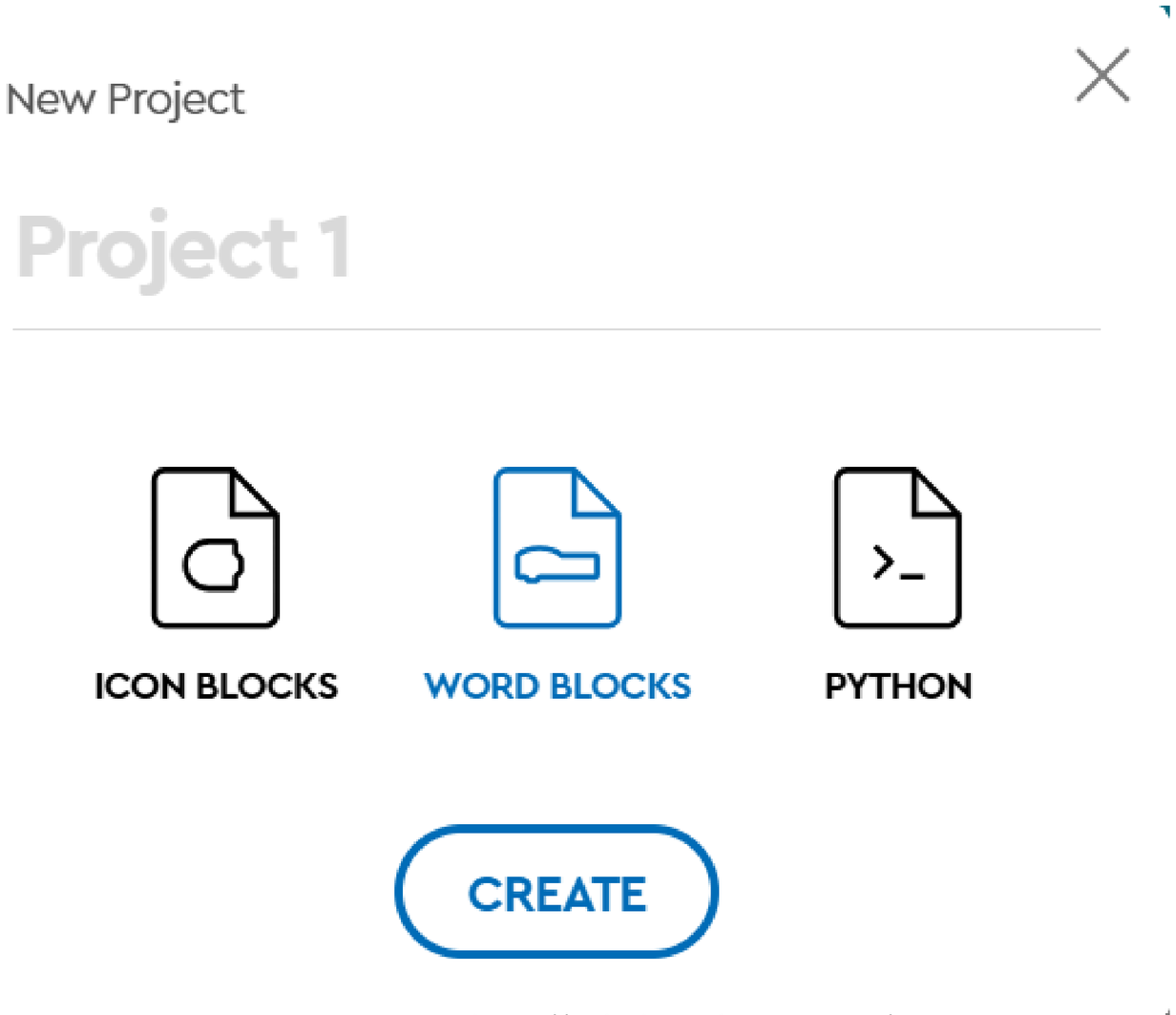

https://spike.legoeducation.com/

Challenge: Rural Tracks Alert!

Scenario

Welcome to a quiet rural community where freight trains pass through open farmland. There's no fancy technology—just basic barriers and watchful eyes. Your engineering team has been hired to pickup and delivery a wheel an axle assembly. design a safety system for a rural grade crossing where cars, tractors, animals, and even people sometimes cross the tracks.

