UNIVERSITY TRANSPORTATION CENTER FOR
RAILWAY SAFETY
Award Number: 69A3552348340
Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)
Award Number: 2112650

Day 1

- Engineering Design Cycle (Process)
- Potential, and Kinetic Energy

Welcome Aboard!!!

- Roll Call
- Shirt Distribution
- Housekeeping Rules
  - Must wear shirt everyday
  - Restroom only when accompanied by an adult
  - NO electronic devices unless instructed
  - Be active, engaged and participate in your group

Objectives:

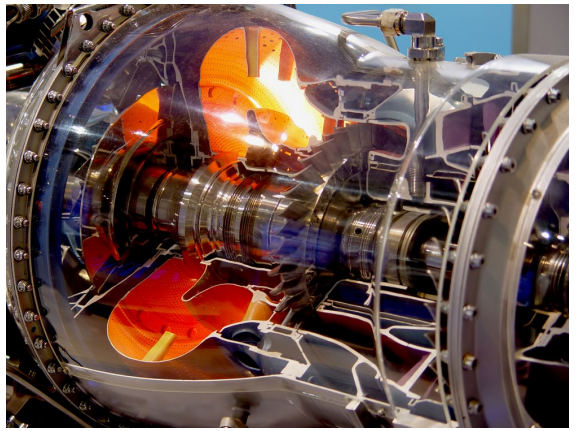
- What is Engineering?
- Engineering Design Cycle (Process)
- Understand how engineers work in teams to achieve a goal
- Compare and Contrast Kinetic and Potential energy

What is Engineering?

- **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.

Basic Engineering Fields Include:

- Civil
- Environmental
- Mechanical
- Electrical
- Chemical
- Biological
- Industrial
- Software
- Materials
- Nuclear
- Aerospace
- Robotics



Aerospace engineering includes the design of jet engines. (Image credit: yuyangc | Shutterstock)

What does it mean to be an engineer?

1. Understand how engineers work in teams to achieve a goal.
2. Learn the importance of each member's role and assuming role functions.
3. Learn to assign tasks based on goals and needs of a team.

Characteristics of an Engineer:

- strong STEM background
- effective speakers
- good communication skills
- good writers

Assign Groups

1. Make sure that students are in groups.
2. **Communication** is key, it is important for you to feel comfortable **communicating** with each other.

Team Building Challenge

Cup Challenge:

Your 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.

Extension

Cup Challenge II:

Now that you've stacked 10 cups, TRY 5 EXTRA CUPS.

REMEMBER: *DO NOT TOUCH CUPS* and keep your hands at the end of the string.

Extension

Ice Cup Challenge III:

Now that you've stacked 15 cups,

Fastest Team wins!!!

REMEMBER: *DO NOT TOUCH CUPS* and keep your hands at the end of the string.

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 is this activity **like working on your project with your team**?

Engineering Design Cycle (Process)

- How does the Engineering Design Cycle (Process) applied during the Ice Cup Challenge?
- Why is it important for each member to know their role?
- Why is it important to assign tasks based on goals and needs of a team?

Railway Engineering

- Railway Engineering is a specialist field in **Transportation** and **Civil** Engineering.
- The incredibly advanced trains which use these rail networks are expensive vehicles and so a Railway Engineer is faced with different challenges to a **Highway Engineer**.

Railway Engineers

- Railway Engineers possess mechanical design skills and knowledge of propulsion systems that allows them to design train vessels.
- Railway Engineers are frequently on site, either supervising the rail system or in a ‘hands on’ capacity.

Freight Trains

- Freight trains are often referred to as goods trains because they transport materials or cargo.
- They are not designed to carry passengers at all.
- Most freight is transported by trains and they are essential to the industry.

Freight Rail & Energy Commodities

- Although rail coal shipments have declined in recent years, coal is still an essential part of the nation's industrial economy and a key rail market.
- Well over 90% of U.S. coal consumption is for electricity generation.
- U.S. coal is also exported to countries all over the world for steelmaking and power generation.

The Infinity Train

Information to look out for:

- What type of energy is used to charge the battery?
- Why is it called the infinity train?
- Name at least one energy transformation that occurs.
- How is gravitational potential energy increased?

Prior Knowledge:

- What is Potential Energy?
- How is Gravitational Potential Energy increased?
- Explain the relationship between Gravitational Potential Energy and Kinetic Energy.

Roles Within Your Group

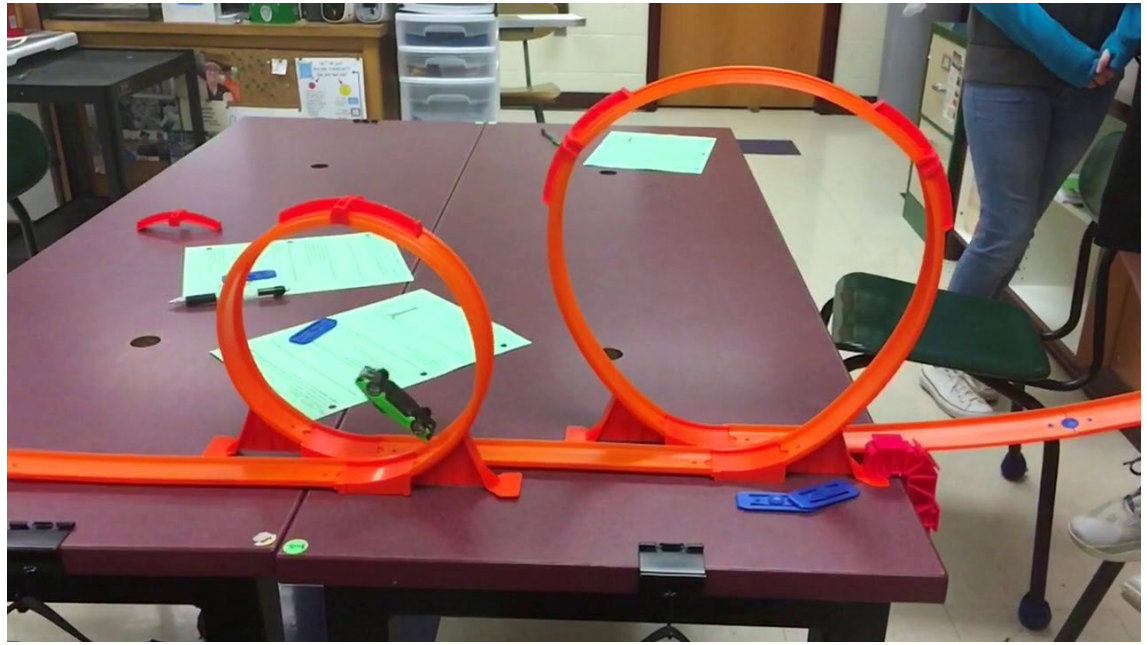
★ **Engineer 1** -Oversees and helps with every single aspect of the project. The Lead engineer is responsible for making sure tasks are completed efficiently on time.

★ **Engineer 2** - Oversees the design and mechanics of the project. Mechanical engineers make sure to plan the blueprint of the design.

★ **Engineer 3** - Oversee and Lead the building process. Manufacturing engineers make sure that the build is complete and works.

★ **Engineer 4** - Oversees the construction of the project. The environmental engineer ensures the proper use of materials (not wasteful).

Hot Wheels® Lab



Hot Wheels® Lab

Learning Objective:

Students will begin to explore how gravitational potential energy 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.

Essential Question:

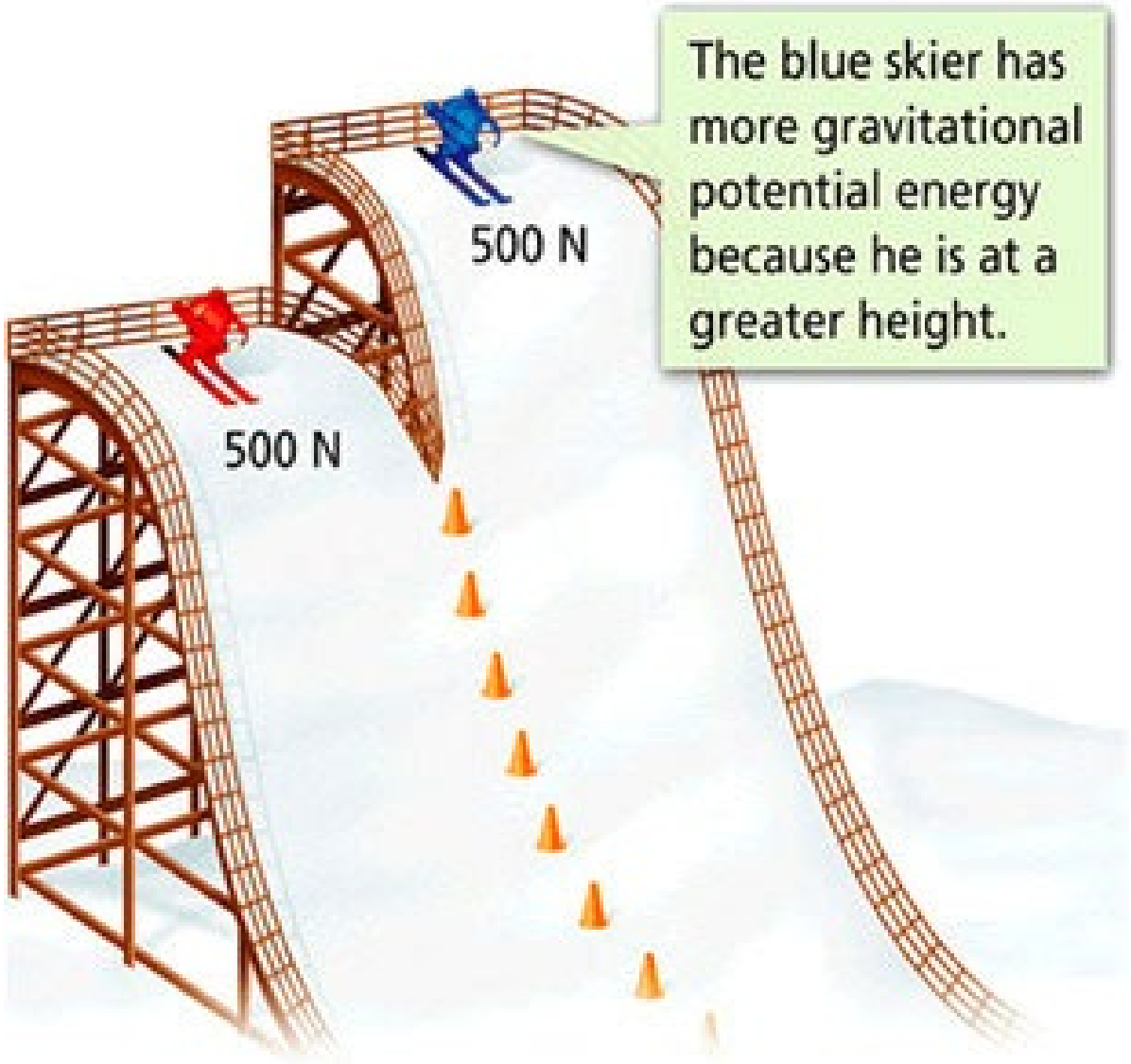
As an engineer, how would you build a track to get your Hot Wheels car to move through a loop **and** go as far as it can?

Engineering process

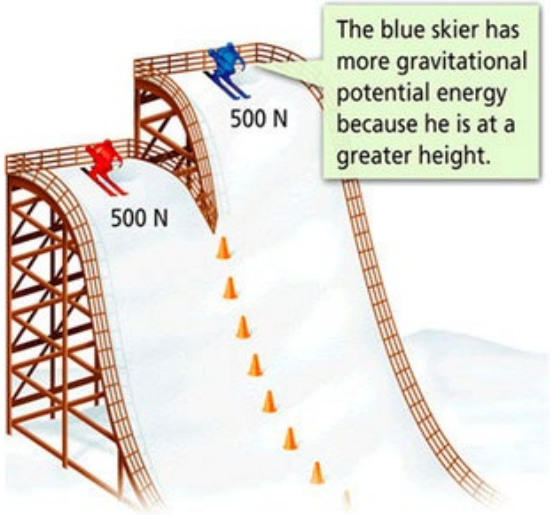
Follow the engineering design process to make your track.

Gravitational Potential Energy

- Make observations
- Think Pair Share,
  - What is gravity?
  - Why does the blue skier have more gravitational potential energy?
  - How do you think height affects gravitational potential energy?
  - How do you think the red skier could get more gravitational potential energy?



Engage:



Mini-lab

1. Connect 6 ramp pieces.
2. Place the car on the flat ramp. Does it move?
3. Elevate one side of the ramp about two inches and place the car on the ramp. Does it move?
4. Continue this process until the ramp reaches 10 inches in height.
5. What are you changing?
6. How does this change in Potential Energy affect Kinetic Energy (motion)?

Explore:

Pre-Lab Questions:

1. What did you notice about the design of the ramp?
2. How do you think the engineers got the car to do the jump?
3. What did you notice about the track and the car?
4. How was the car different from cars you usually see people drive?
5. How were the tracks different from the streets in your neighborhood?

Explore:

- 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.

Explore:

- With your group create at least 4 different track designs.
- Record the design changes that you make to your track and loop after each new set of trials. (Draw/sketch, time and Measure)
- 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.

Explore:

- With your group create at least 4 different track designs with different **HEIGHTS**.
- Record the design changes that you make to your track and loop after each new set of trials. (Draw/sketch, time and Measure)

Results/Data:

Trials	Loop Size (S/M/L)	Ramp Size (S/M/L)	Car's Distance Traveled	Track Design

Evaluate:

- What do you think caused the car to go farther?
- What are some of the factors that could have affected your results?
- Do you think the type of car your group used affected your results?
- How would you improve your ramp design?

Cleanup

Make sure students:

- look around the floor
- count, and put all materials back in the box
- ensure no Lego parts are missing, misplaced, or left behind.

Plug your block in to charge.

Cleanup and Closing Discussion

1. How was today's challenge applicable to Railway Engineering?
2. What are some real challenges engineers face?
3. What are some of your team's strengths and weaknesses?

End of Day 1

Day 1 References

Crash Course Kids (n.d.). What's an Engineer? Crash Course Kids #12.1. What's an Engineer? Crash Course Kids #12.1. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=owHF9iLyxic (Slide 4)

(2022). The Infinity Train Can Run Forever Using Only Gravity. The Infinity Train Can Run Forever Using Only Gravity. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=zo6lzznXljI (Slide 19)

Eyler, S. (2021). Gravitational Potential Energy. PS2L3 1b Gravitational Potential Energy. Retrieved October 7, 2021, from https://www.youtube.com/watch?v=1Ix4Ey2CTJ0 (Slide 20)

Hot Wheels (n.d.). The Yellow Driver's World Record Jump (Tanner Foust) | Team Hot Wheels. The Yellow Driver's World Record Jump (Tanner Foust) | Team Hot Wheels. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=zo6lzznXljI (Slide 28)

(2024). *Lego Spike Prime*. Welcome to our Teacher Resources. https://education.lego.com/en-us/

UNIVERSITY TRANSPORTATION CENTER FOR
RAILWAY SAFETY
Award Number: 69A3552348340

Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)
Award Number: 2112650

Day 2

- Potential, and Kinetic Energy
- Time for Squat Jumps
- Uphill

Reminders and Procedures:

- Roll Call
- Housekeeping Rules
  - Must wear shirt everyday
  - Restroom only when accompanied by an adult

(Please ensure to keep restrooms clean)

  - NO Electronic devices unless instructed
  - Be active, engaged and participate in your group
  - Be respectful and leave room organized

Objectives:

- What is Potential Energy?
- Learn about the Infinity Train
- Explore ways of measuring the height of a jump
- Use that value to calculate potential energy

Prior Knowledge:

- What is Potential Energy?
- How is Gravitational Potential Energy increased?
- Explain the relationship between Gravitational Potential Energy and Kinetic Energy.

The Infinity Train

Information to look out for:

- What type of energy is used to charge the battery?
- Why is it called the infinity train?
- Name at least one energy transformation that occurs.
- How is gravitational potential energy increased?

Calculating for Potential Energy

Potential Energy = m * g * h

- m = mass (kg)
- g = gravity (9.8 N/kg)
- h = height

Potential Energy (Joules)

Introduction to Equipment

- We are going to be using the LEGO SPIKE PRIME for our investigations the remainder of the week.
- Let's take some time to become familiar with the equipment's:
  - parts
  - function
  - connection

Process and Procedure

1. You will be working with robots to learn more about transportation engineering.
2. You will be building and programming your own robot.
3. Teams will construct a basic robot from LEGO® SPIKE® Prime robotics kit using the LEGO® Education SPIKE Prime App .

Process and Procedure

- For each round of three steps, you will be changing roles:
  - The function of the “lead engineer” is to construct the robot. The rest of the team will be “assistant engineers”. Assistants look for parts and help the lead engineer.
  - There are about 600 pieces in each robot kit. Those functioning as “assistant engineers” have the responsibility to manage pieces, including taking care to not lose or misplace any of the parts.

Roles and Responsibilities

Assign the following roles for this build. We will be rotating roles as we will be building numerous times throughout the week.

1. Computer Science Engineer: will control the iPad
2. Materials Engineer: will gather parts
3. Mechanical Engineer: will put the pieces together
4. Industrial Engineer: will evaluate and improve production (ensure team is on task and working cooperatively)

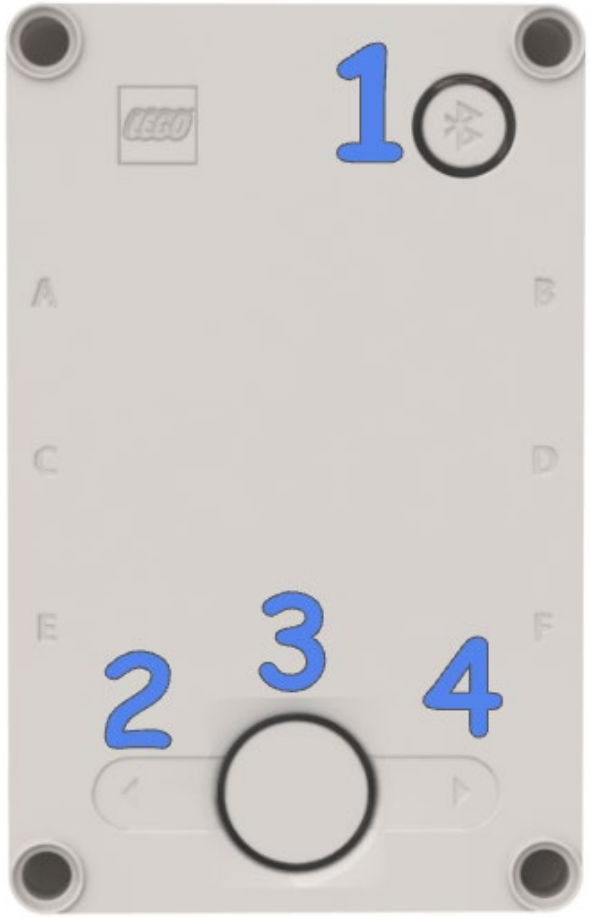
Control Brick

There is one Control Brick in each set. This Control Brick is often referred to as:

- Brick
- Brain
- Block
- Hub

Hub Buttons

1. Puts Hub in Bluetooth pairing mode
2. Left button for program navigation
3. Select or exit program
   - Power button
   - Hold down for 5 seconds to power off
4. Right button for program navigation



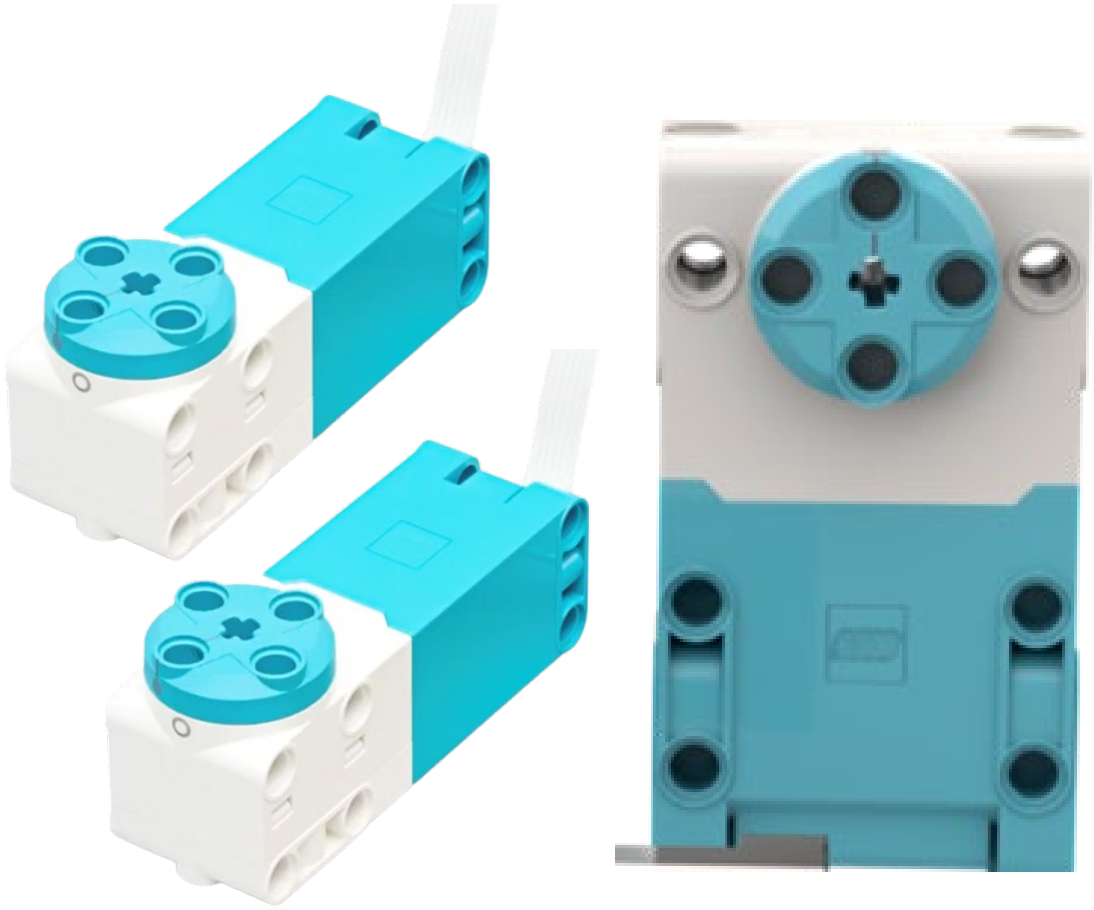
Control Brick

- The Brick has 6 built in ports A-F
- Any port can be used for any motor or sensor

Motors

There are 3 motors

- 1 Large Motor
- 2 Medium Motors



Color Sensor

There is one color sensor

Distance Sensor

There is one distance sensor, it uses echolocation to detect distance of solid objects.