Task

Challenge: Inspection Detection

Your prototype must be able to:

- Detect an object (a cow, car, or tractor) near or on the crossing.
- If something is detected: stop the train automatically and remove the obstacle.
- Once the object has been removed, the train will continue its course.

Students will Program a LEGO Spike Prime train to detect an object on the railroad.

Debrief Questions

1. How did your sensor-based system help prevent a collision at the rural crossing?

2. Why is it especially important to have a reliable detection system at rural crossings?

Final Stop

Debrief, Clean Up, and Departure

Disassemble

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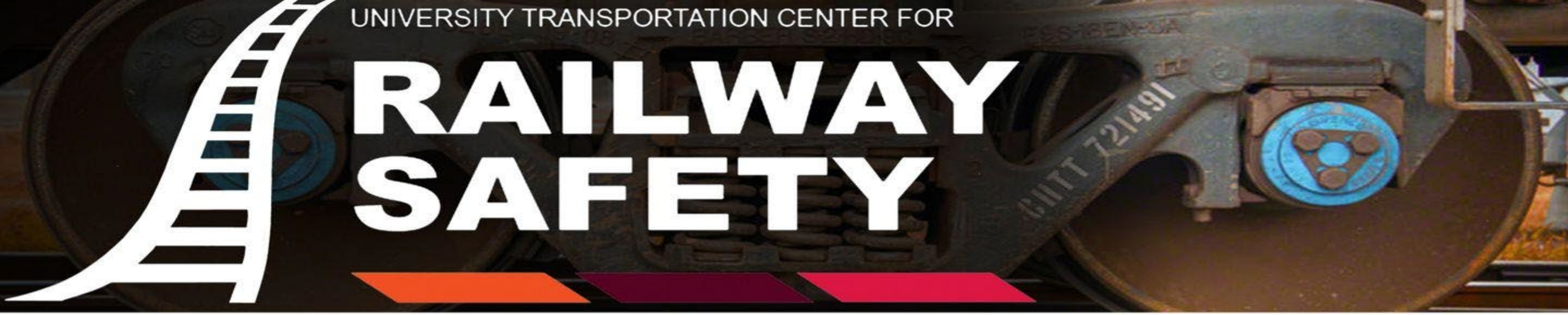

Day 5

Full Steam Ahead

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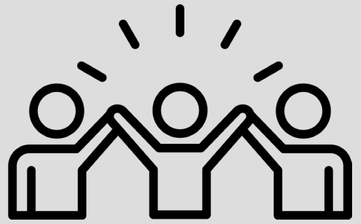


Be active, engaged, and participate in your group.

Railway Systems 101

Intro to Locomotive Science

Cargo Containers Types

Dry Container

(Box Containers)
Carry clothes, toys, books, tools and things that don't need to be cold.

Refrigerated

(Reefers) Carry food like fruits, veggies, meat or medicine that must stay cold.

Tank

Carry liquids like milk, oil or chemicals, think of it like a soda on wheels!

Freight Classifications

(Class 1, 2, 3 Railroads)

Class 1

01

- Major national freight railroads
- Operate across multiple states and even internationally
- Move massive volumes of cargo