Force Sensor

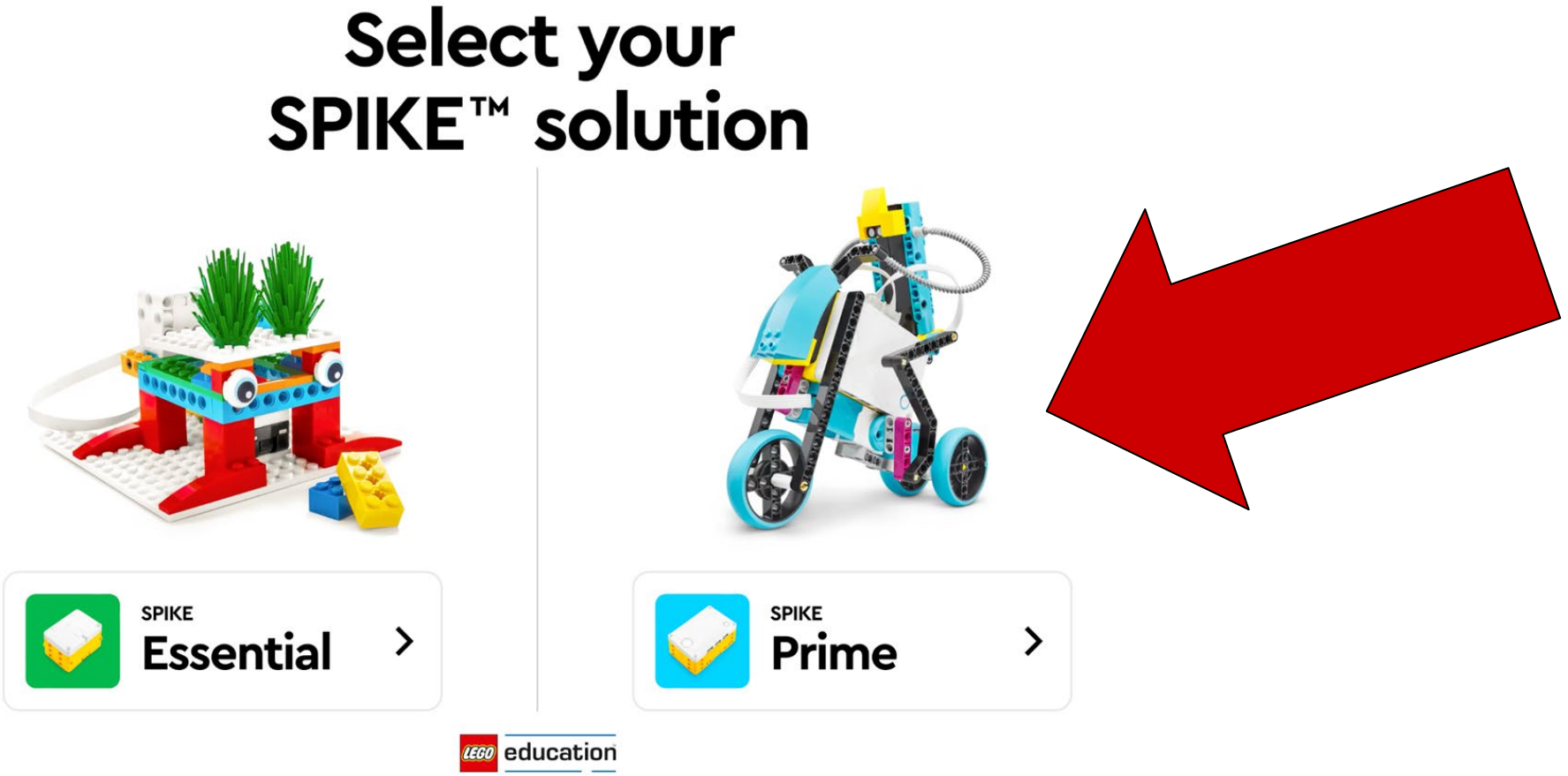
There is one force sensor. It is used to measure how much Force is being applied, this is measured in Newtons)

LEGO APP and Tutorials

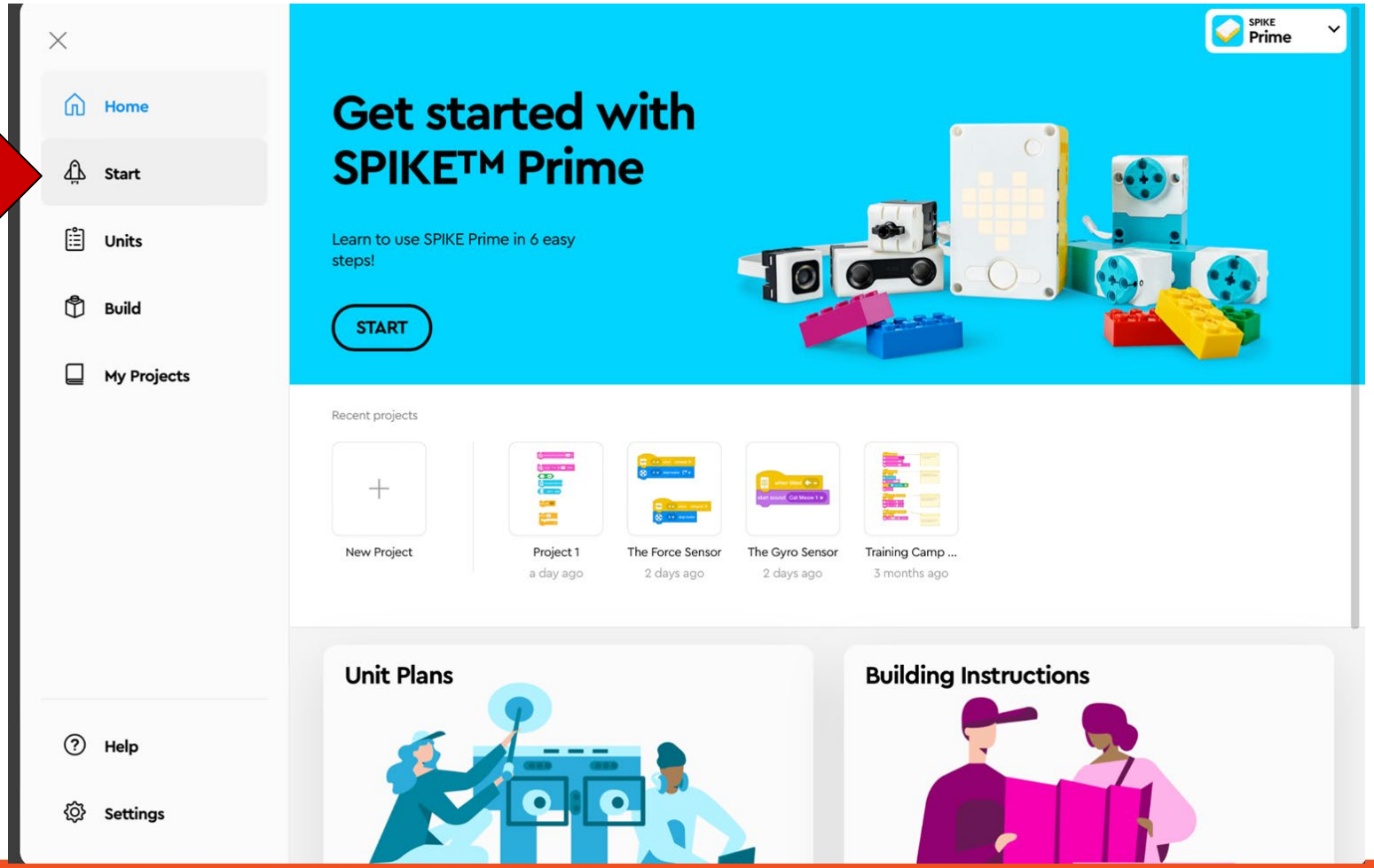
On you iPad find the LEGO SPIKE App.

Open the App and follow along.

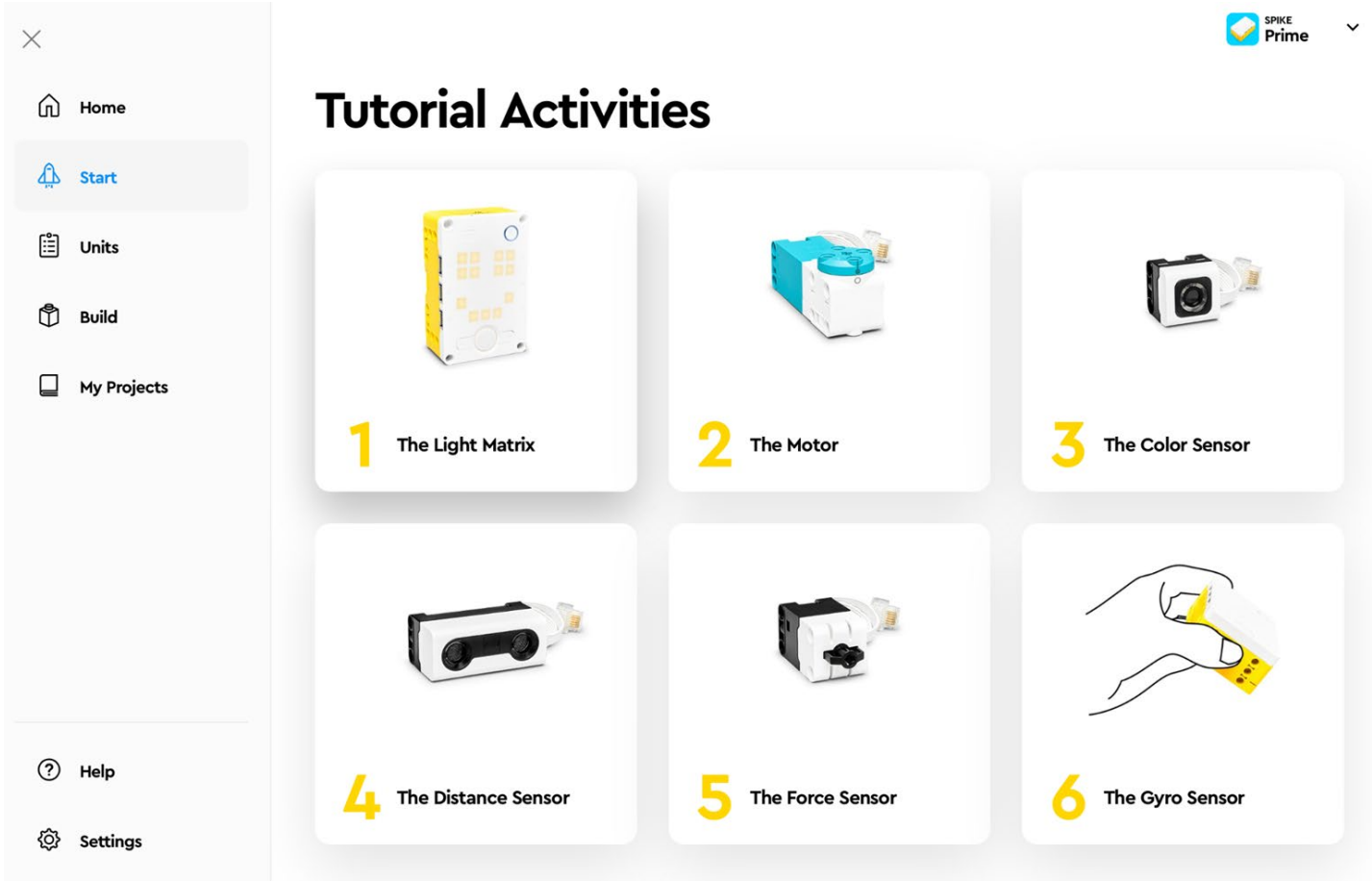
LEGO® APP and Tutorials



LEGO® APP and Tutorials



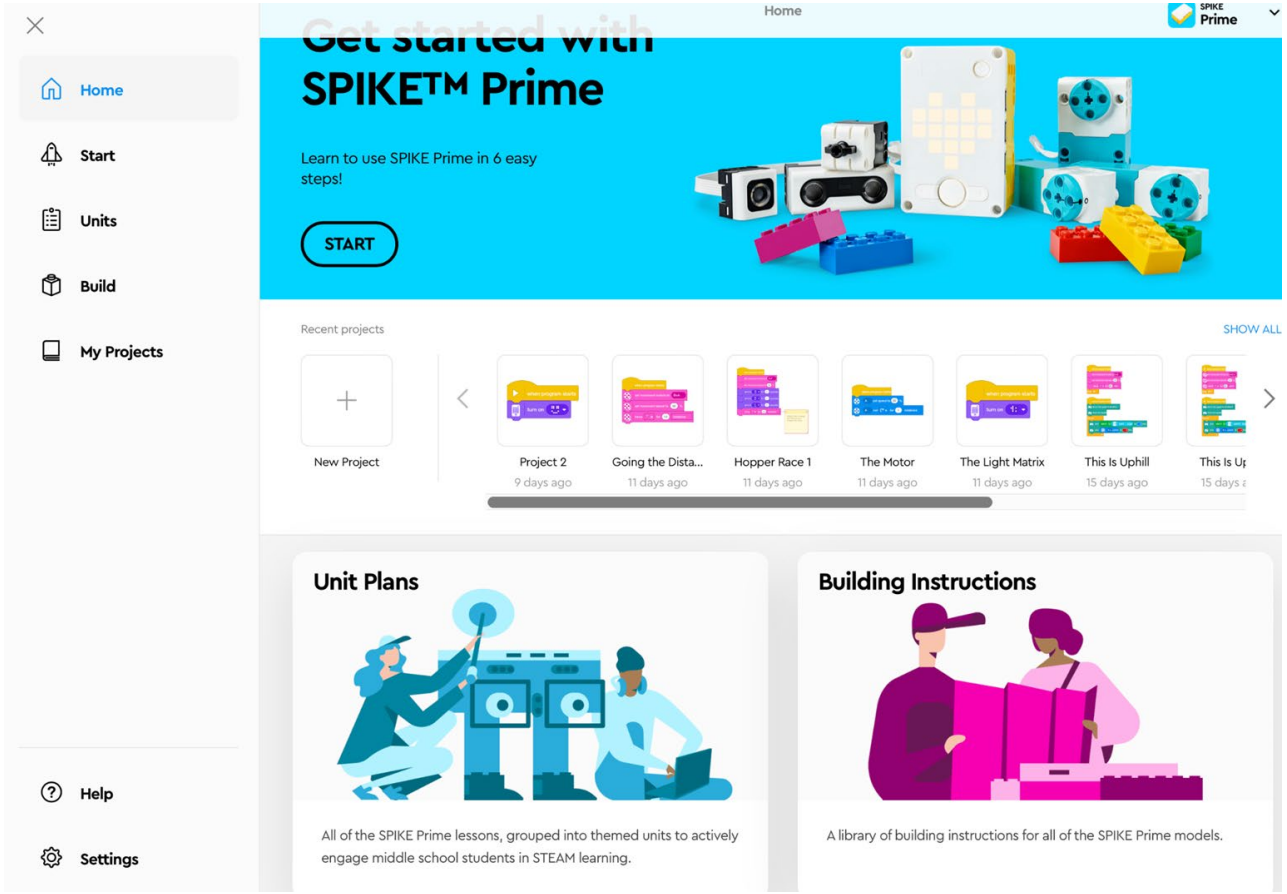
LEGO® APP and Tutorials



Activity 1

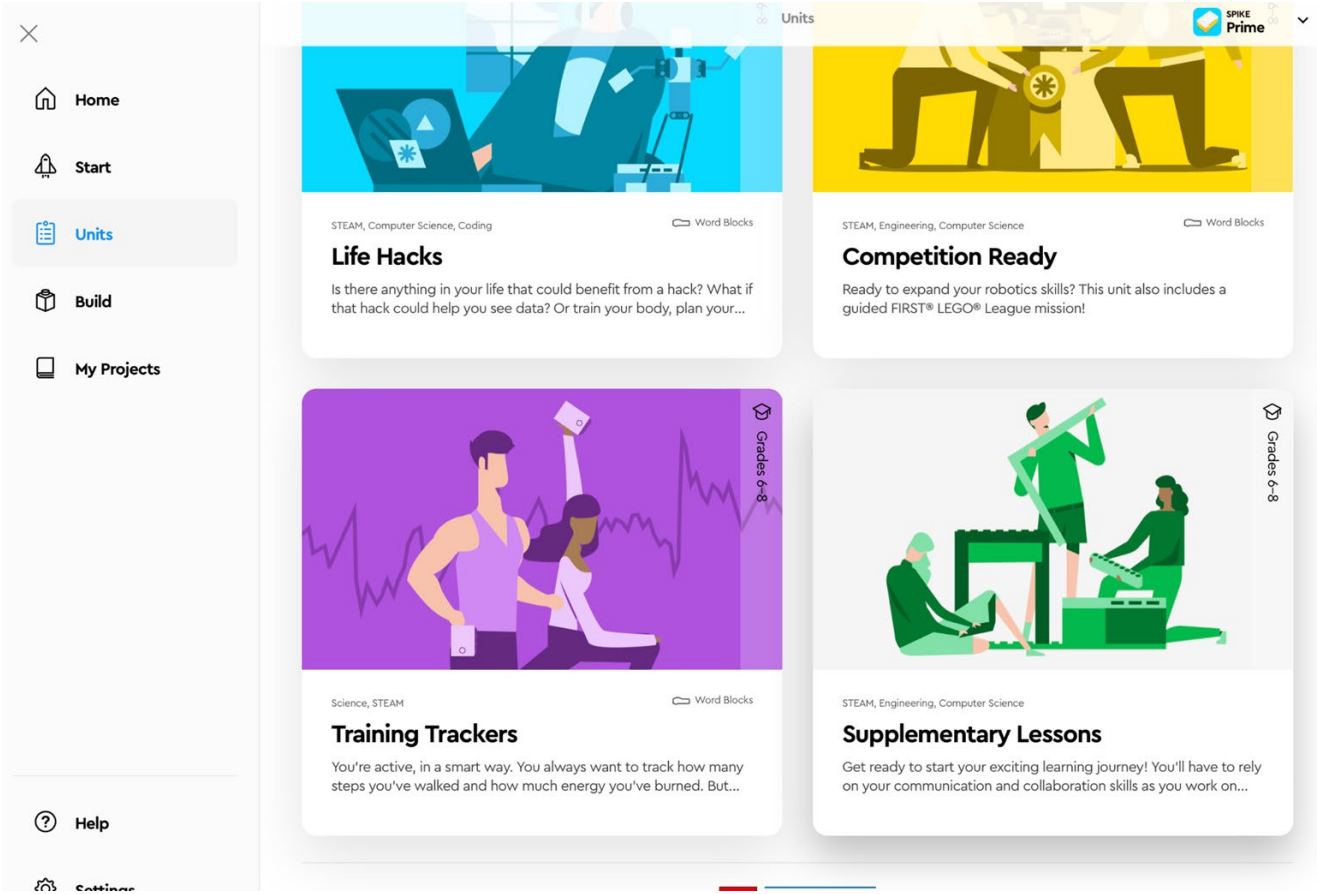
Let's Begin Building

- Now that you are familiar with your equipment, let's start our first project.
- Click **Home**
- Click on **Unit Plans**



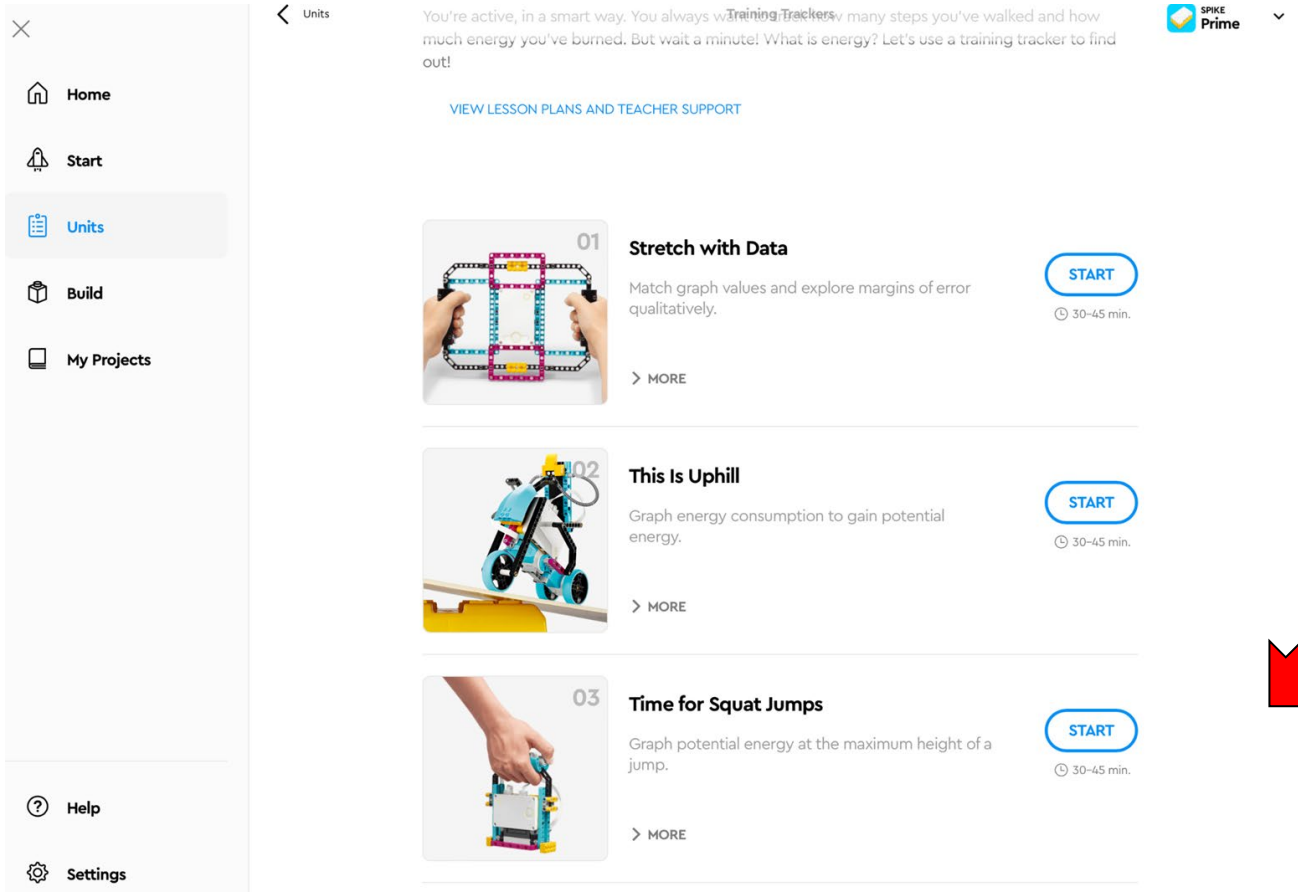
Training Trackers Lesson

- Scroll down and Find **Training Trackers**



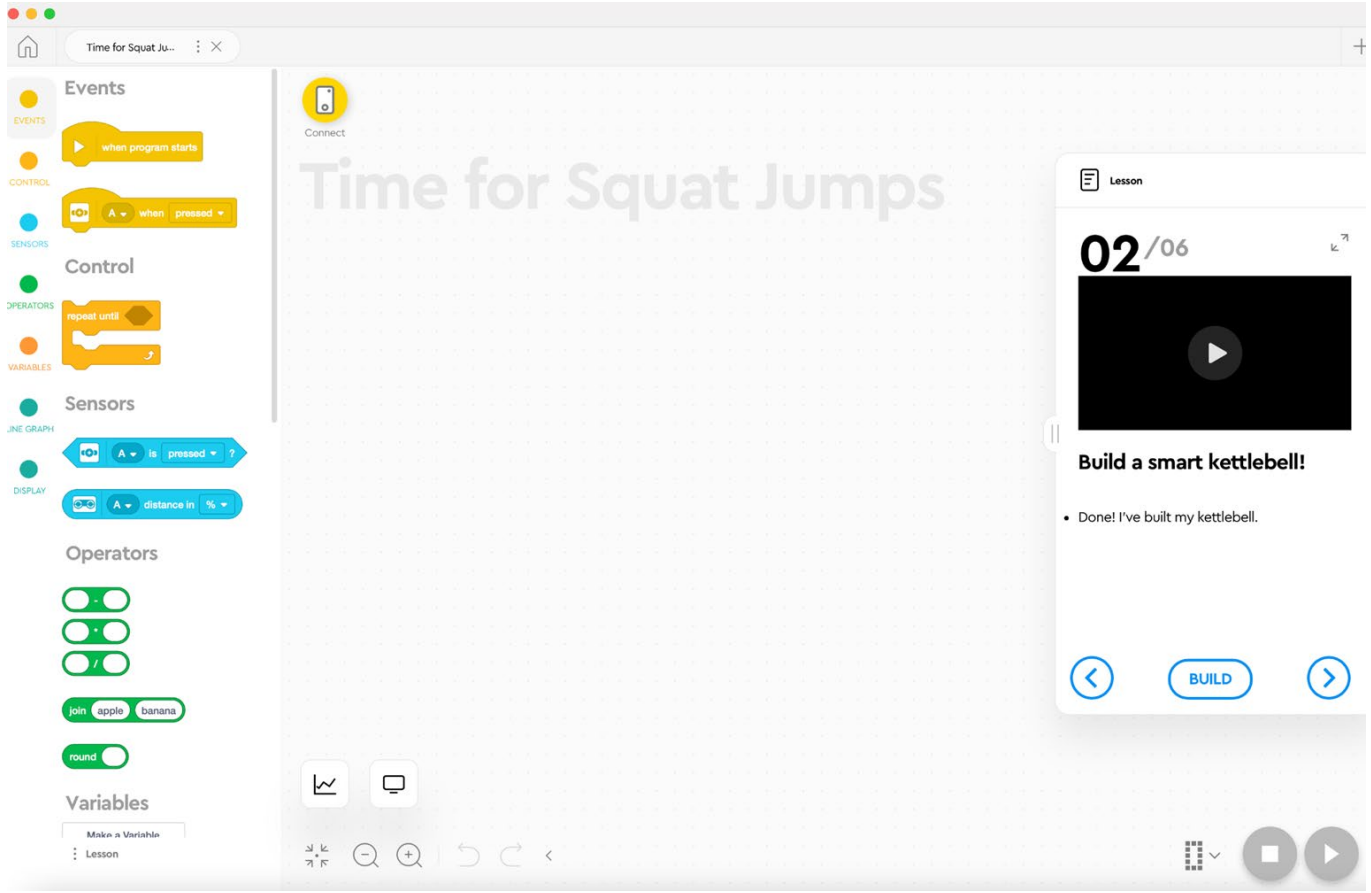
Training Trackers Lesson

- Scroll down to the third lesson:
  - Time for squat jumps
- Click Start
- Watch the Video