Class 2

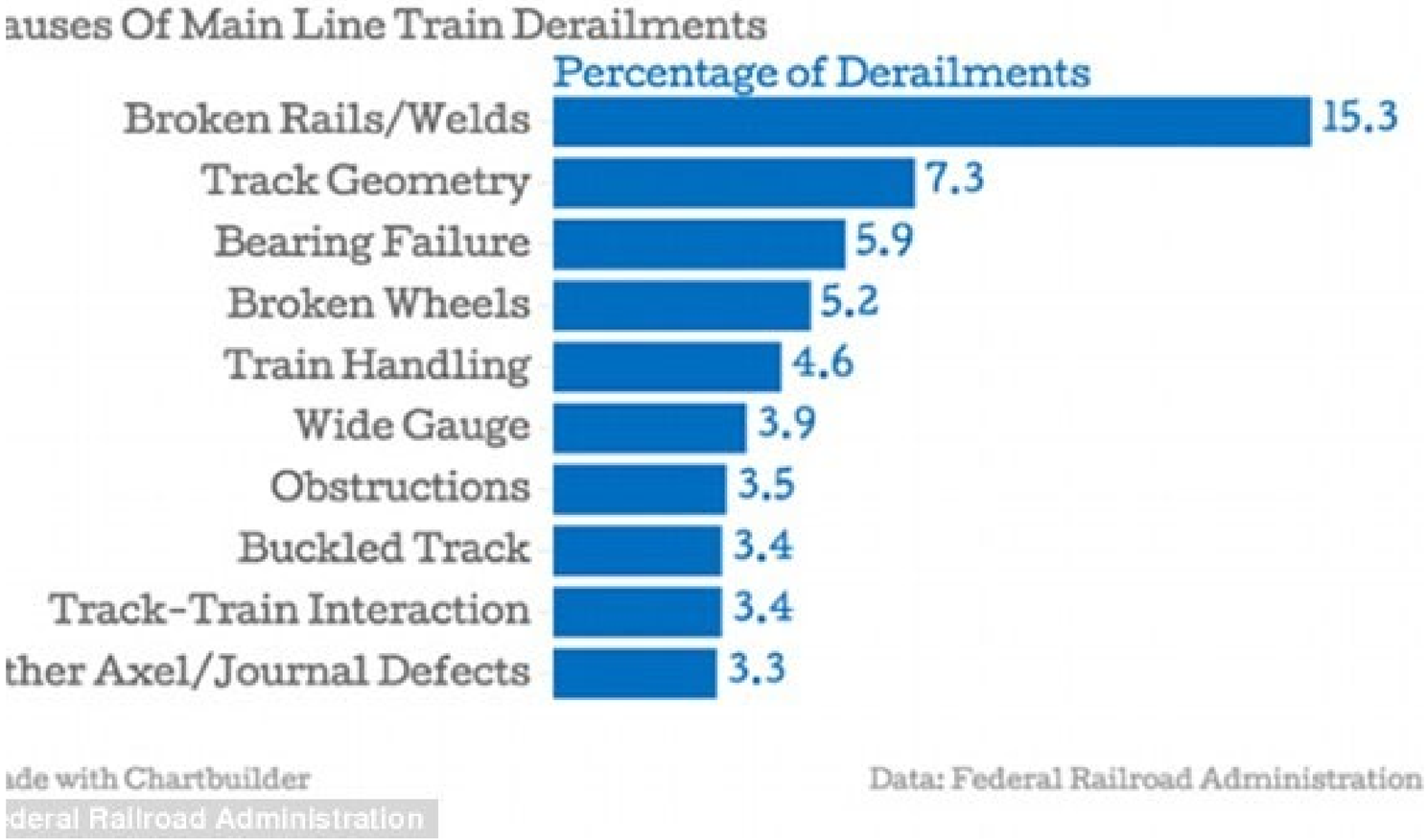
02

- Regional railroads
- Operate within a specific region
- Connect rural or mid-sized areas to Class 1
- Handle medium-distance freight