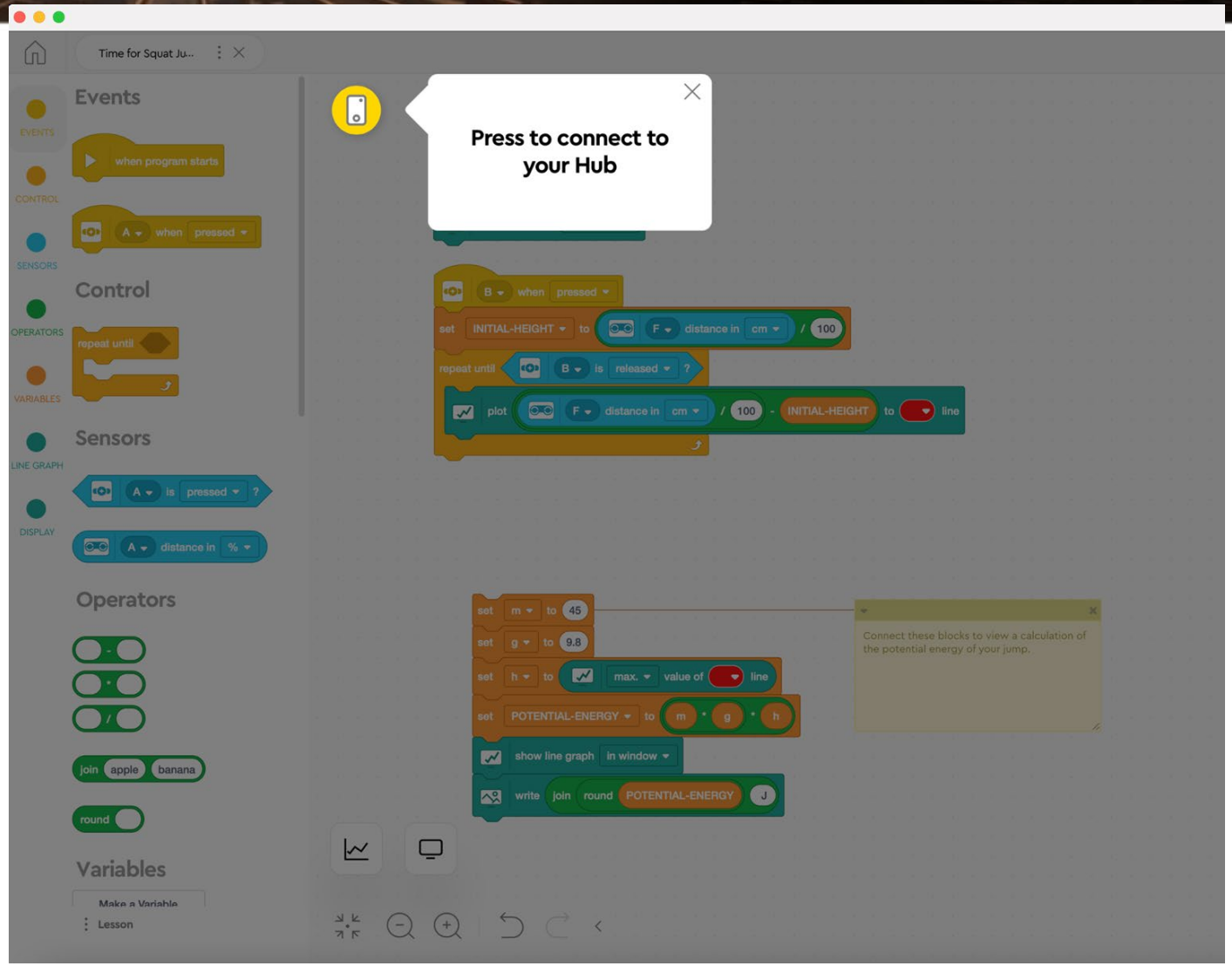
Training Trackers Lesson

- Click on the arrow on the right hand side to go on to step 2
- Click the Build Button
- Follow the Building Instructions



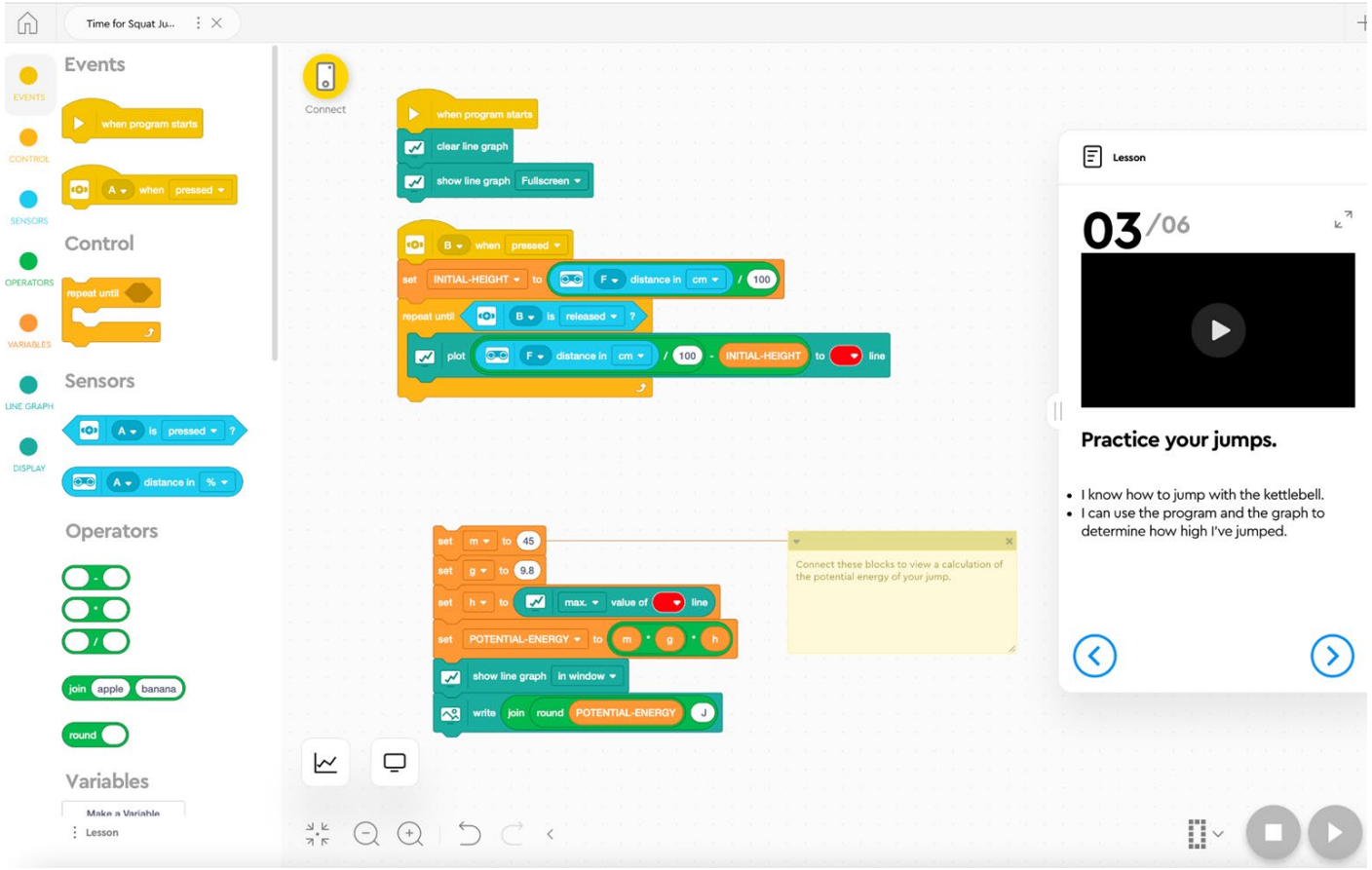
Pairing Your Hub

- Follow the steps on your screen to pair your iPad to your Hub.



Practice Your Jumps

- Try out your model using the suggested program.
- Ensure that you jump in a very controlled way:
  - Pointing the kettlebell straight toward a smooth surface



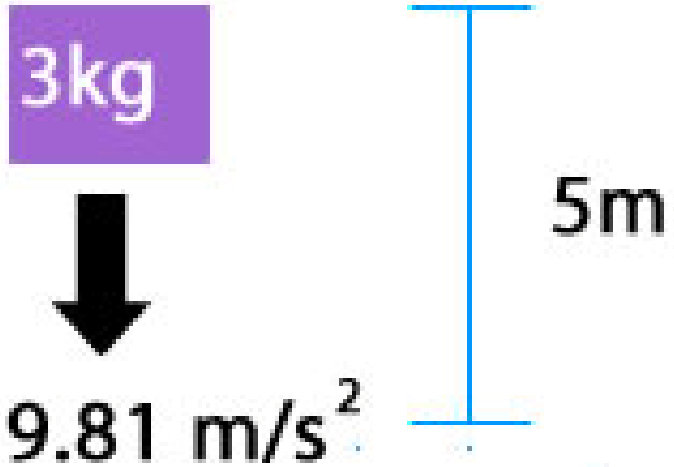
Calculating for Potential Energy

Potential Energy = m * g * h

- m = mass (kg)
- g = gravity (9.8 N/kg)
- h = height

Potential Energy (Joules)

Calculating for Potential Energy



Pe = m * g * h

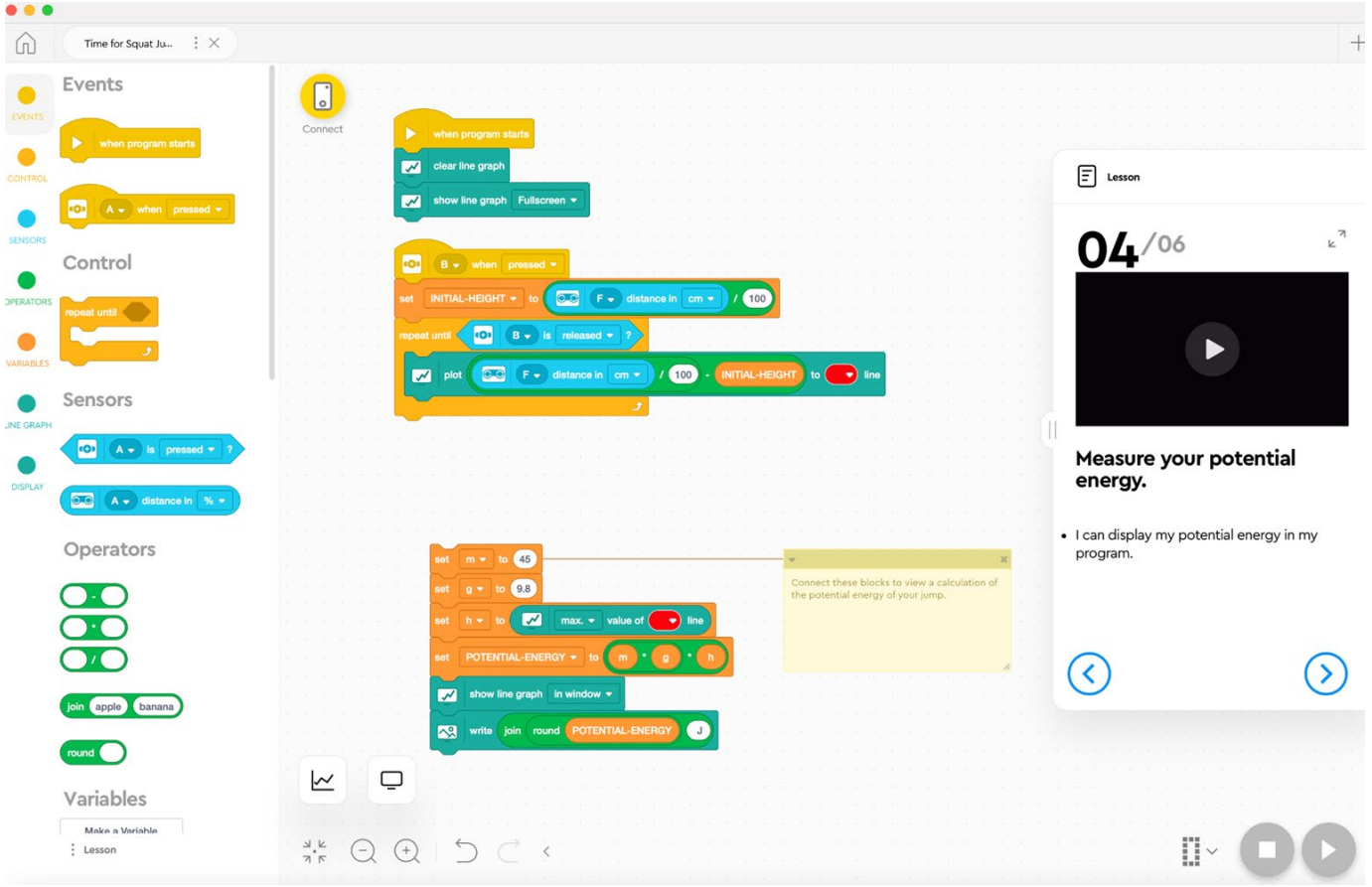
Potential Energy = m * g * h

- m = mass (kg)
- g = gravity (9.8 N/kg)
- h = height

Let's Practice Calculating for Potential Energy

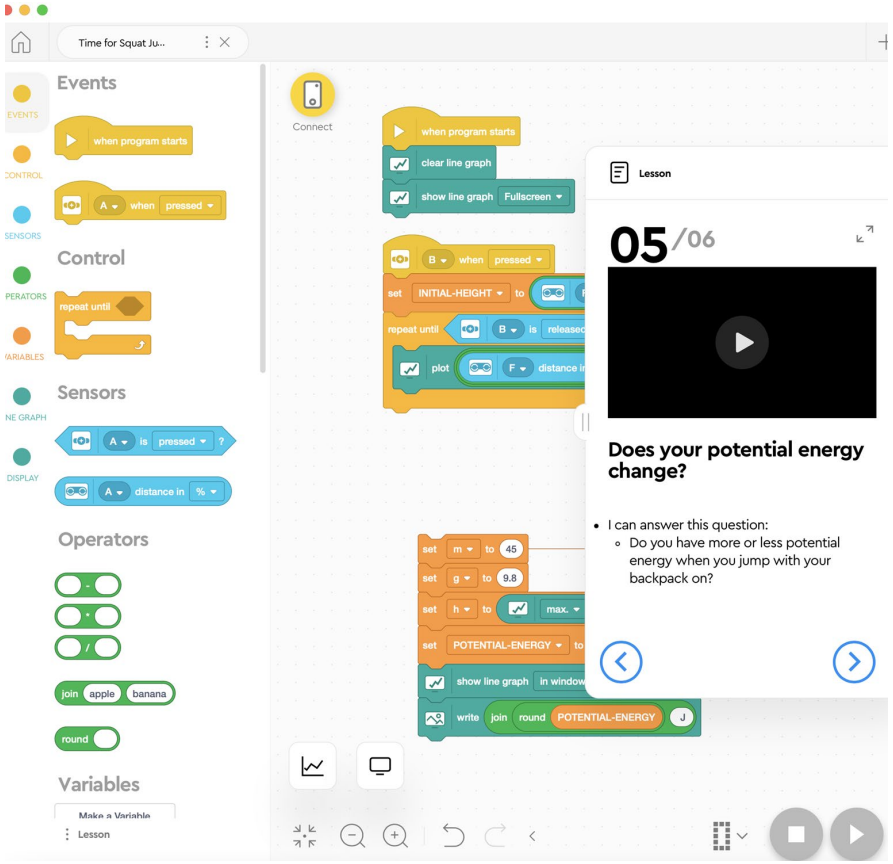
Measure Your Potential Energy

- Try out your model
- Calculate your Potential Energy
- Use the following:
  - gravity (round off to 10)
  - mass (if you don't know your mass use 45 kg)
  - height (gather data from the app)



Manipulating Potential Energy

- Try jumping with your backpack on, or carrying something.
- Use the following:
  - gravity (round off to 10)
  - mass (if you don't know your mass use 45 kg)
  - height (gather data from the app)



Evaluating Your Experience

- How well did you and your team do?
- What did you do well?
- Is there anything you could have done better?
- What did you learn about Potential Energy and how it is affected by:
  - height
  - mass

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

Day 2
Part 2

Activity 2

Smart Bike

Time to Build Again!

Roles and Responsibilities will be rotated.

1. Computer Science Engineer: will control the iPad
2. Materials Engineer: will gather parts
3. Mechanical Engineer: will put the pieces together
4. Industrial Engineer: will evaluate and improve production (ensure team is on task and working cooperatively)

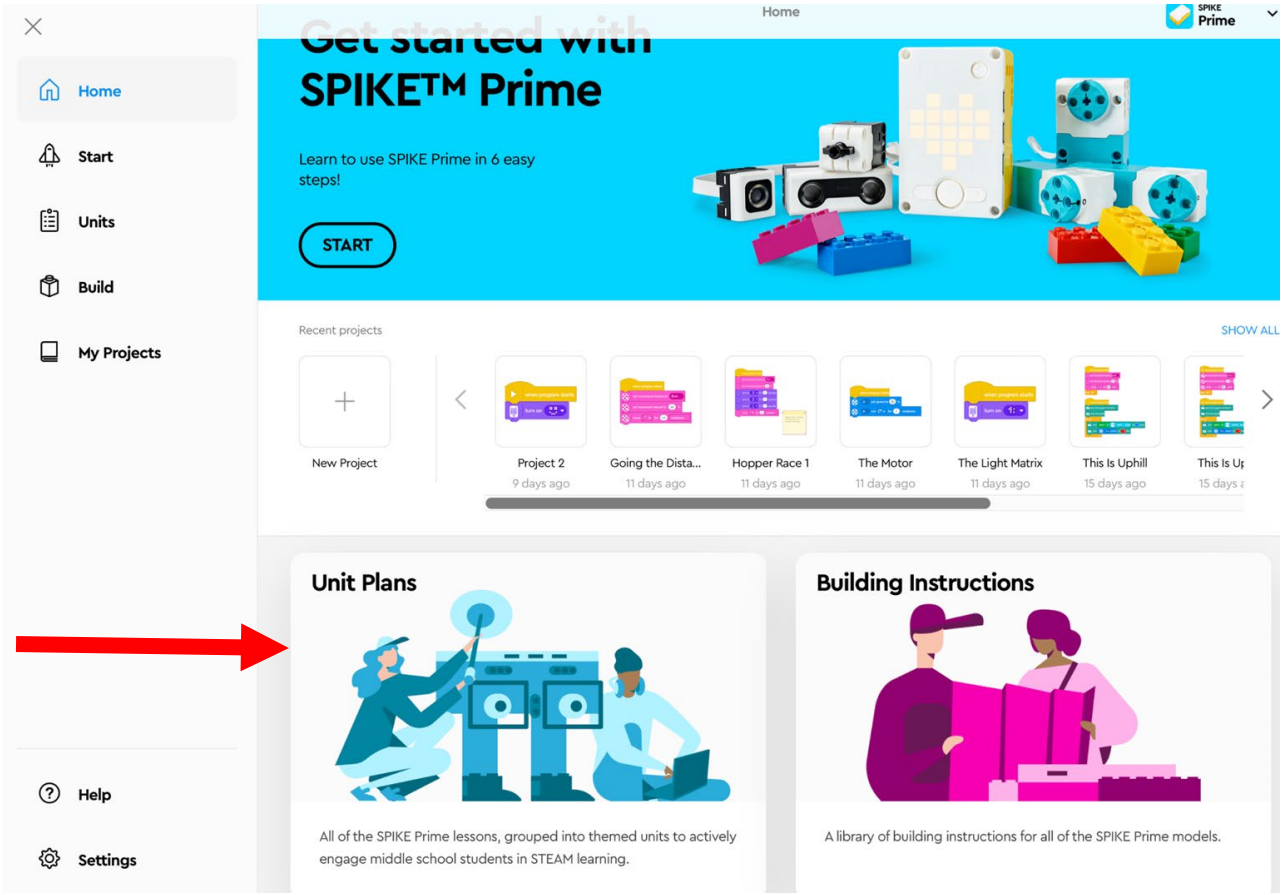
Roles and Responsibilities

Assign the following roles for this build. We will be rotating roles as we will be building numerous times throughout the week.

1. Computer Science Engineer: will control the iPad
2. Materials Engineer: will gather parts
3. Mechanical Engineer: will put the pieces together
4. Industrial Engineer: will evaluate and improve production (ensure team is on task and working cooperatively)

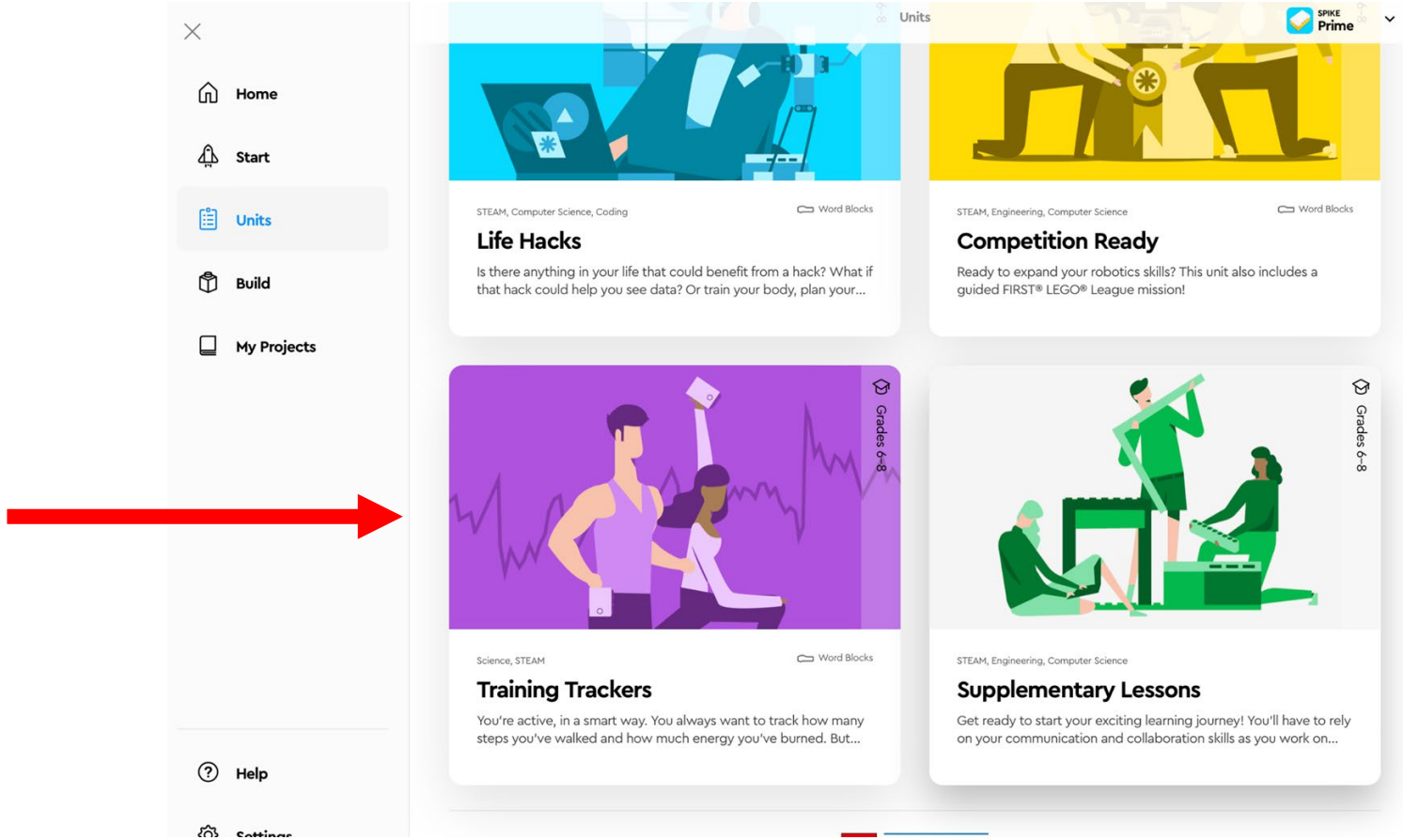
Let's Begin Building

- Now that you are familiar with your equipment, let's start our second project.
- Click Home
- Click on Unit Plans



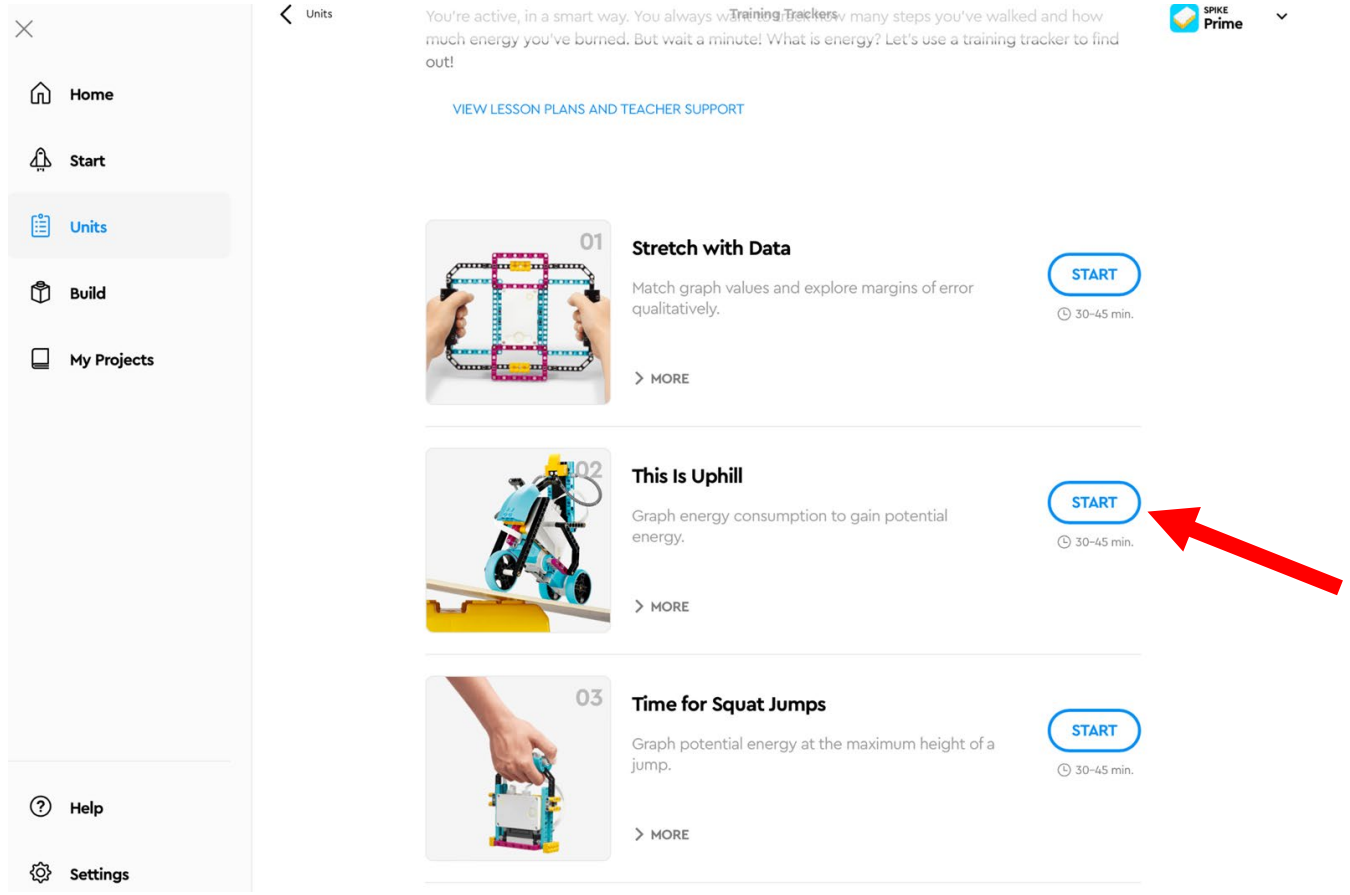
Training Trackers Lesson

- Scroll down and Find Training Trackers



Training Trackers Lesson

- Scroll down to the second lesson:
  - This is Uphill
- Click Start
- Watch the Video
- Follow the steps



Evaluating Your Experience

- How well did you and your team do?
- What did you do well?
- Is there anything you could have done better?
- How would you summarize your experiment?
- Can you describe one way to gain potential energy?