Class 3

03

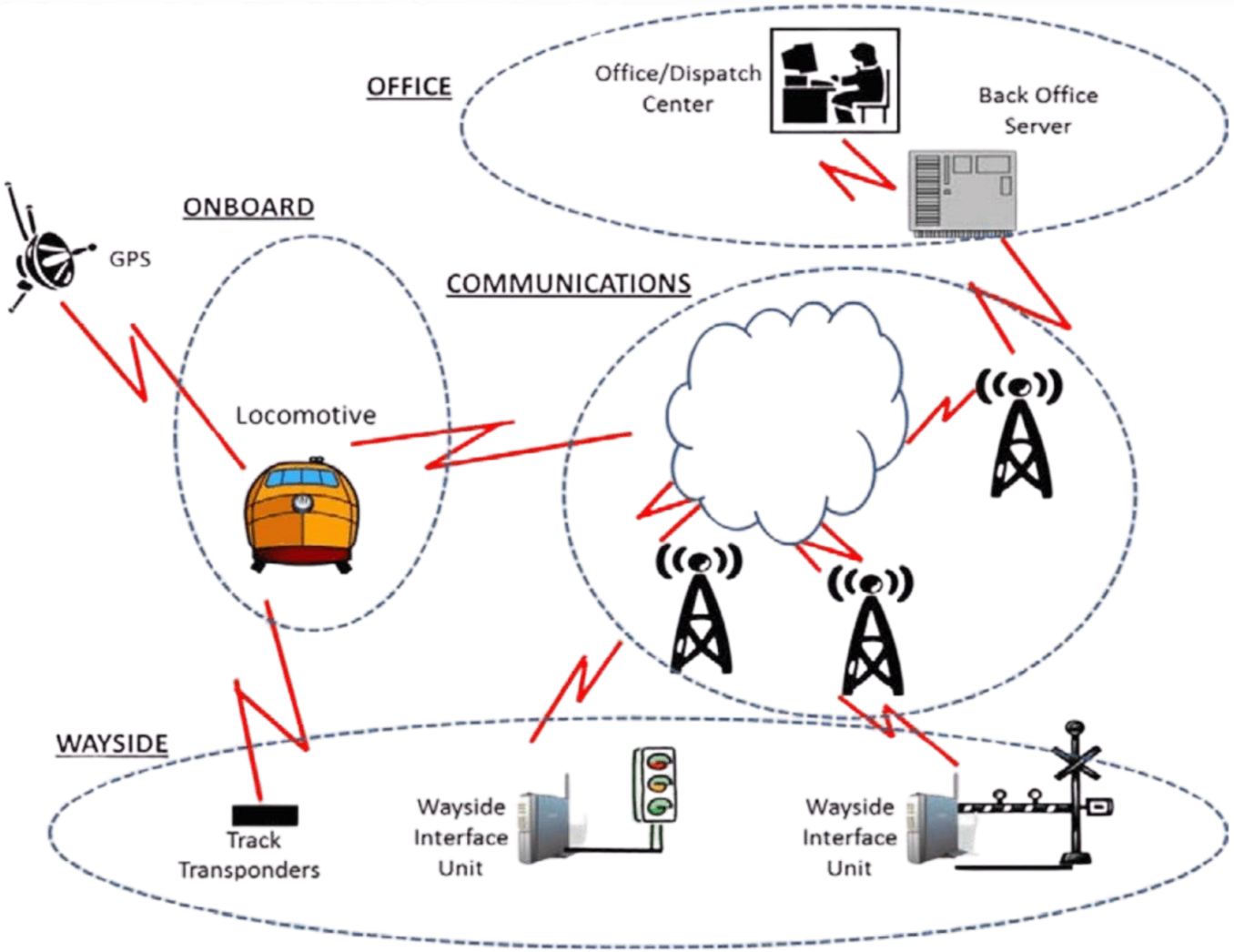
- Short line & local railroads
- Often within cities or short rural stretches
- Serve vital role moving goods to and from Class 1 or Class 2 railroads



Zolfagharifard, E. (2015, May 13). Broken rails and welds are the biggest causes of train derailments. Mail Online. https://www.dailymail.co.uk/sciencetech/article-3080438/What-biggest-causes-rail-derailments-Graphic-reveals-broken-rails-welds-main-culprits.html

Based on this data, what are the primary reasons for derailments?

Signals and Sensors



https://www.researchgate.net/profile/Daniel-Brod/publication/331134575/figure/fig1/AS:726625322799104@1550252385092/Generic-PTC-Architecture.png

Rural Grade Crossings

https://thetracksidephotographer.com/2018/01/11/grade-crossings-3/

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https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQEa8R3KT5nLMbcFBo0kCo3U9OB8GrunNpJIQ&s

https://www.alamy.com/stock-photo/rural-railroad-crossing.html?sortBy=relevant

Based on these images, can you determine what rural grade crossings are?

Innovation Depot 141

Engineering Design Challenge

Winning Contract

The instructors will select a winning team that is successful in the challenge, demonstrates good teamwork, and shows determination despite minor issues.

Engineering Roles

- Lead Engineer (communicates with teacher)
- Systems Engineer (iPad)
- Mechanical Engineer (keeps parts organized)
- Mechatronics Engineer (builder)