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

Cleanup

Make sure students:

- look around the floor
- count, and put all materials back in the box
- ensure no Lego parts are missing, misplaced, or left behind.

Plug your block in to charge.

Cleanup and Closing Discussion

1. How was today's challenge applicable to Railway Engineering?
2. What are some real challenges engineers face?
3. What are some of your team's strengths and weaknesses?

End of Day 2

Day 2 References

Furey, Edward "Gravitational Potential Energy Calculator" at https://www.calculatorsoup.com/calculators/physics/gravitational-potential.php from CalculatorSoup, *https://www.calculatorsoup.com* - Online Calculators (Slide 30)

(2024). *Lego Spike Prime*. Welcome to our Teacher Resources. https://education.lego.com/en-us/

Day 3

- Balloon Race
- Speed
- Forklift

Reminders and Procedures:

- Roll Call
- Housekeeping Rules
  - Must wear shirt everyday
  - Restroom only when accompanied by an adult
  - NO Electronic devices unless instructed
  - Be active, engaged and participate in your group
  - Be respectful and leave room organized

Objectives:

- The evolution of trains and their speed.
- Calculate speed
- Implement the Engineering Design Cycle (Process)
- Investigating the Wheel-Axle Assembly

Let's talk about the history & **SPEED** of Trains

Railcarts were pulled by people or horses

Glacier Express

The **SLOWEST** in

the world, which runs at **24 miles per hour**

(*Average running human's speed is 18 mph. Usain Bolt's speed is 27.8 mph*

Used mainly for travel.

The Jacobite

Steam locomotive train.
Runs at **50 miles per hour**

Train was used in the movie Harry Potter!

Acela Express

Runs at approximately **150 miles per hour**

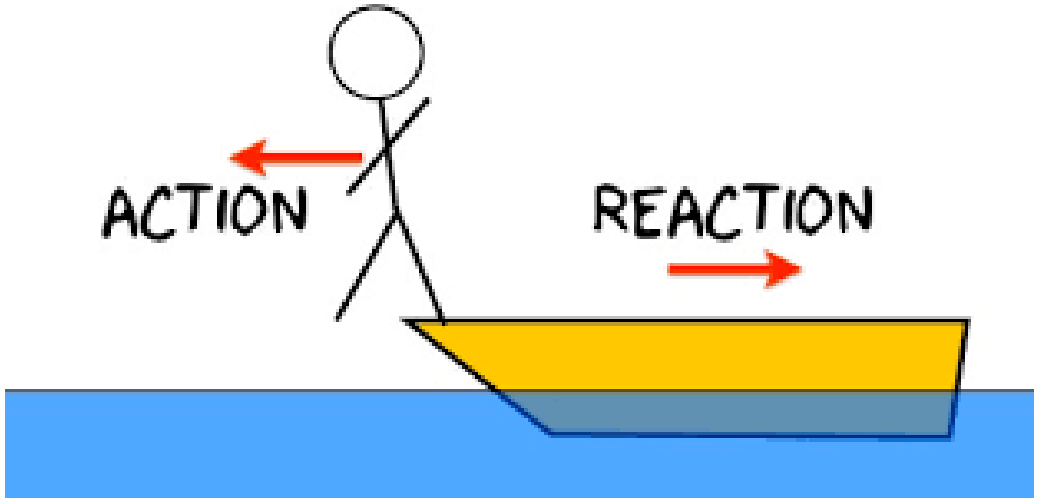
This is a tilting train

Shanghai Maglev

Most **FASTEST** in the world!
Runs at **267 miles per hour**

Runs by magnetic levitation.

Newton's Third Law of Motion



Rocket Balloon Racing

Materials:

- fishing line
- balloons
- tape
- plastic straws

We are going to conduct a little experiment to investigate jet **propulsion**, **aerodynamics** and **friction**.

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 project?
4. How is this activity **like working on your project with your team**?
5. what are some improvements you would like to implement?

Engineering Design Cycle (Process)

Process and Procedure

1. You will be working with robots to learn more about transportation engineering.
2. You will be building and programming your own robot.
3. Teams will construct a basic robot from LEGO® SPIKE® Prime robotics kit using the LEGO® Education SPIKE Prime App .

Process and Procedure

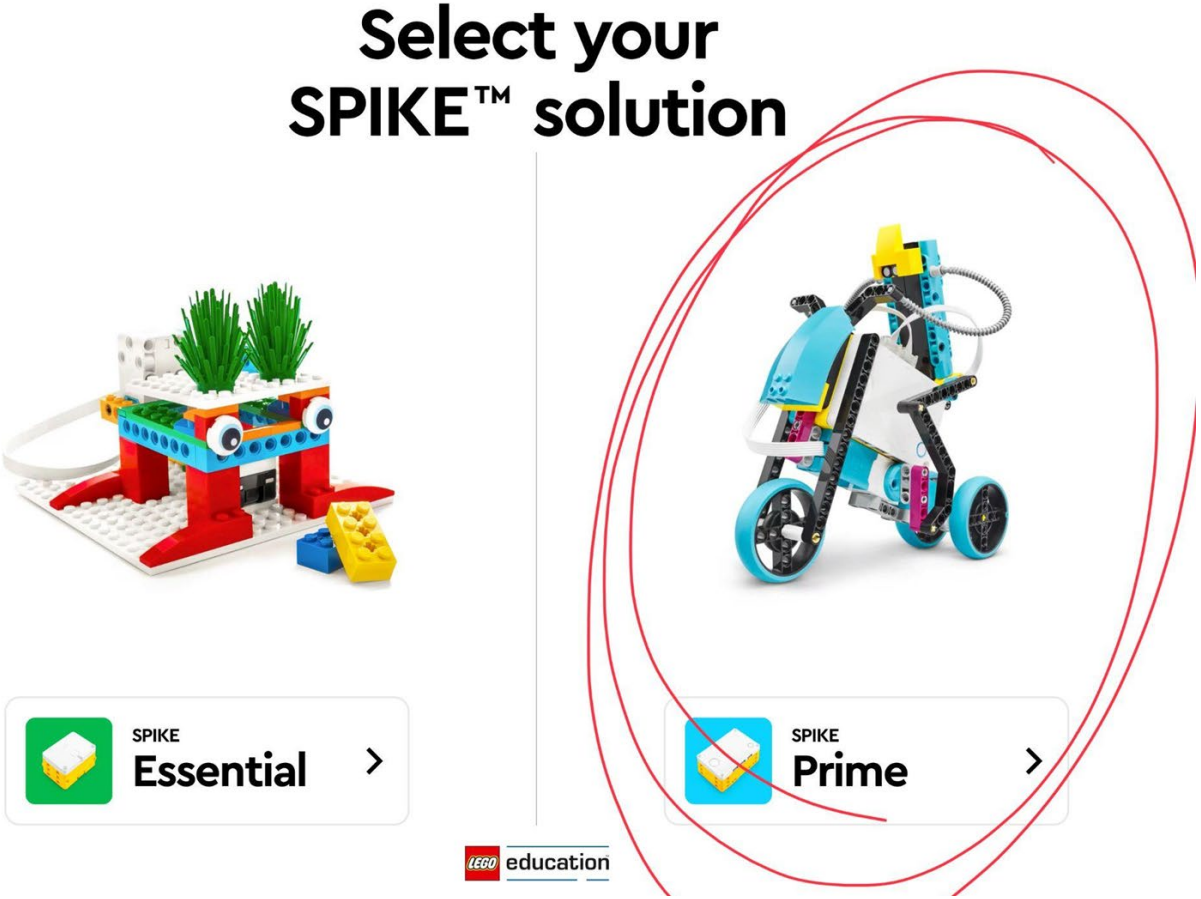
- For each round of three steps, you will be changing roles:
  - The function of the “lead engineer” is to construct the robot. The rest of the team will be “assistant engineers”. Assistants look for parts and help the lead engineer.
  - There are about 600 pieces in each robot kit. Those functioning as “assistant engineers” have the responsibility to manage pieces, including taking care to not lose or misplace any of the parts.

Roles and Responsibilities

Assign the following roles for this build. We will be rotating roles as we will be building numerous times throughout the week.

1. Computer Science Engineer: will control the iPad
2. Materials Engineer: will gather parts
3. Mechanical Engineer: will put the pieces together
4. Industrial Engineer: will evaluate and improve production (ensure team is on task and working cooperatively)

Programming Basics



Unit Plans

All of the SPIKE Prime lessons, grouped into themed units to actively engage middle school students in STEAM learning.

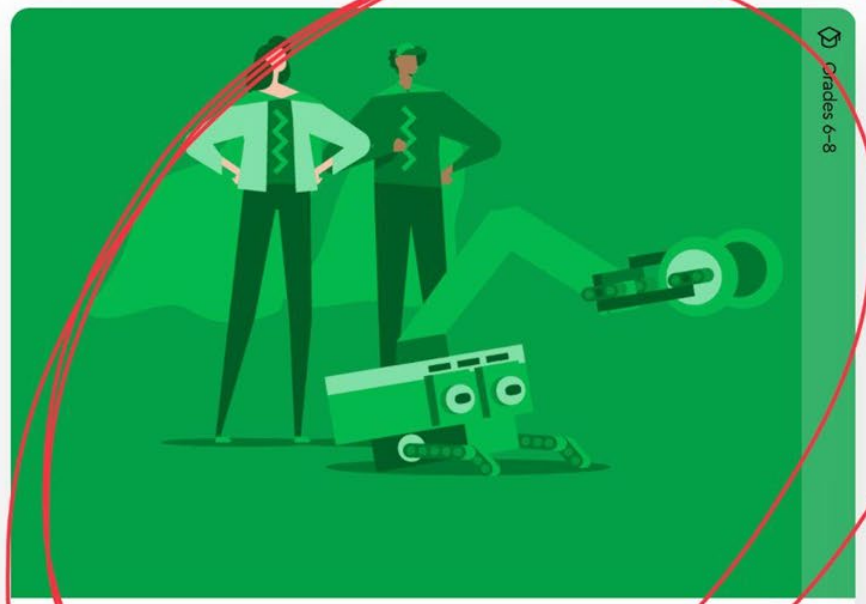
Building Instructions

A library of building instructions for all of the SPIKE Prime models.

Home | Start | Units | Build | My Projects | Help | Settings

Unit Plans

VIEW LESSON PLANS AND TEACHER SUPPORT



STEAM, Engineering

Word Blocks

Invention Squad

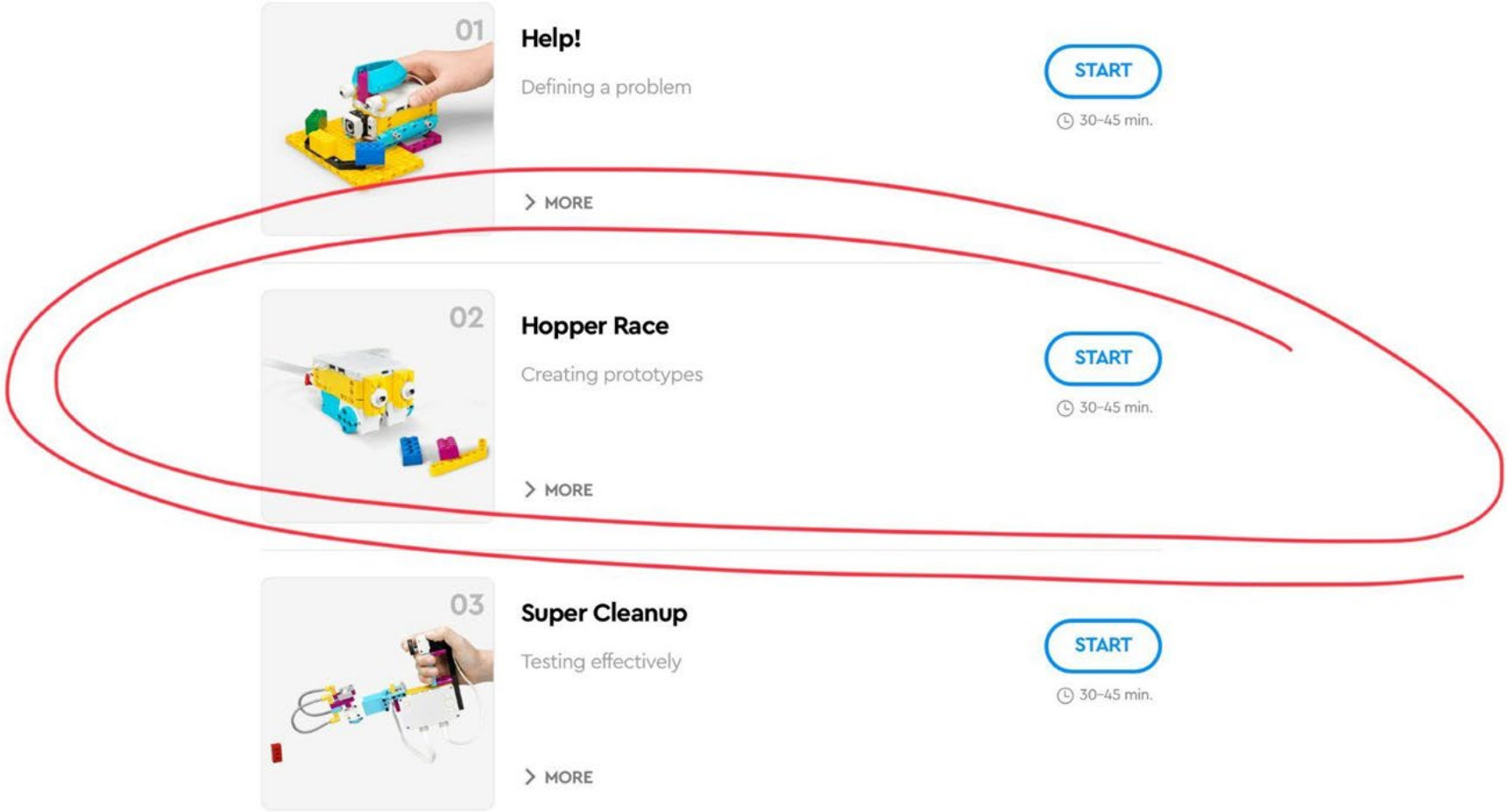
Inventing stuff? Fixing stuff? Always helping people with your ideas? Then you might be an elite member of the Invention Squad!...

STEAM, Computer Science, Coding

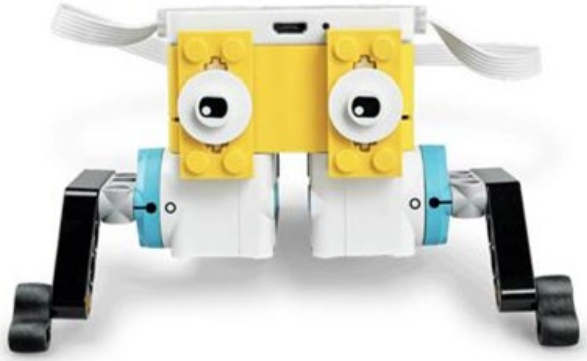
Word Blocks

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, so get ready to transform your thoughts into...

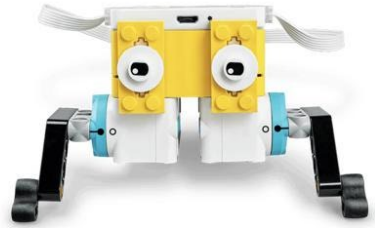

01
Help!
Defining a problem
START
30–45 min.
MORE
02
Hopper Race
Creating prototypes
START
30–45 min.
MORE
03
Super Cleanup
Testing effectively
START
30–45 min.
MORE
Home
Start
Units
Build
My Projects
Help
Settings

Let's Build!



Lesson

02/07



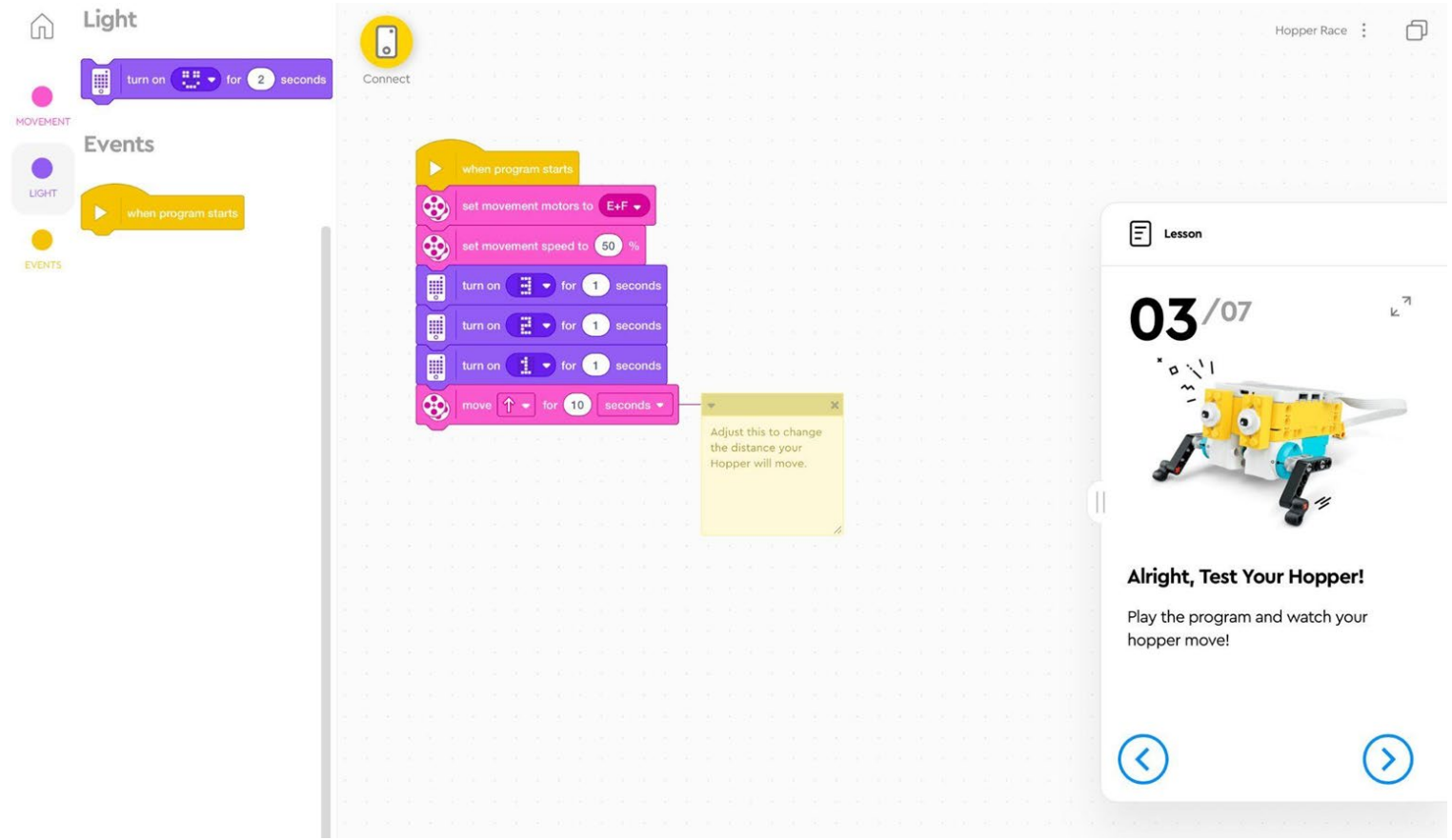
Build your Hopper.

You'll start here.
You'll test this one and then modify it to (hopefully) create the fastest hopper!

BUILD

Pairing and Observations

- Follow the instructions prompted on your screen.
- Pair your robot.
- Press play and make observations.
- Make sure you read the yellow block.

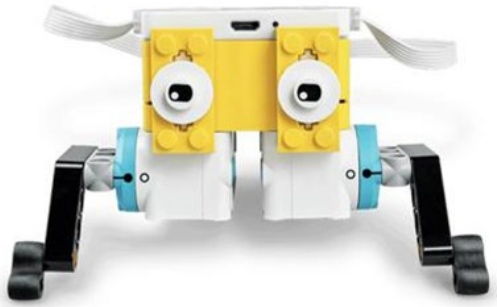


Let's Reflect...

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. What are some improvements you would like to make to your robot?

It's Time for a Prototype!

LEGO education SPIKE™



Lesson

04/07

Prototype New Legs

Come up with at least 2 new ideas to make your Hopper move even faster. **Remember:** Anything's possible, but no wheels!

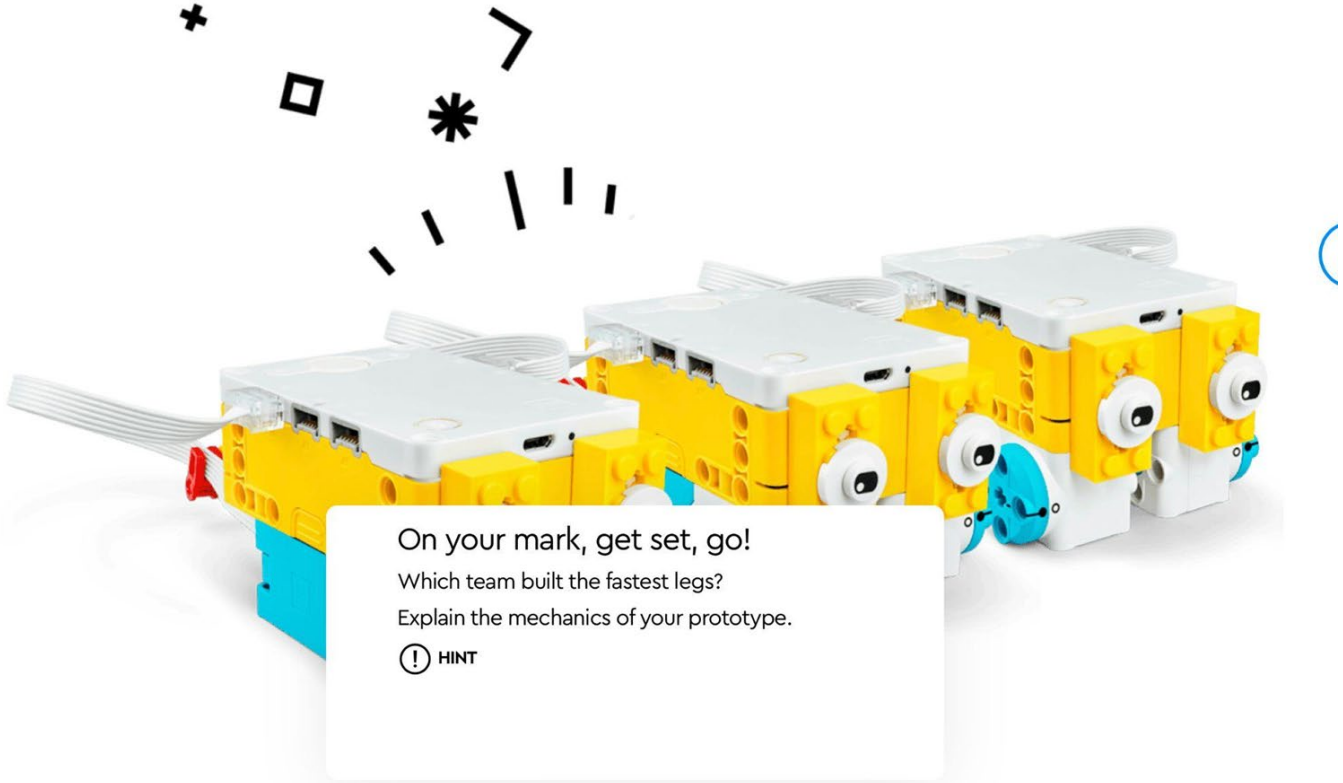
Let's Calculate Your Bot's Speed!

1. Set your bot to move for 10 seconds.
2. Measure the distance traveled in centimeters.
3. Divide the distance(cm) traveled by time(s).

$$speed = \frac{distance}{time}$$

Time to Race!

- Take your prototype to the starting line.
- Make careful observations, as we will be racing one more time.



Calculating the winning bot's speed…

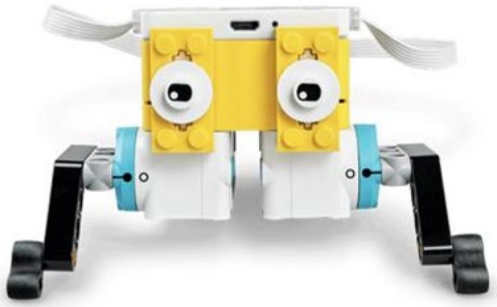
1. Set your bot to move for 10 seconds.
2. Measure the distance traveled in centimeters.
3. Divide the distance(cm) traveled by time(s).

$$speed = \frac{distance}{time}$$

Let's Reflect...

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. What are some improvements you would like to make to your robot?

Make Modifications!

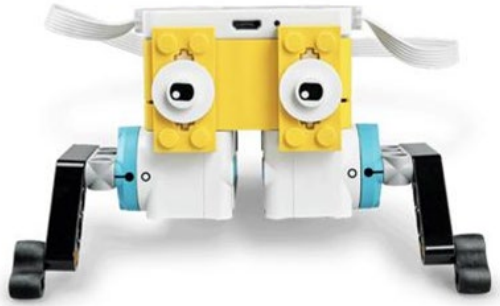


LEGO education SPIKE™

This time, Add WHEELS!

Time to Race!

- Take your prototype to the starting line.
- Make careful observations, you will be calculating the speed of your robot with wheels.



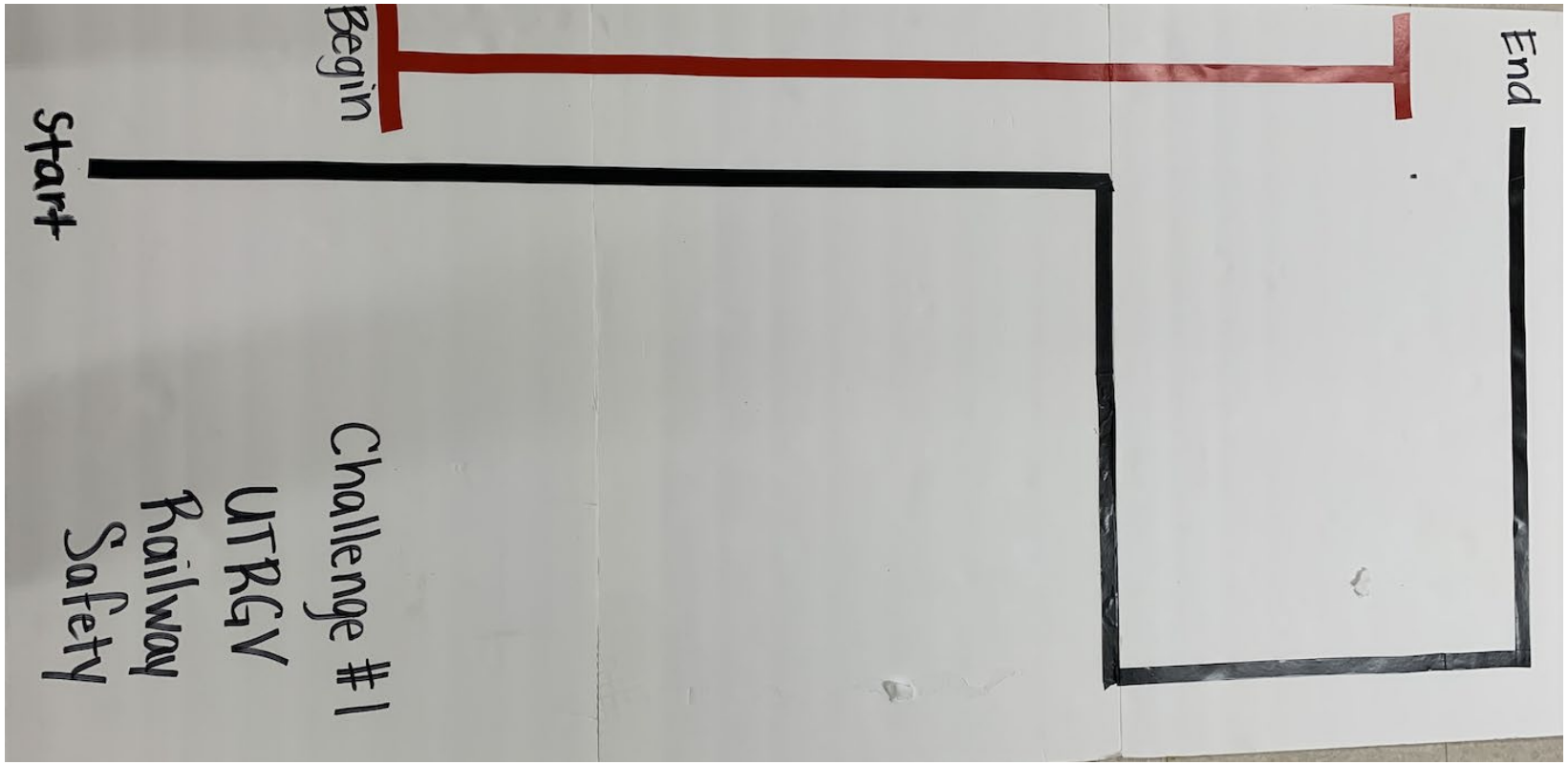
Calculating the winning bot's speed…

1. Set your bot to move for 10 seconds.
2. Measure the distance traveled in centimeters.
3. Divide the distance(cm) traveled by time(s).

$$speed = \frac{distance}{time}$$

Additional Maze Challenge

If time allows students will create a maze similar to picture and calculate the time it takes their robot to complete.



Let's Reflect...

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. What are some improvements you would want to make to your robot?
4. What did you learn about the efficiency of vehicles with wheels?
5. Next, we are going to explore the design, efficiency and engineering behind train wheels.


UNIVERSITY TRANSPORTATION CENTER FOR
RAILWAY SAFETY
Award Number: 69A3552348340
NSF
Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)
Award Number: 2112650

Day 3: Part 2

Wheel-Axle Assembly

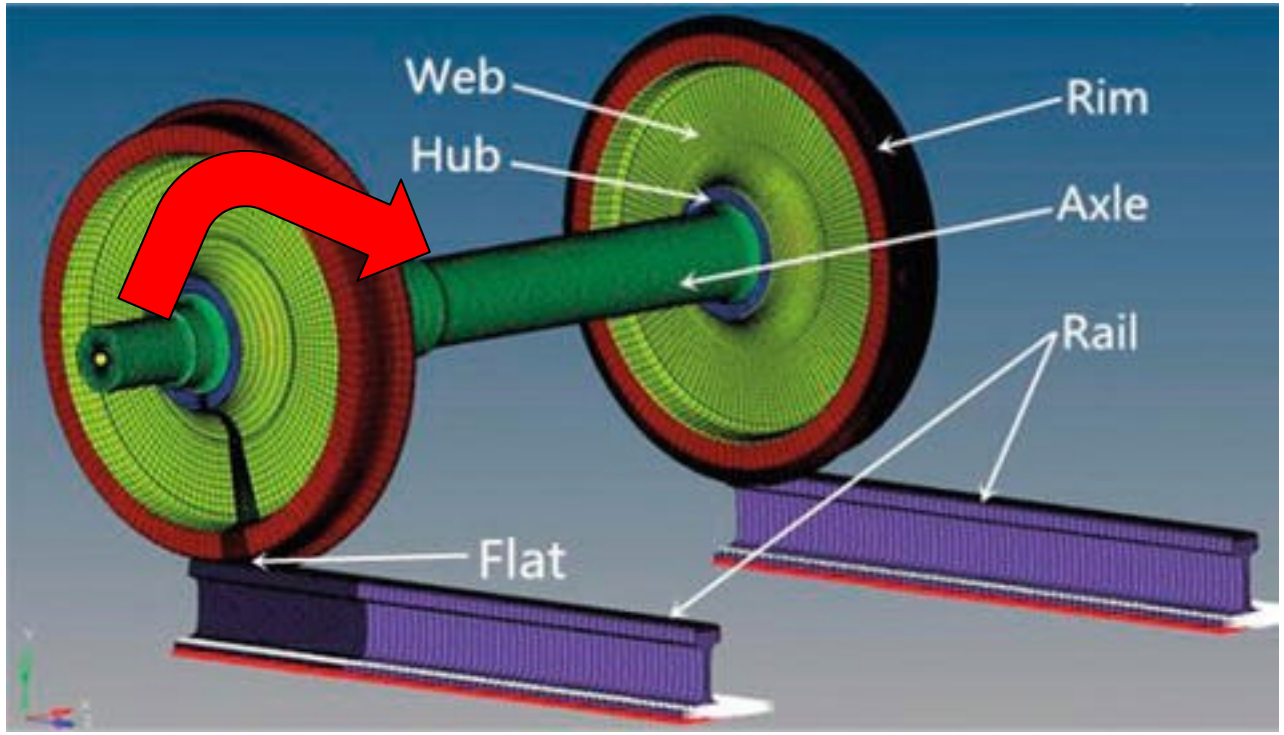
The axle connects both wheels where they move together while traveling at the same speed.

Approximately weighs 400 pounds (depending on size & material)

Wheel-Axle Assembly

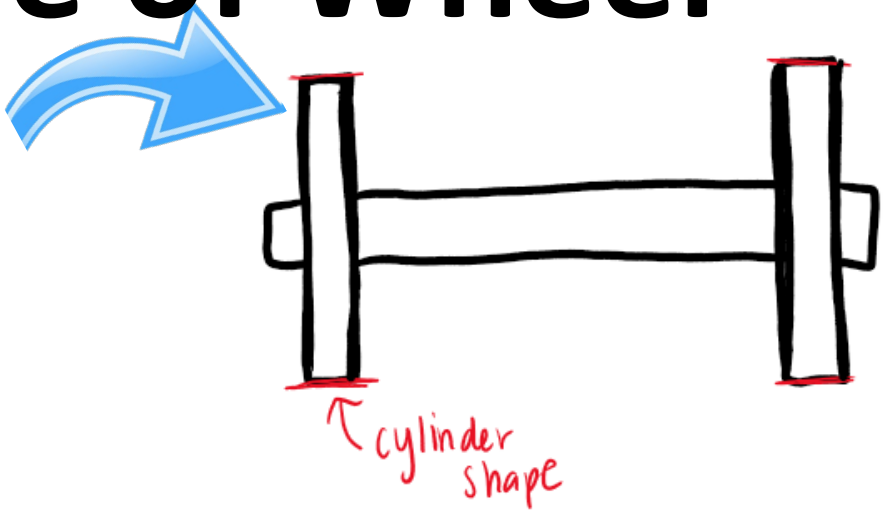
The axle connects both wheels where they move together while traveling at the same speed.

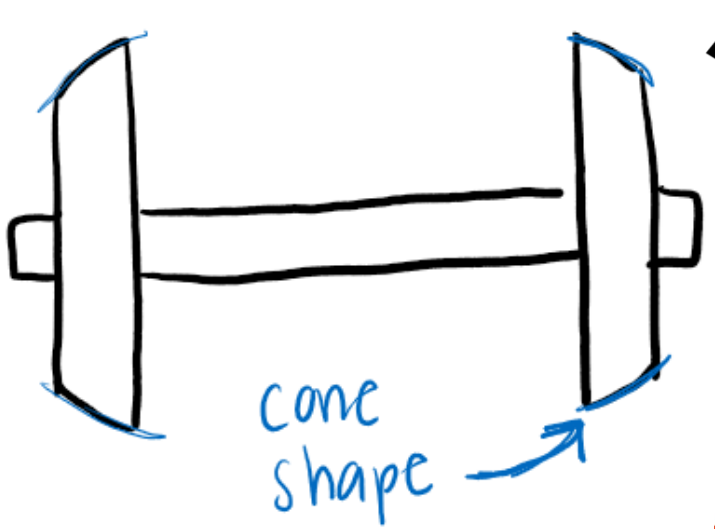
Approximately weighs 400 pounds (depending on size & material)



Shape of Wheel

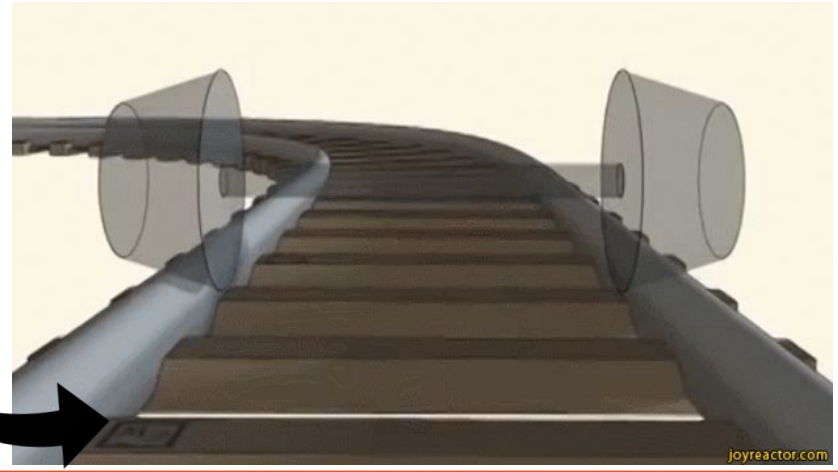
Wheels are **NOT** completely cylindrical.





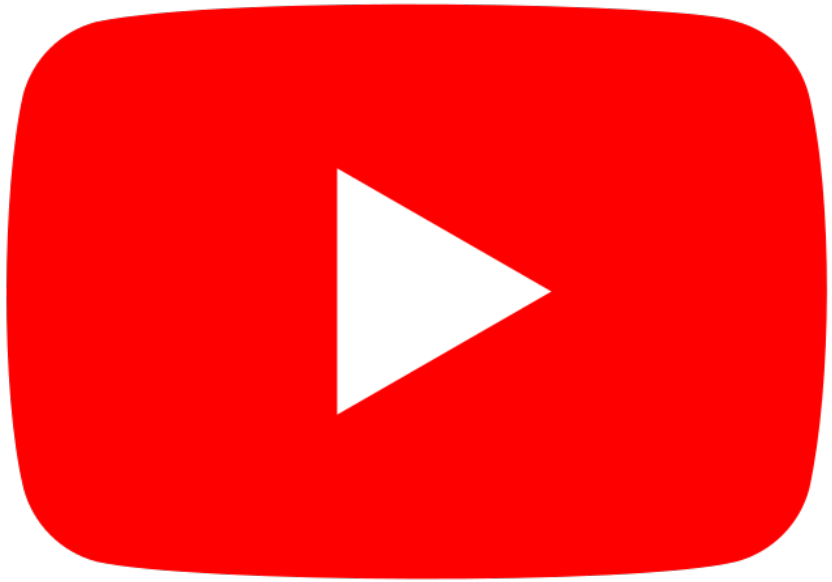
They are **cone shaped**.

This helps a train turn at different speeds.



Let's Explore Train Wheel Science

In this activity you will put different wheel shapes to the test to find out why the conical wheel is superior to other designs.



Roles Within Your Group

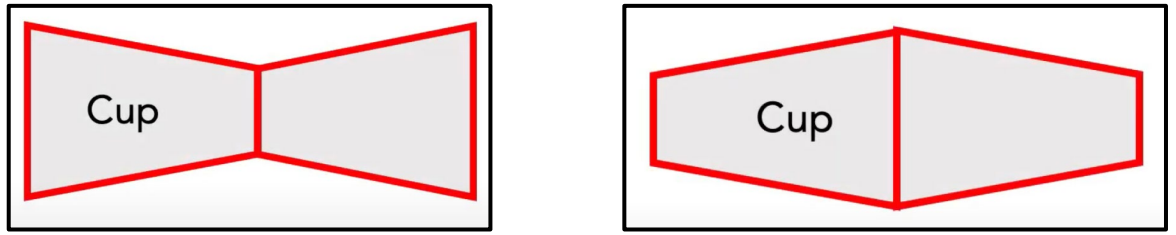
1. **Lead Engineer** - responsible for making sure tasks are completed efficiently on time.
2. **Mechanical Engineer** - Oversee motors and sensors and make sure the wires are also plugged in correctly.
3. **Manufacturing Engineer** - Oversees and leads the building process, make sure that the build is complete and works.
4. **Electrical/Software Engineer** - Programming and functions of robot, make sure that the program is set to complete the tasks.

Materials

- 4 cups
- tape
- 2 meter sticks
- 1 box

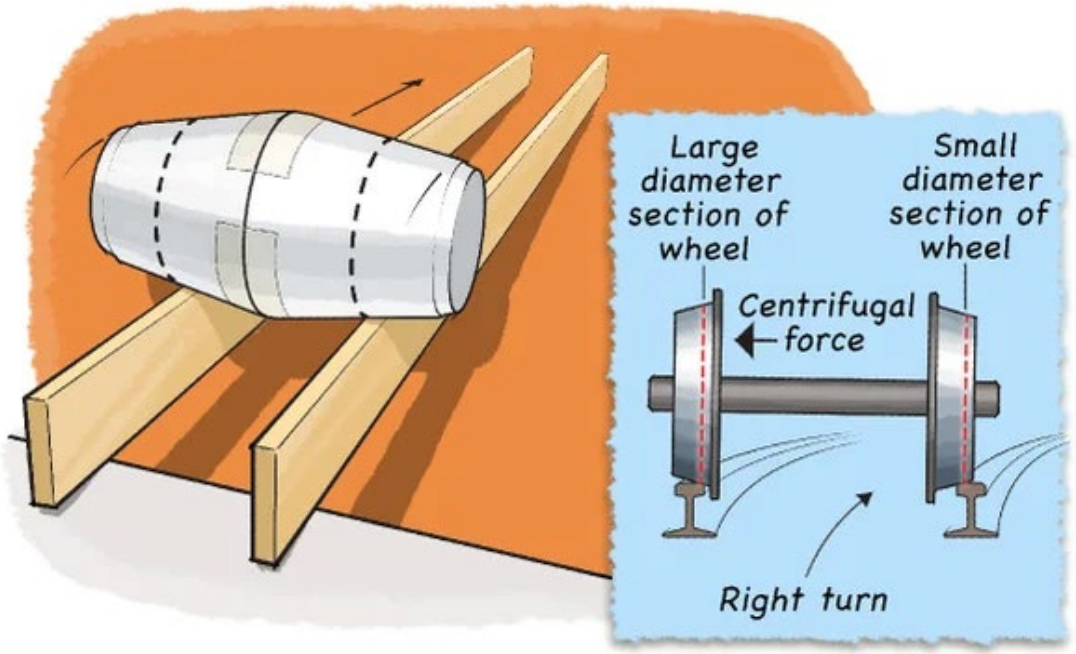
Procedure

1. Tape 2 cups together to form the 2 sets of wheels.



1. Set up the two yard sticks into an inclined plane and tape them in place.
2. Place your cups (wheels) at the top and let it drop.

A Glance of how cone-shaped wheels adjust to turns & errors



How Are They Damaged?

Most of the time is due to **sudden braking(stopping)**.

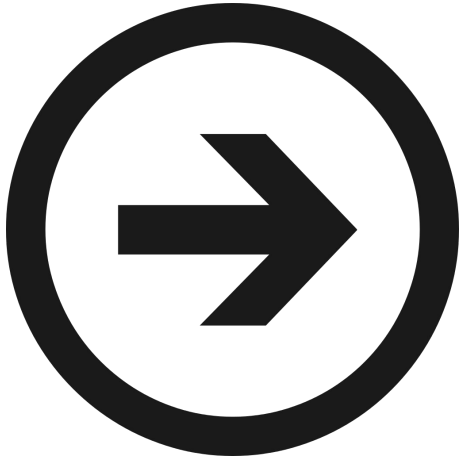
The **more weight & load the freight train carries, the more dangerous** it can become.

Train Derailments

What caused the train derailment in Ohio? Could it have been prevented?

What can we do?

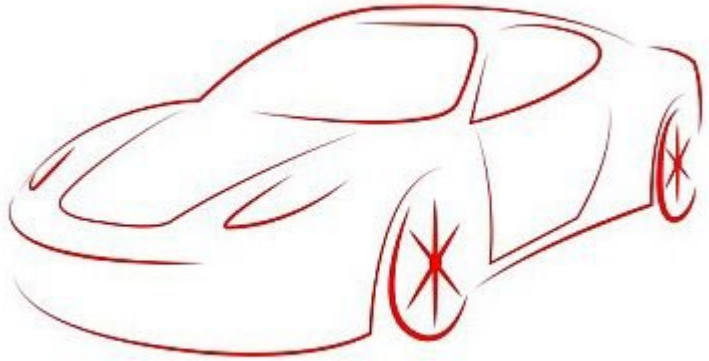
Severe braking over time can cause **fractures, scrapings & deterioration of the Wheel-Axle Assembly**...which can then cause **accidents**.



This needs **maintenance** very frequently. This is where Rail Flaw Detection can be used to **avoid** such accidents and failures.

Also...

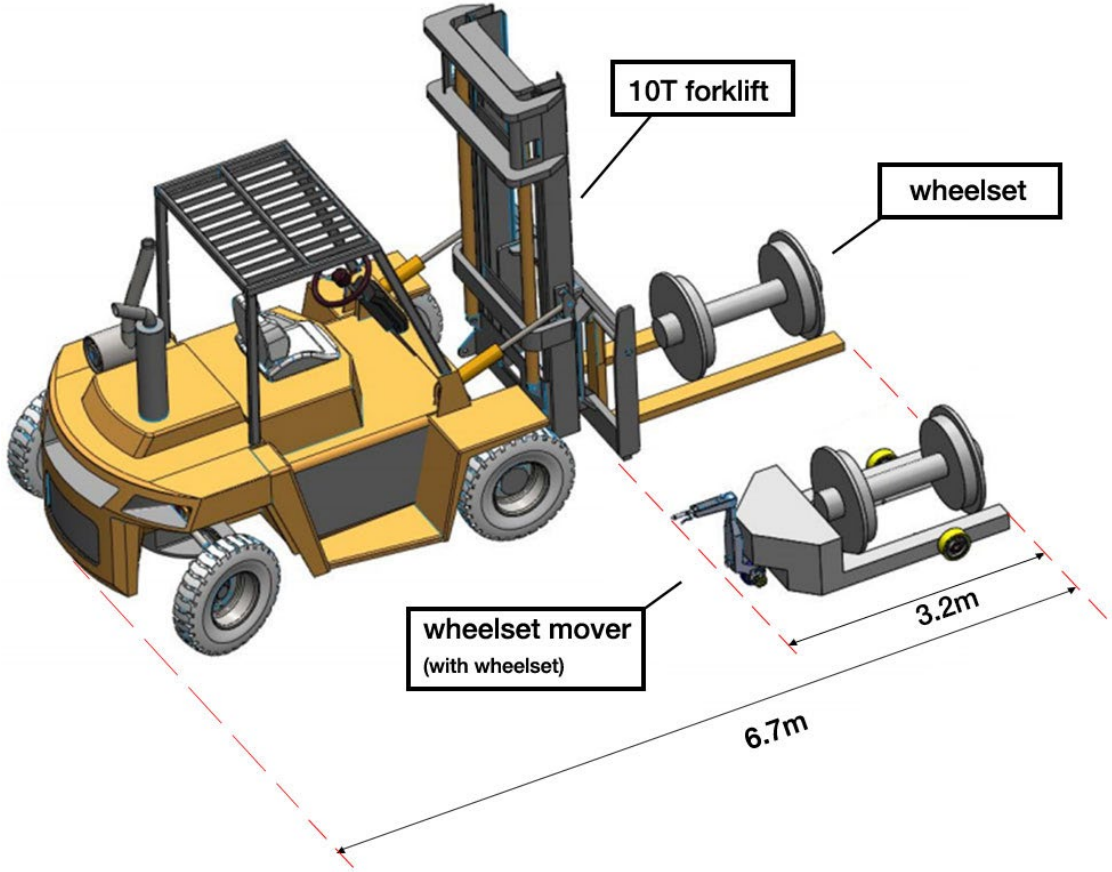
Just like we change the wheels of our cars very often (for every 50,000 miles traveled).....