Spike Prime Forklift

Forklift Schematics

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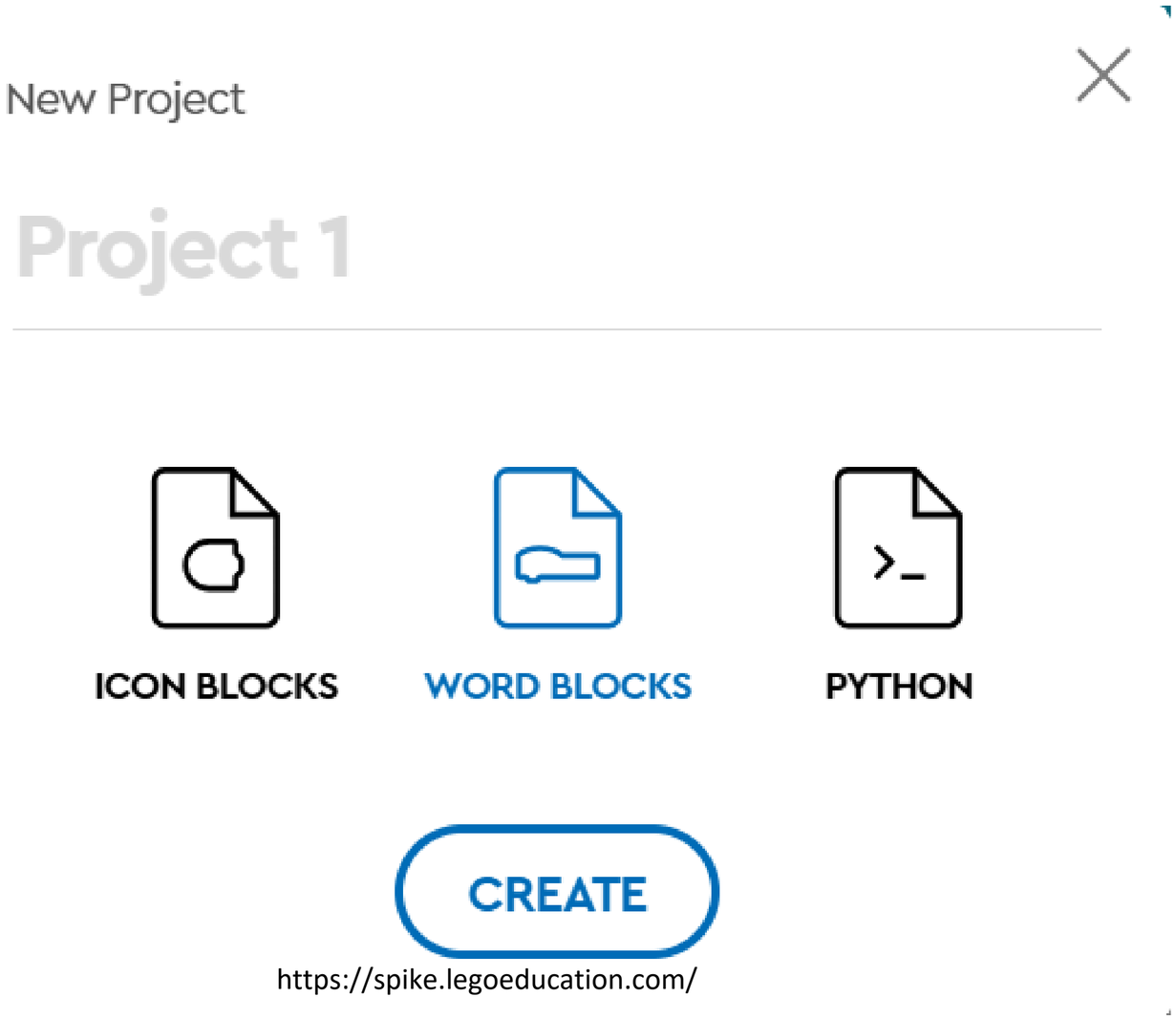

https://spike.legoeducation.com/

Scenario

Final Forklift Challenge

You are part of a transportation engineering team working for a national railway company. A freight train carrying refrigerated medical supplies must travel from a Class 1 (100%)rail line through Class 2 (40%) and Class 3(25%) territories, pass through a rural grade crossing, and arrive safely at a distribution station.

Along the way, your train must stay on track, pick up a wheel and axle assembly, and relocate it. Respect the routing logic for each class of track.

Requirements

- use at least one sensor
- represent all 3 classes
- lift and relocate a wheel and axle
- stay on the track

Debrief Questions

1. How does your design use sensors to prevent accidents?
2. How does cargo type affect how fast or carefully the train should move?
3. What would happen if coordination between train companies failed?

Final Stop

Debrief, Clean Up, and Departure

Disassemble

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