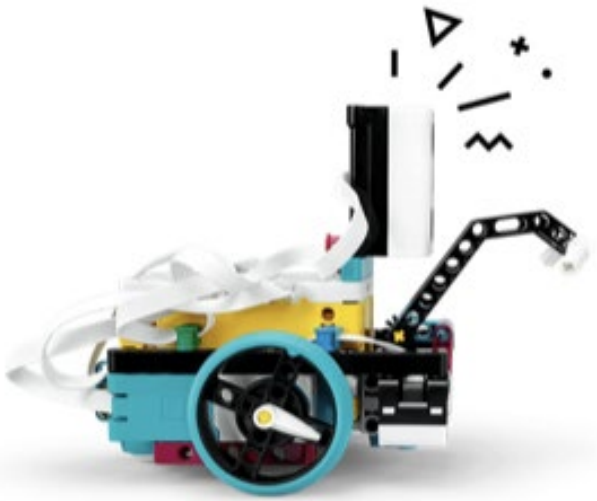
....Freight trains need an exchange of Wheel-Axle Assemblies for every 500,000 miles as well.

How Are They Moved?

Wheel-Axle Assemblies are moved by **forklifts** to make the process more **efficient(easy)**. Helps place Wheel-Axle Assemblies at a desirable spot as well.



Build and Program a Forklift



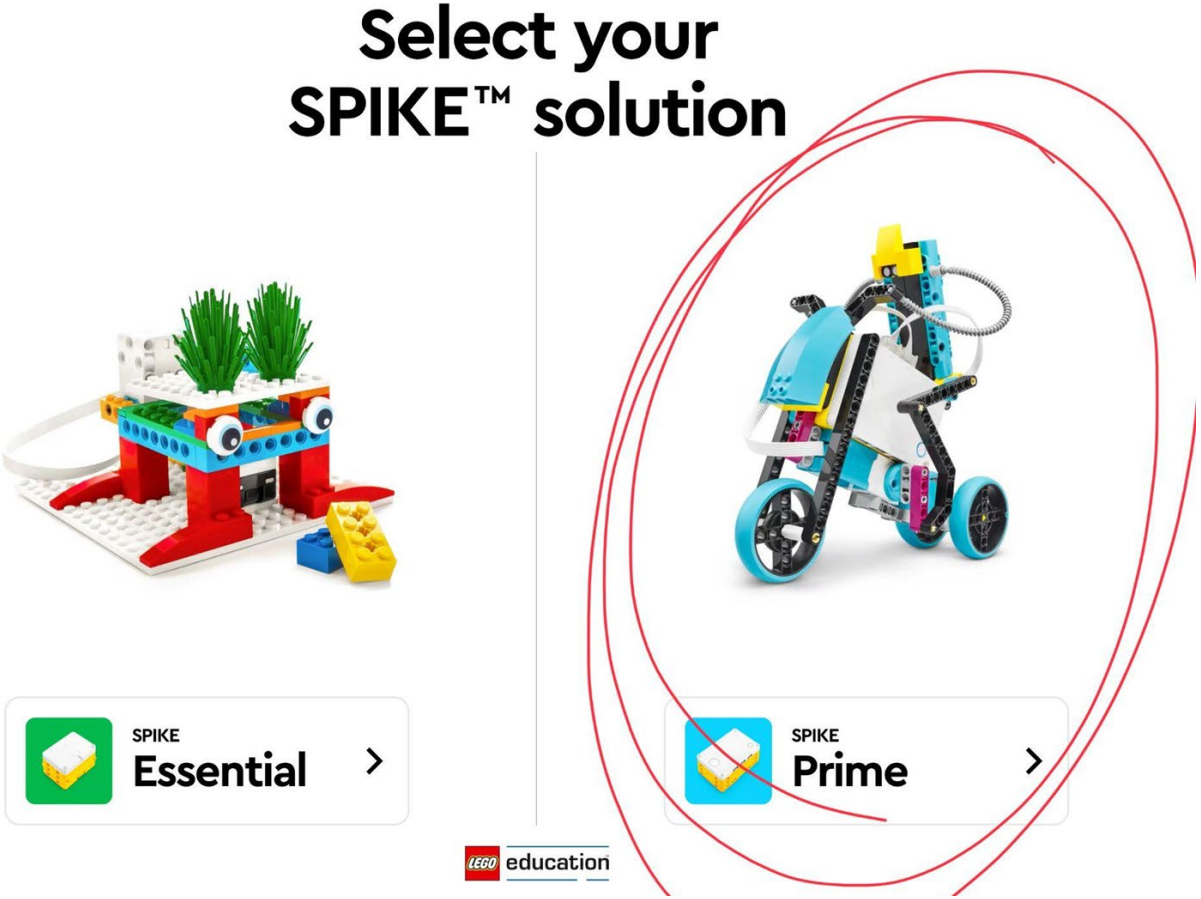
Process and Procedure

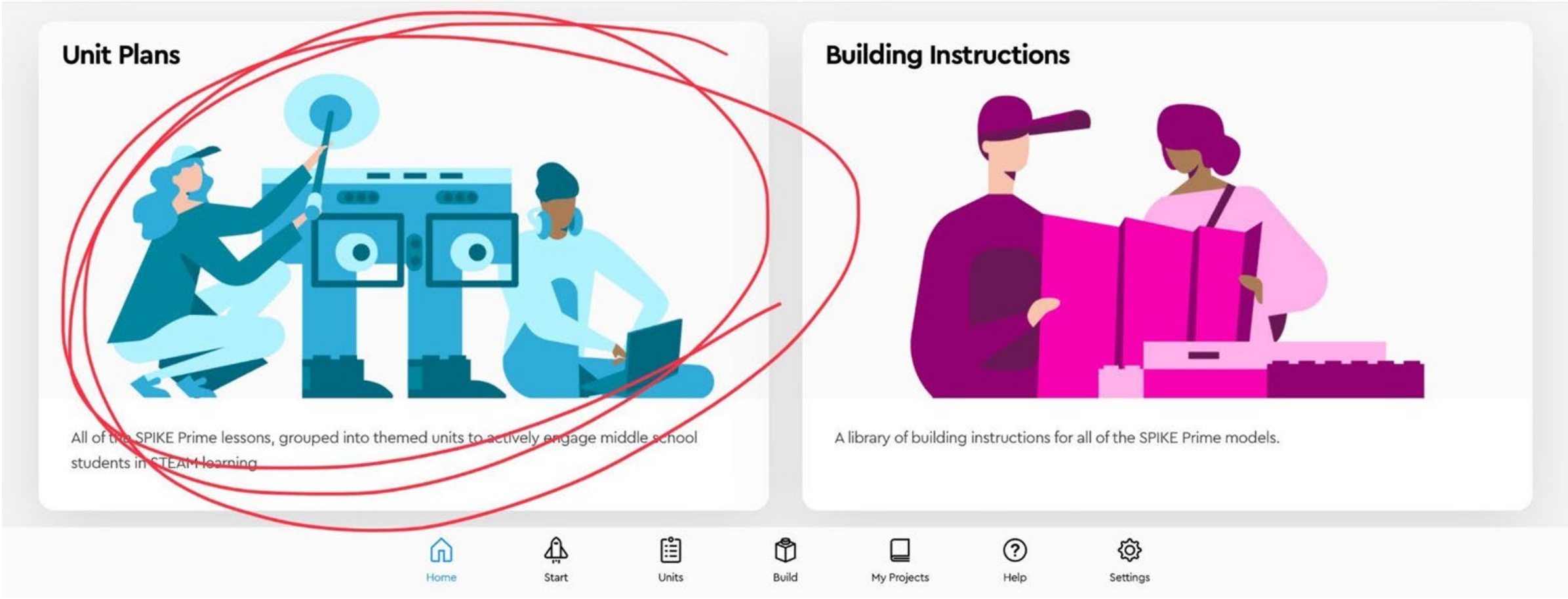
1. Teams will construct a basic robot from LEGO® SPIKE® Prime robotics kit using the LEGO® Education SPIKE Prime App.
2. Using the Medium Motor, we will build a functioning forklift.
3. We are going to use the medium motor to lift a “Wheel-Axle Assembly” and drop it off at UTRGV Transportation Center for Railway Safety.

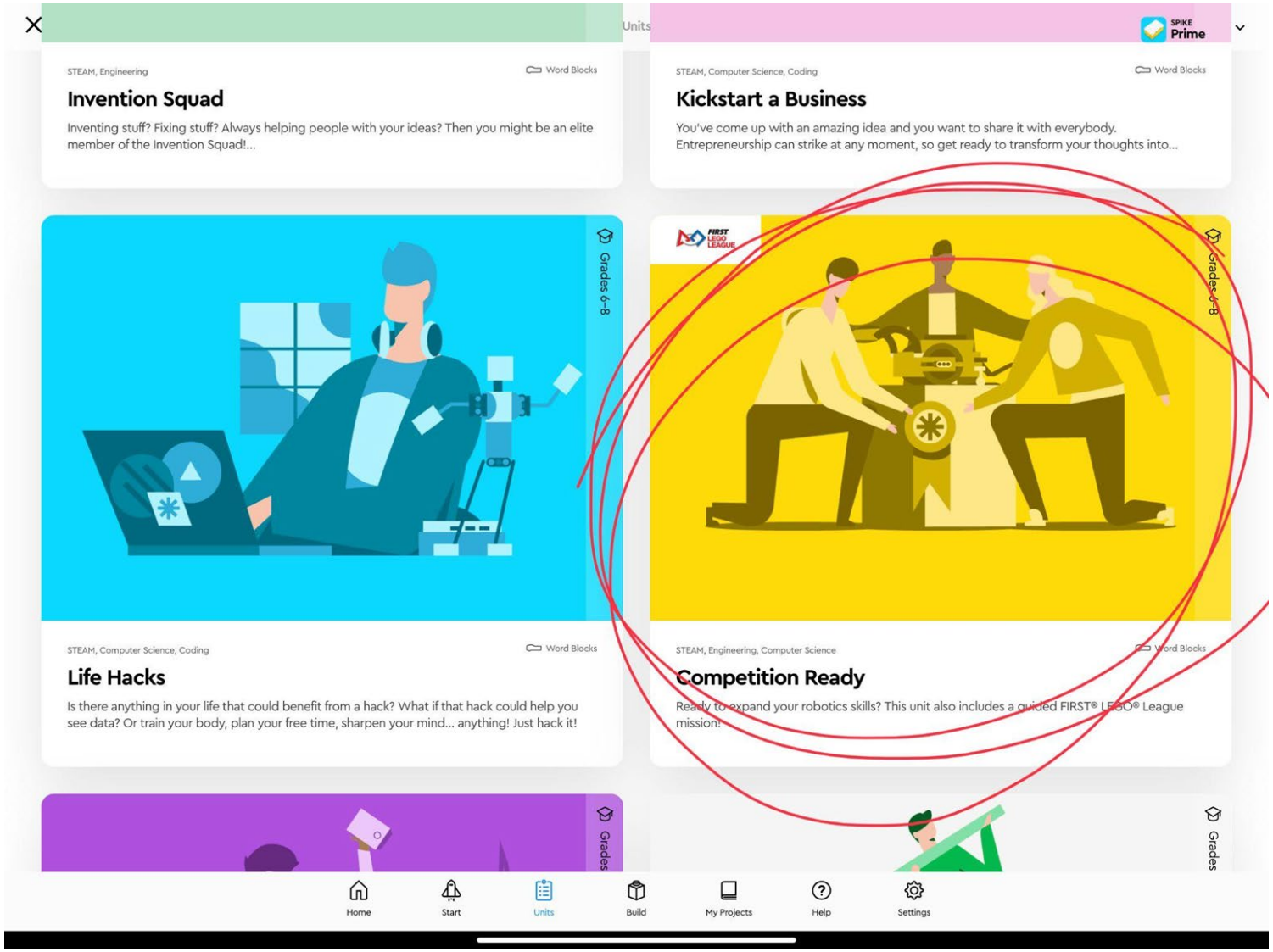
Roles Within Your Group

1. **Lead Engineer** - responsible for making sure tasks are completed efficiently on time.
2. **Mechanical Engineer** - Oversee motors and sensors and make sure the wires are also plugged in correctly.
3. **Manufacturing Engineer** - Oversees and leads the building process, make sure that the build is complete and works.
4. **Electrical/Software Engineer** - Programming and functions of robot, make sure that the program is set to complete the tasks.

Programming Basics




Unit Plans
All of the SPIKE Prime lessons, grouped into themed units to actively engage middle school students in STEAM learning
Building Instructions
A library of building instructions for all of the SPIKE Prime models.
Home
Start
Units
Build
My Projects
Help
Settings


Units
SPIKE Prime
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 Squad!...
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, so get ready to transform your thoughts into...
Grades 6-8
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 your free time, sharpen your mind... anything! Just hack it!
FIRST LEGO League
Grades 6-8
STEAM, Engineering, Computer Science
Word Blocks
Competition Ready
Ready to expand your robotics skills? This unit also includes a guided FIRST® LEGO® League mission!
Grades
Grades
Home
Start
Units
Build
My Projects
Help
Settings

01

Training Camp 1: Driving Around

Controlling Movements using the Gyro Sensor

START

30–45 min.

> MORE

02

Training Camp 2: Playing with Objects

Controlling Movements Using the Distance Sensor

START

30–45 min.

> MORE

03

Training Camp 3: Reacting to Lines

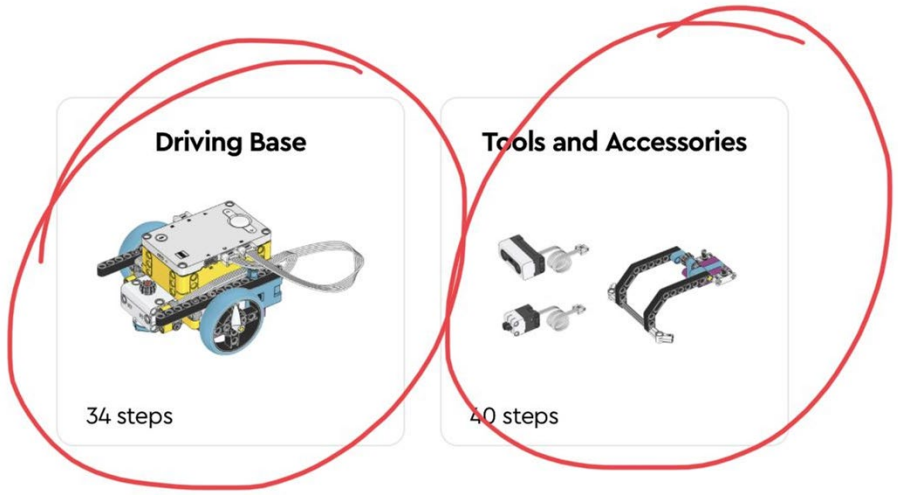
Control Movements Using the Color Sensor

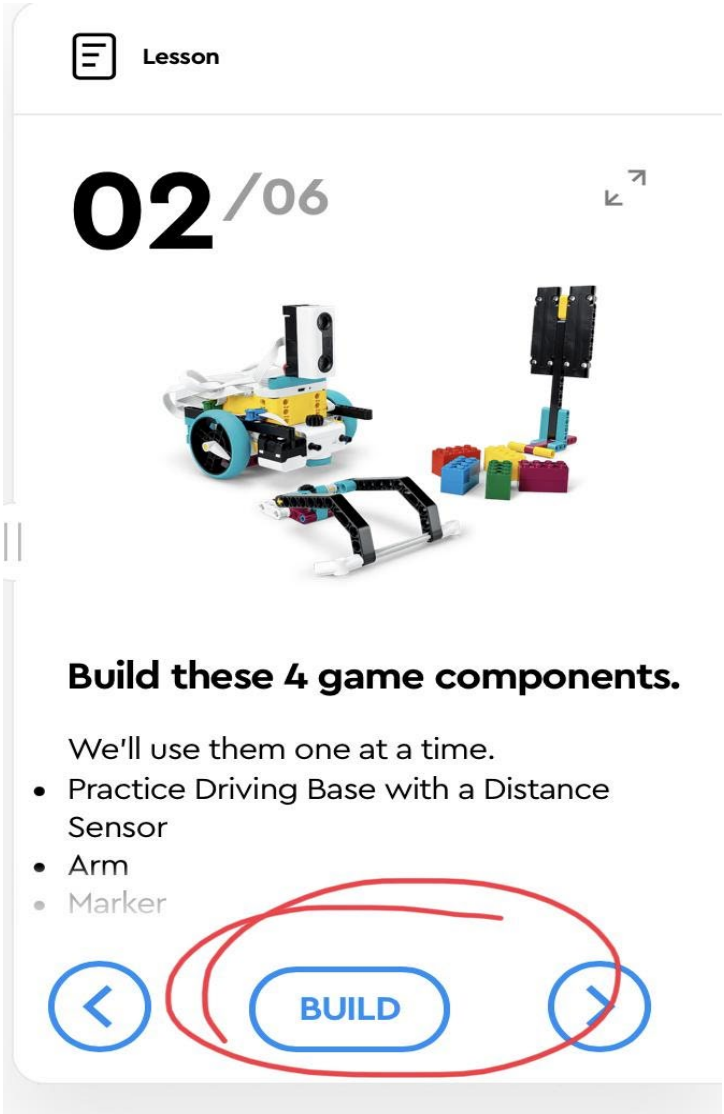
START

30–45 min.

> MORE

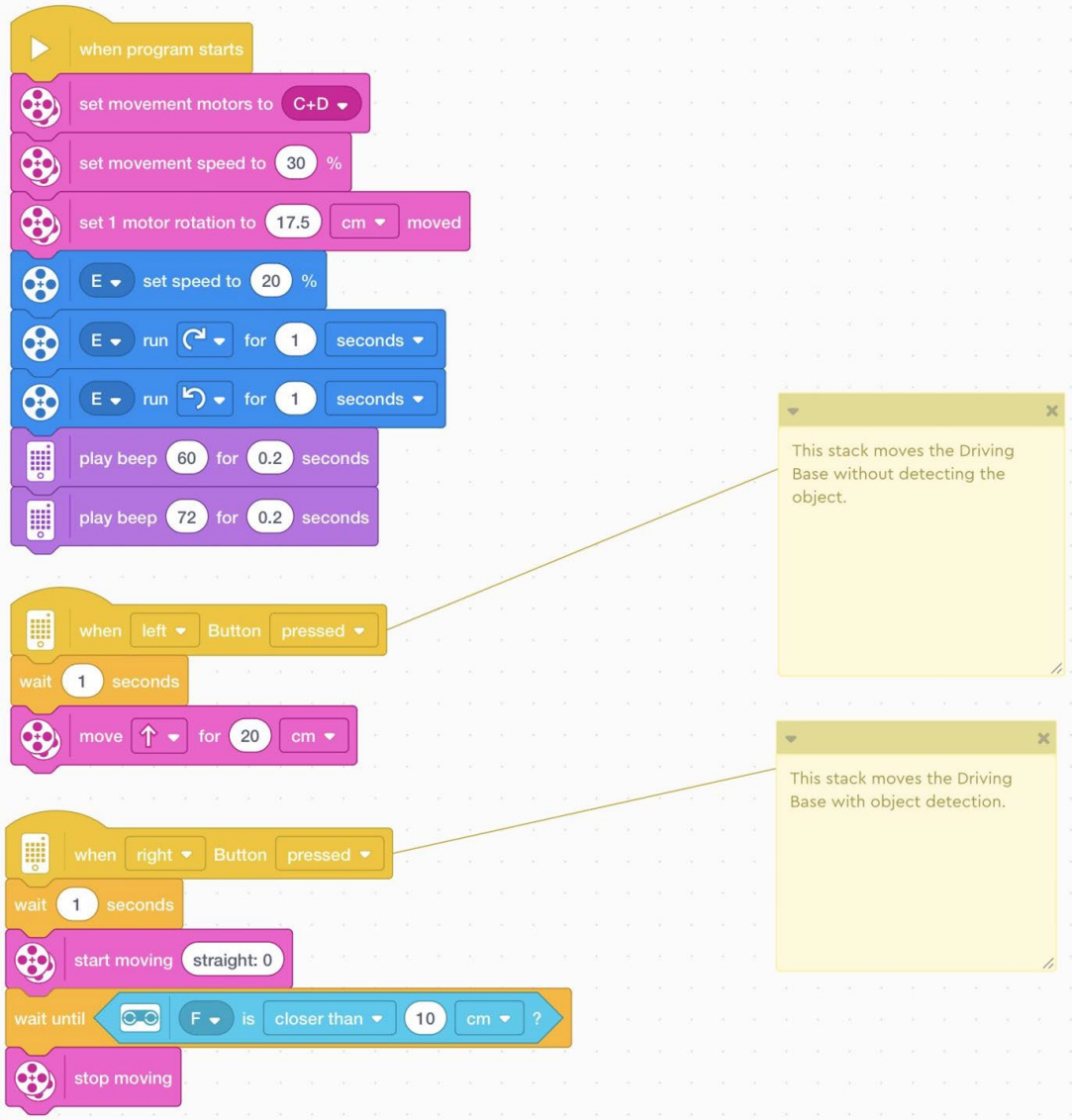
Let's Build!


Driving Base
34 steps
Tools and Accessories
40 steps


Lesson
02/06
Build these 4 game components.
We'll use them one at a time.
Practice Driving Base with a Distance Sensor
Arm
Marker
BUILD

Pairing and Observations

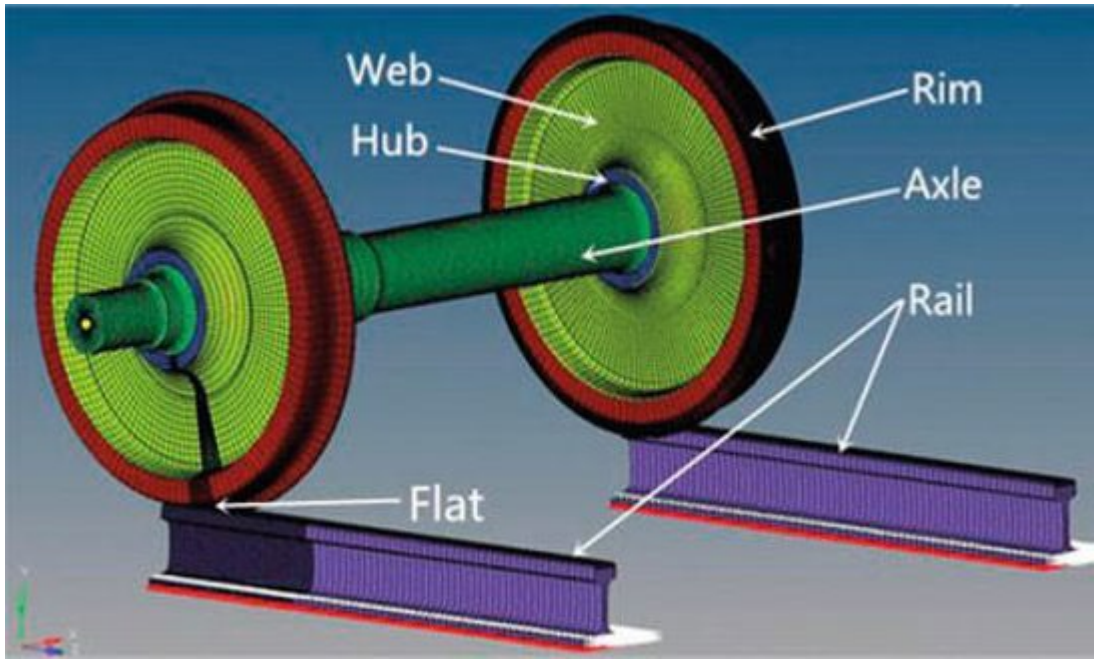
- Follow the instructions prompted on your screen.
- Pair your robot.
- Press play and make observations.
- Make sure you read the yellow block.



It's Time for a Challenge!

Wheel-Axle Assembly Activity

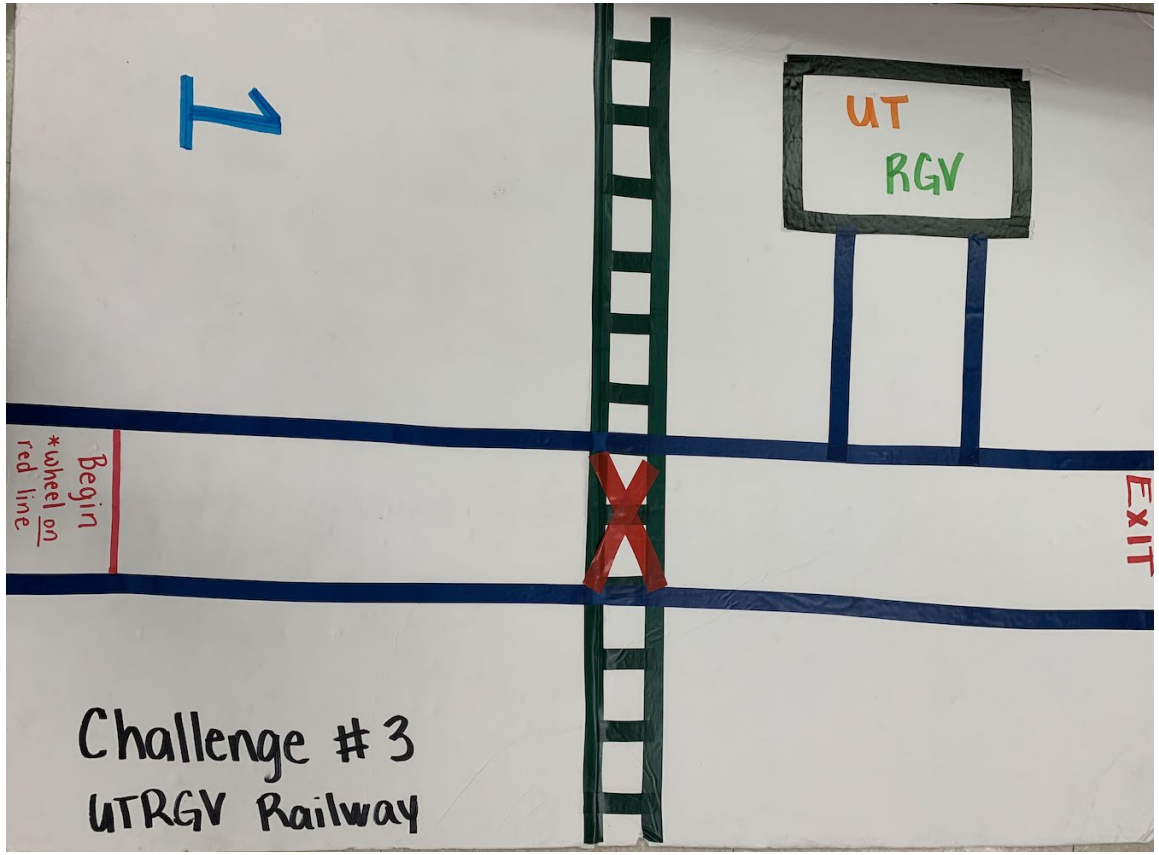
Directions: Use the Lego pieces to build a model Build 1 axle with two wheels



Challenge #3

Make modifications to your bot so that it can lift a “Wheel-Axle Assembly” and drop it off at UTRGV Transportation Center for Railway Safety.

Make observations and adjustments to your code as needed.



Let's Reflect...

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

Let's Reflect...

1. A train travels a distance of 250 km in 5 hours. What is the speed of the train?

1. A 1.11 kg red ball sits at rest on a table 1.72 m above the ground. What is the potential energy of the red ball?

1. How can we increase the potential energy of the red ball?

Let's Reflect...

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. What are some improvements you would like to make to your robot?
4. Is this a practical application for trains? Why or why not?

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

Cleanup

Make sure students:

- look around the floor
- count, and put all materials back in the box
- ensure no LEGO parts are missing, misplaced, or left behind.

Plug your block in to charge.

Cleanup and Closing Discussion

1. How was today's challenge applicable to Railway Engineering?
2. What are some real challenges engineers face?
3. What are some of your team's strengths and weaknesses?

End of Day 3

Day 3 References

Learn Bright (n.d.). Newton's Third Law of Motion | Newton's Laws of Motion | Video for Kids. Newton's Third Law of Motion | Newton's Laws of Motion | Video for Kids. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=a-wh3fJRdjo (Slide 10)

Jing, L. (2018). Wheel-Rail Impact by a Wheel Flat. InTech. doi: 10.5772/intechopen.70460 (Slide 36)

Science Buddies (n.d.). How Train Wheels Stay On Track - STEM activity. How Train Wheels Stay On Track - STEM Activity. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=l9NpcJqclSY (Slide 38)

Science Buddies (n.d.). Train Wheel Science. Scientific American. Retrieved October 7, 2024, from https://www.scientificamerican.com/article/train-wheel-science/ (Slide 41)

(n.d.). Moving rail bogie wheelsets with Electrodrive's Powered Wheelset Mover. Electrodrive. Retrieved October 7, 2024, from https://www.electrodrive.com.au/our-solutions/moving-train-bogies.aspx (Slide 42)

(2023, February 24). 3News Investigates: Railway experts weigh in on axle inspection after East Palestine train derailment. WKYC. Retrieved October 7, 2024, from https://www.wkyc.com/article/news/investigations/railway-experts-weigh-in-axel-inspection-east-palestine-train-derailment/95-8ca7d329-0d09-4603-bd4e-e7f70968b095 (Slide 43)

(n.d.). Moving rail bogie wheelsets with Electrodrive's Powered Wheelset Mover. Electrodrive. Retrieved October 7, 2024, from https://www.electrodrive.com.au/our-solutions/moving-train-bogies.aspx (Slide 46)

(2024). *Lego Spike Prime*. Welcome to our Teacher Resources. https://education.lego.com/en-us/

Day 4

- Rail Flaw Detection
- High-Bay Tour

Objectives:

- Train Track Maintenance
- Rail Flaw Detection and Ultrasonic Sensors
- Safety Procedures in the High-Bay
- Review wheel and axle maintenance and replacement, sensors that can be used for preventive maintenance.
- Tour of High-Bay

Reminders and Procedures:

- Roll Call
- Housekeeping Rules
  - Must wear shirt everyday
  - Restroom only when accompanied by an adult
  - NO Electronic devices unless instructed
  - Be active, engaged and participate in your group
  - Be respectful and leave room organized

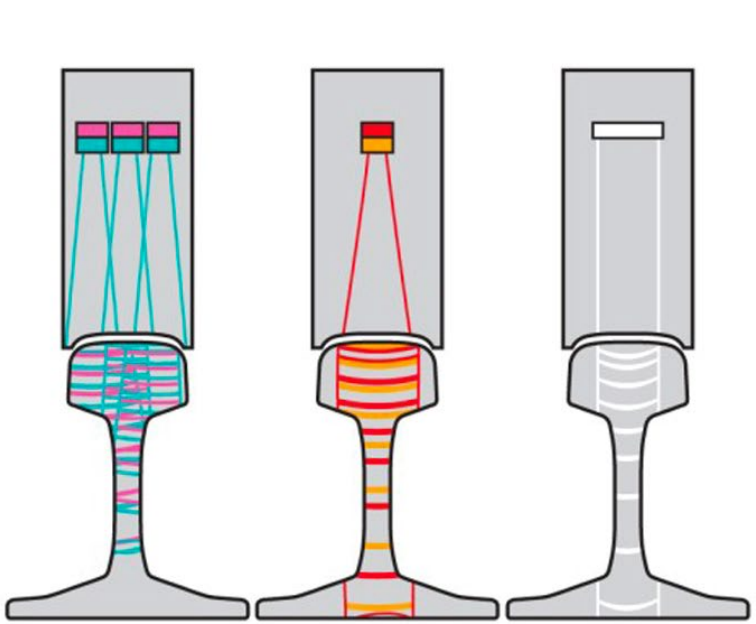
Rail Flaw Detection

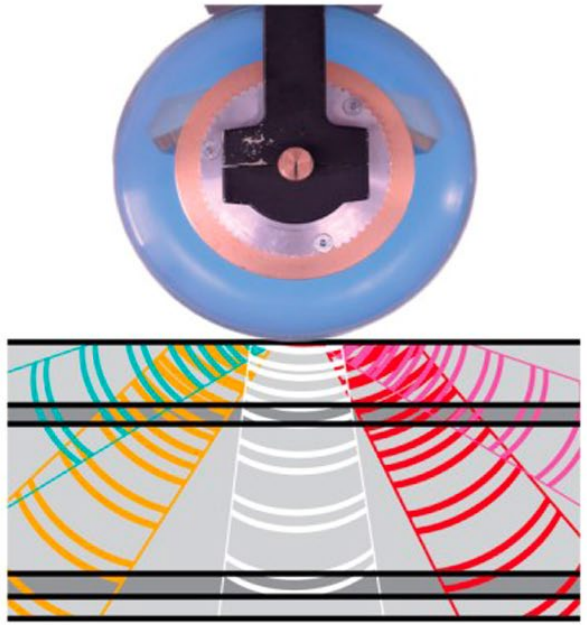
Rail integrity is critical to the railroad industry, especially since rail flaws and defects can lead to broken rails or even derailments.

Rail Flaw Detection

Because of the serious nature of rail flaws and their impact on safety, the industry has responded with improved rail maintenance practices and flaw detection methods.

Ultrasonic Sensor





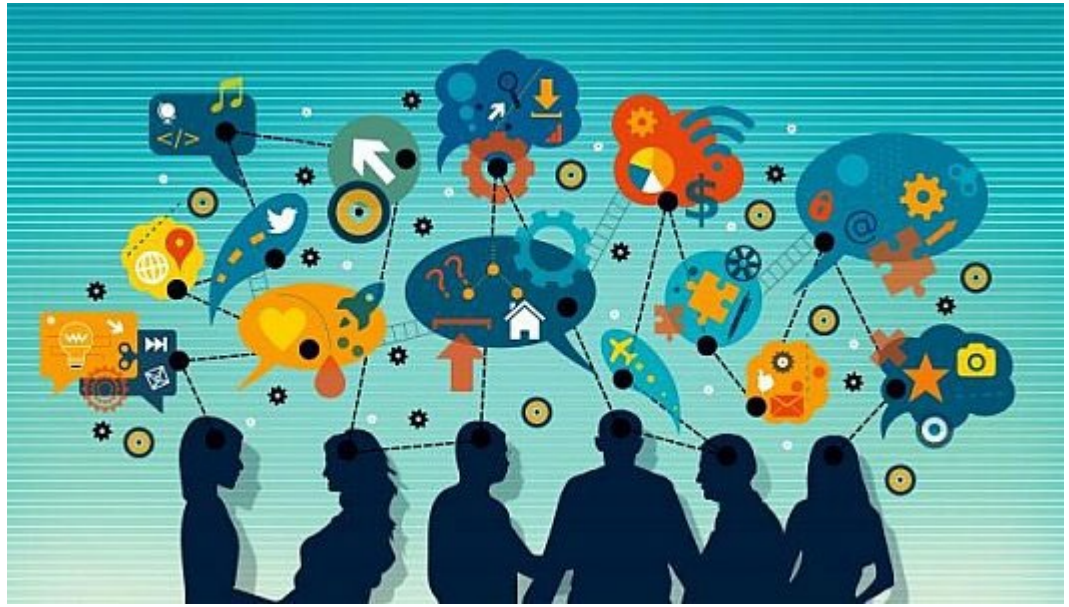
70 °-transducers 40 °-transducers 0 °-transducer

Transmit

Sensor

Let's Discuss

How is the Ultrasonic sensor used to detect Railway Flaws?



Roles Within Your Group

1. **Lead Engineer** - responsible for making sure tasks are completed efficiently on time.
2. **Mechanical Engineer** - Oversee motors and sensors and make sure the wires are also plugged in correctly.
3. **Manufacturing Engineer** - Oversees and leads the building process, make sure that the build is complete and works.
4. **Electrical/Software Engineer** - Programming and functions of robot, make sure that the program is set to complete the tasks.

Process and Procedure

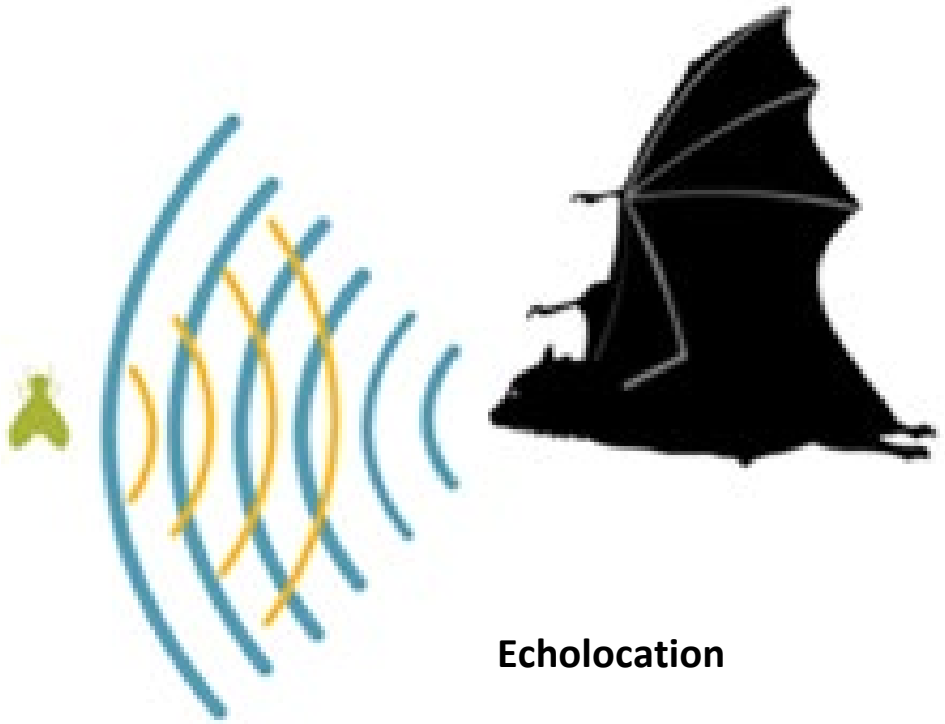
1. You will be working with robots to learn more about transportation engineering.
2. You will be building and programming your own robot.
3. Teams will construct a basic robot from LEGO® SPIKE® Prime robotics kit using the LEGO® Education SPIKE Prime App .

Process and Procedure

➔ For each round of three steps, you will be changing roles:

- The function of the “lead engineer” is to construct the robot. The rest of the team will be “assistant engineers”. Assistants look for parts and help the lead engineer.
- There are about 600 pieces in each robot kit. Those functioning as “assistant engineers” have the responsibility to manage pieces, including taking care to not lose or misplace any of the parts.

Ultrasonic Sensor



Echolocation

Roles and Responsibilities

Assign the following roles for this build. We will be rotating roles as we will be building numerous times throughout the week.

1. Computer Science Engineer: will control the iPad
2. Materials Engineer: will gather parts
3. Mechanical Engineer: will put the pieces together
4. Industrial Engineer: will evaluate and improve production (ensure team is on task and working cooperatively)

Objectives:

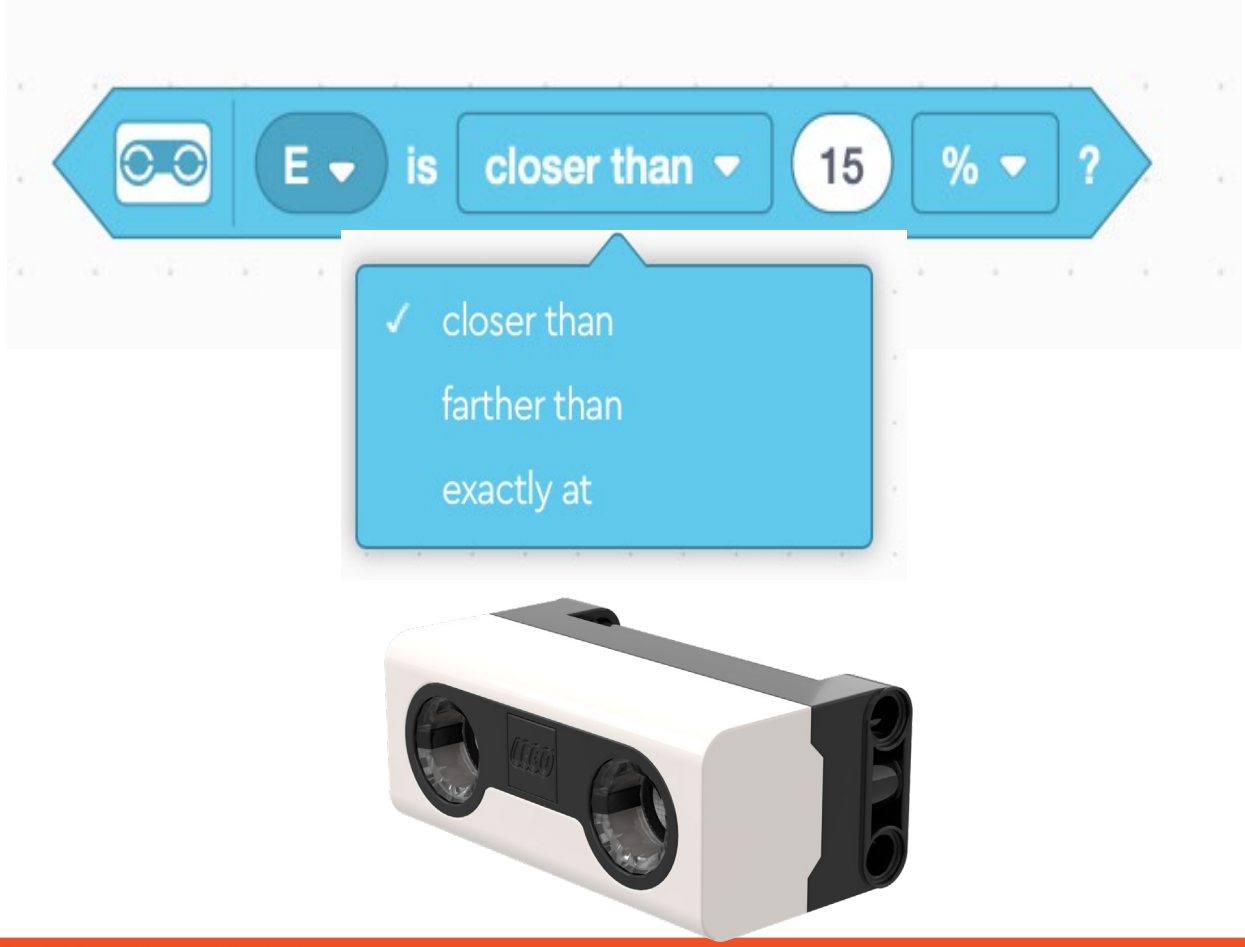
- Learn how to use the Distance Sensor
- Learn how to use the Wait Until Block

Distance/Ultrasonic Sensor

- Measures the distance to an object or surface using ultrasonic technology
- There are also lights around the ultrasonic sensor that can be programmed individually

Programming the Distance/Ultrasonic Sensor

- The distance sensor can measure the distance to an object or surface using ultrasonic.
- Units can be measured in percent, centimeters, or inches.



Challenge 1

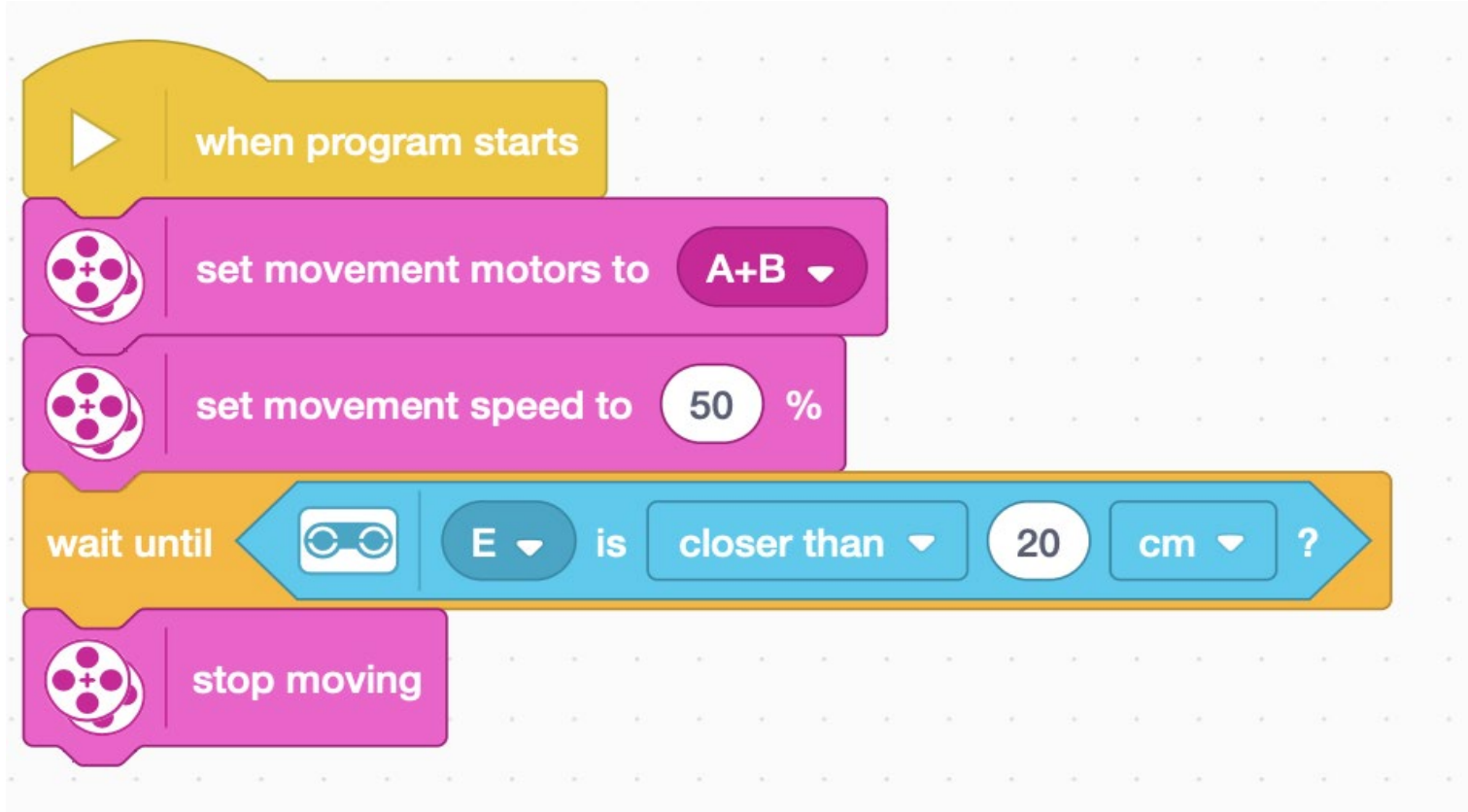
- Program your robot to move straight until it is less than 20 cm from the wall.
- You will need to use the Wait For block and the Boolean block for the Distance Sensor

➔ Basic Steps:

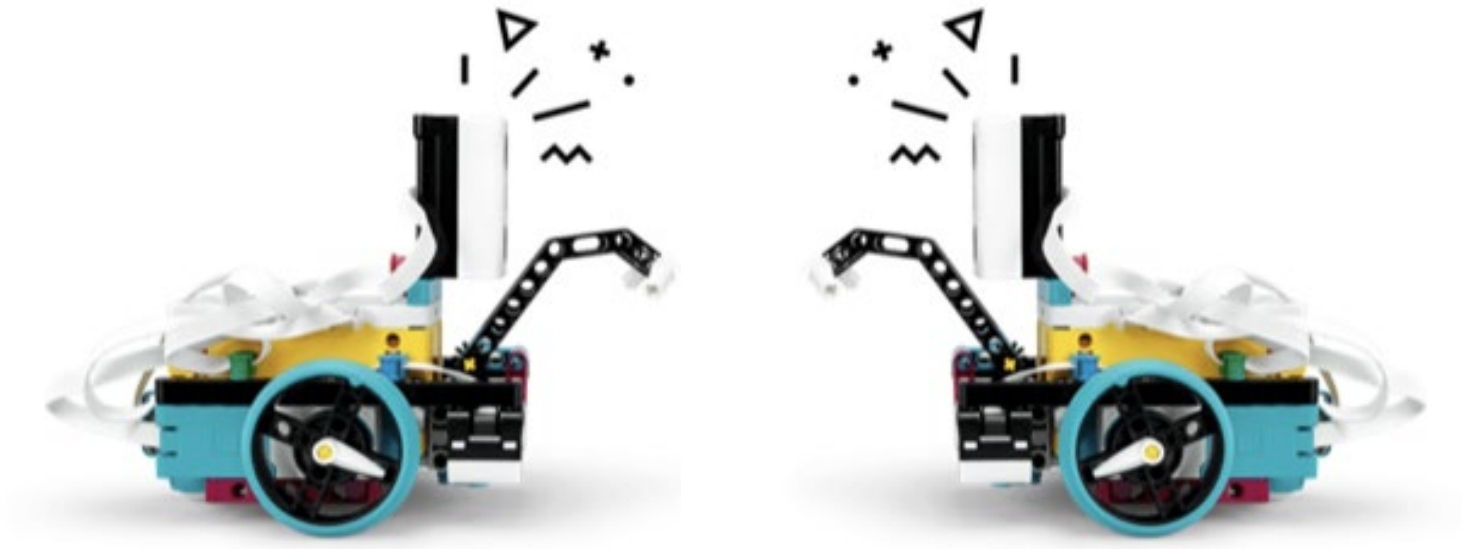
- Set the movement motors for your robot
- Set the speed for your robot
- Start moving straight
- Use the wait until block to detect it is less than 20 cm from the wall.
- Stop moving

Possible Solution

- Basic Steps:
  - Set the movement motors for your robot
  - Set the speed for your robot
  - Start moving straight
  - Use the wait until block to detect it is less than 20 cm from the wall.
  - Stop moving



Put it to the Test!



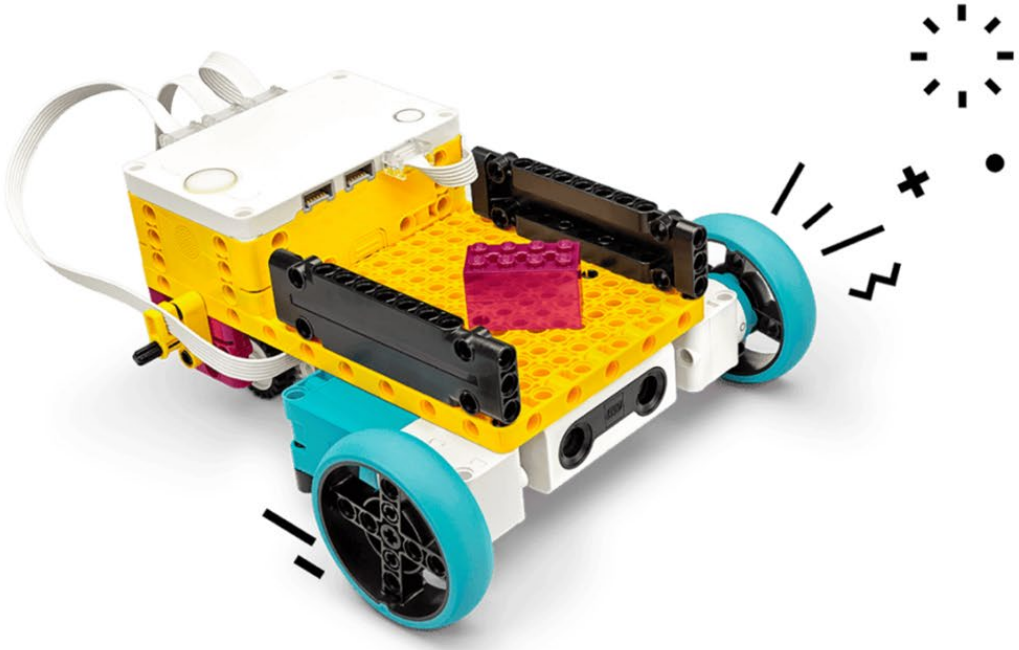
We are going to put all of our Bots in a central location, let's see if they avoid each other, or collide.

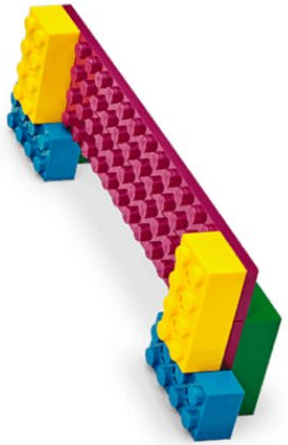
Let's Reflect...

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. What are some improvements you would like to make to your robot?

Day 4 Part 2

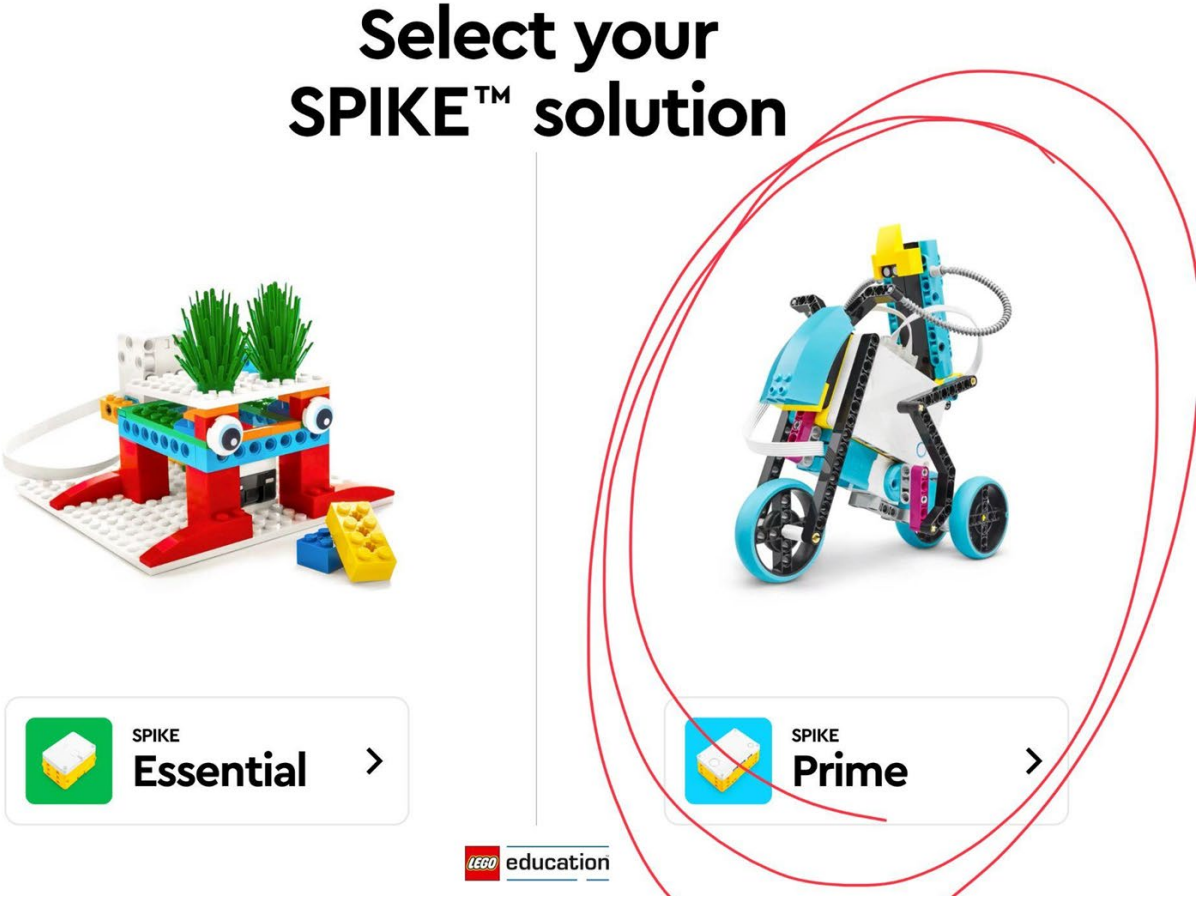
It's Time for a Challenge!

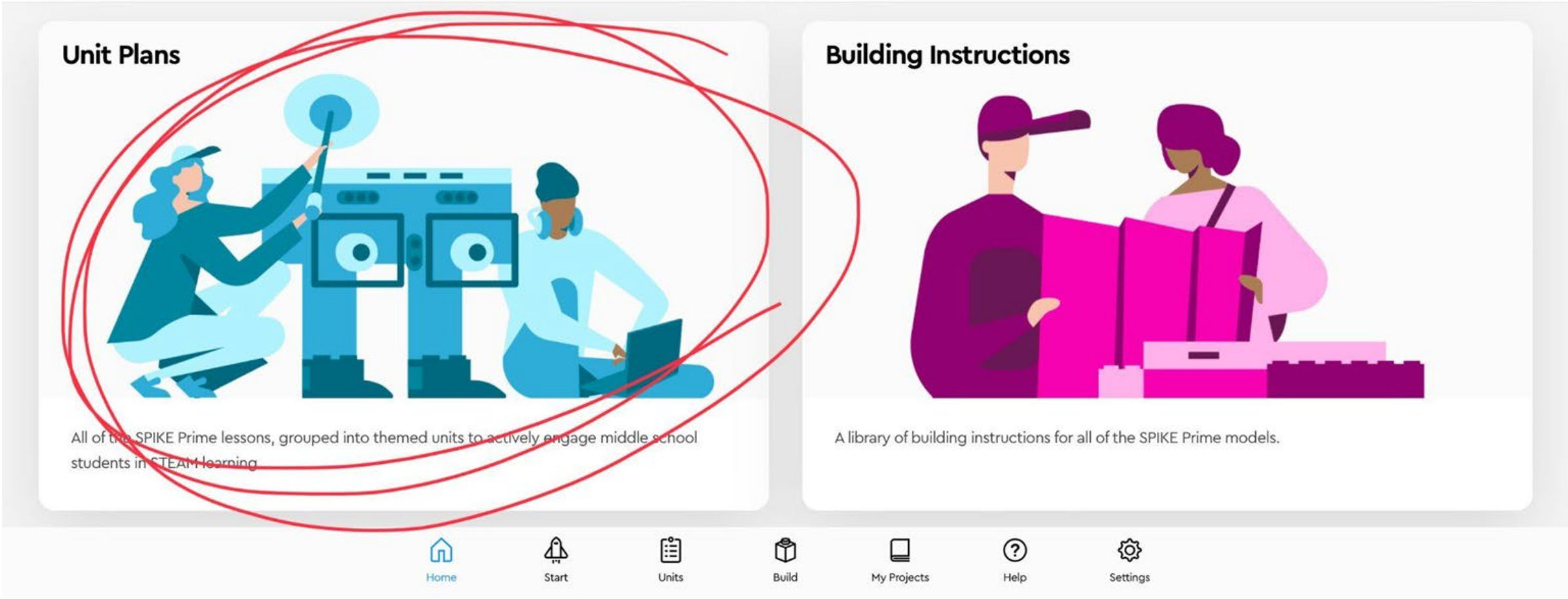




LEGO education SPIKE™

Debugging a Program




Unit Plans
All of the SPIKE Prime lessons, grouped into themed units to actively engage middle school students in STEAM learning
Building Instructions
A library of building instructions for all of the SPIKE Prime models.
Home
Start
Units
Build
My Projects
Help
Settings

Unit Plans

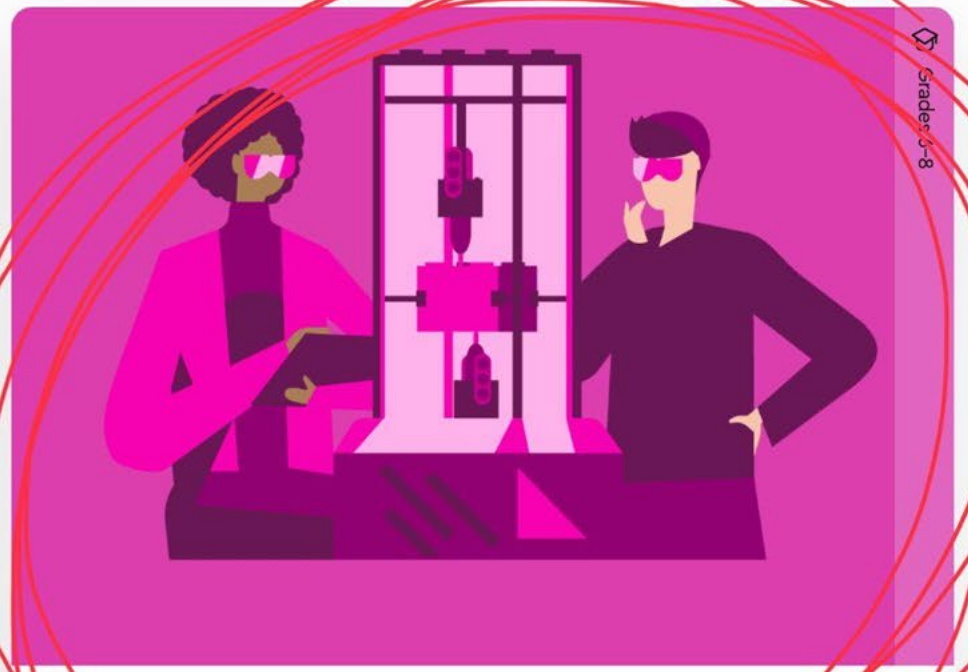
VIEW LESSON PLANS AND TEACHER SUPPORT

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 Squad!...

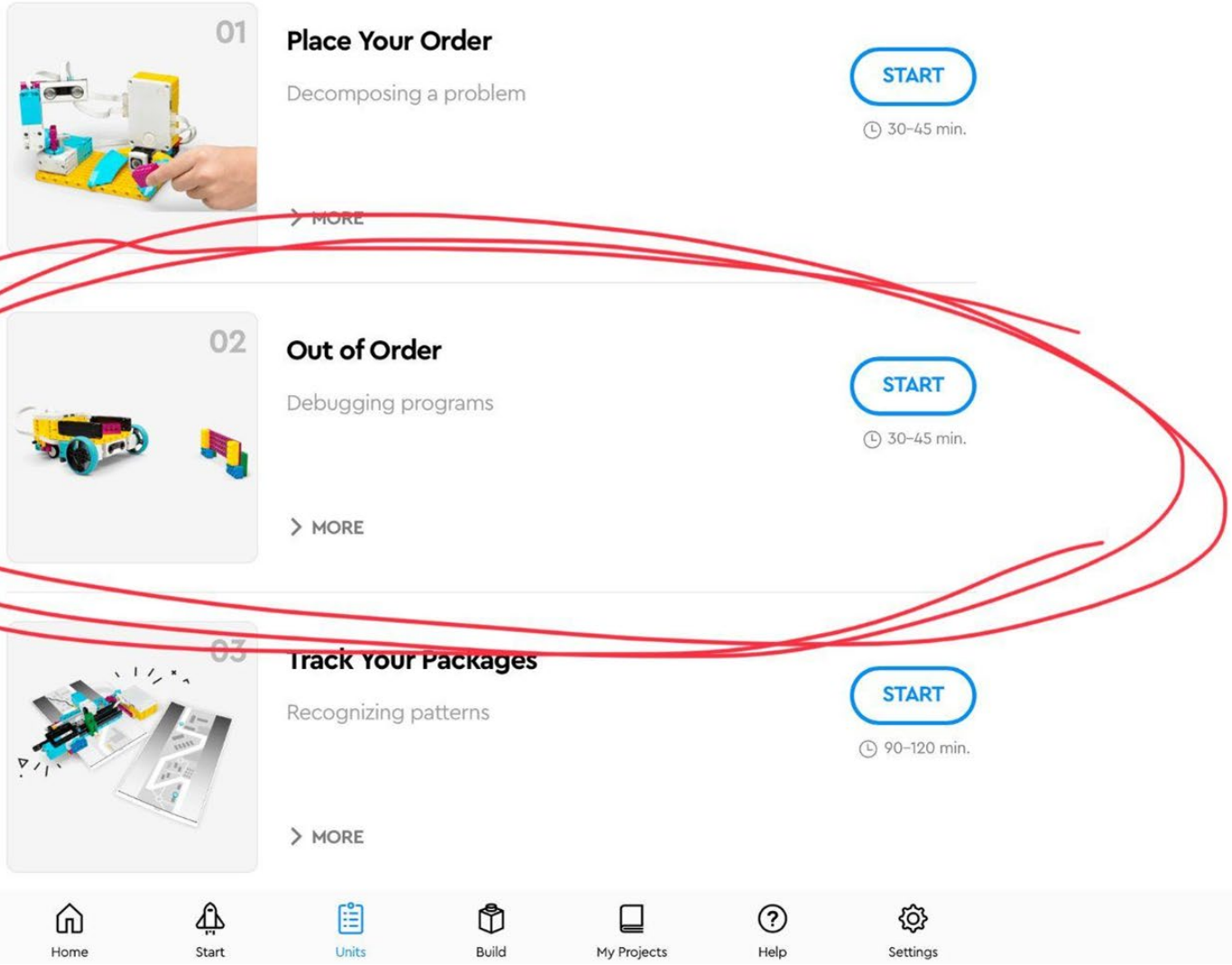


STEAM, Computer Science, Coding

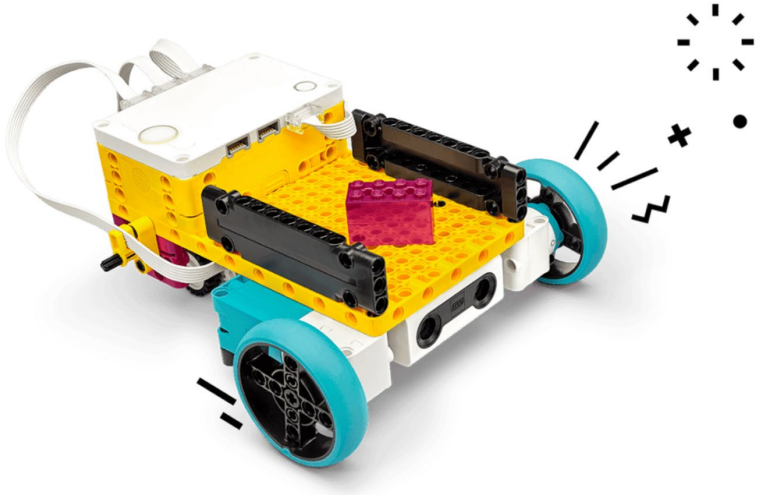
Word Blocks

Kickstart a Business

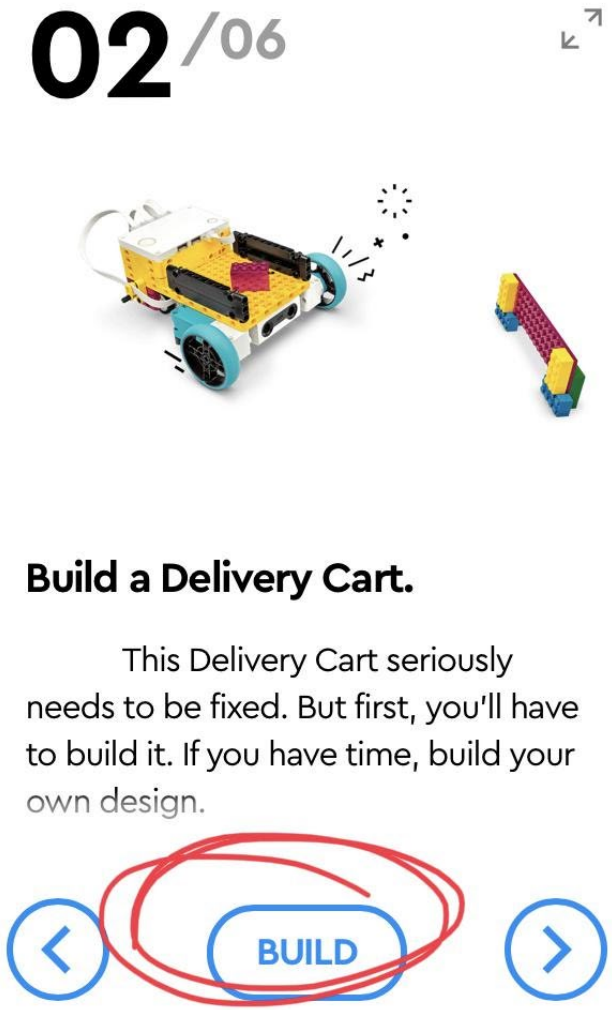
You've come up with an amazing idea and you want to share it with everybody. Entrepreneurship can strike at any moment, so get ready to transform your thoughts into...


01
Place Your Order
Decomposing a problem
START
30–45 min.
MORE
02
Out of Order
Debugging programs
START
30–45 min.
MORE
03
Track Your Packages
Recognizing patterns
START
90–120 min.
MORE
Home
Start
Units
Build
My Projects
Help
Settings

Let's Build!

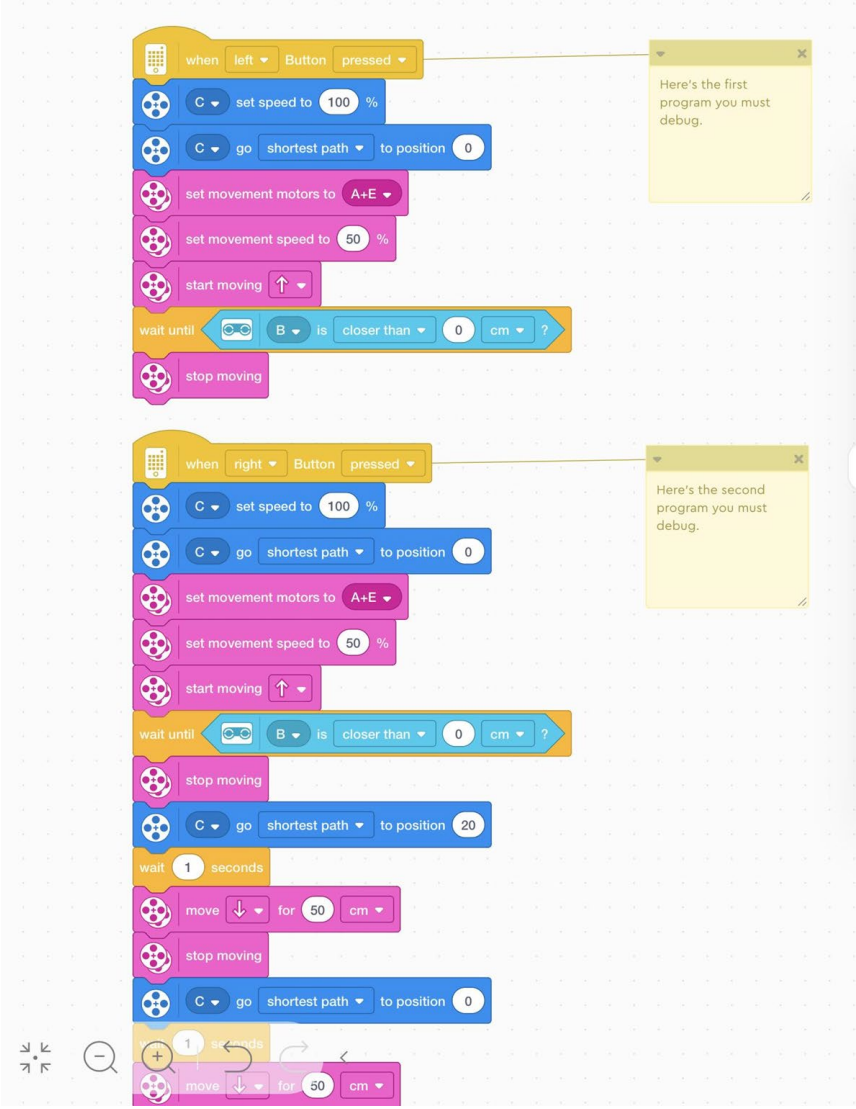


30:00



Pairing and Observations

- Follow the instructions prompted on your screen.
- Pair your robot.
- Press play and make observations.
- Make sure you read the yellow block.



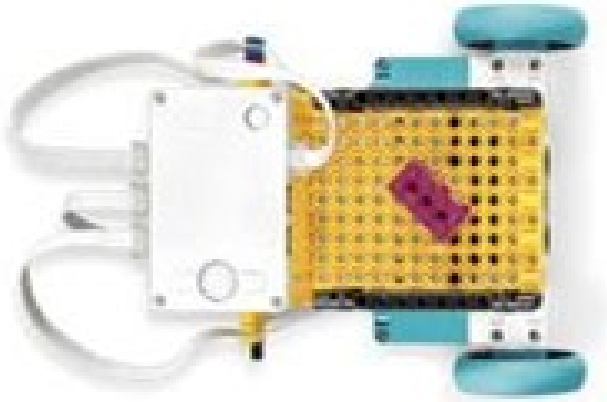
Let The Debugging Begin.

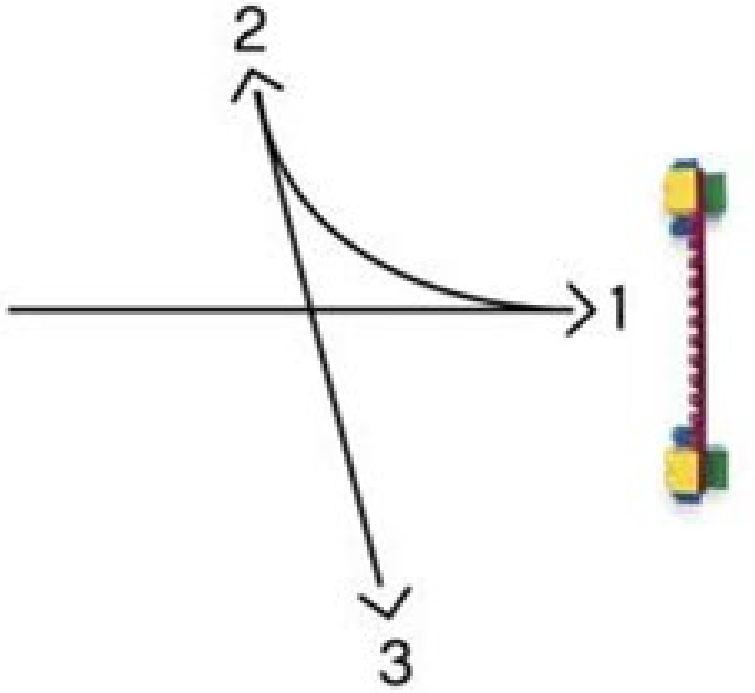
Play this program to try out your cart

- It should stop right at the marker.
- Does it?
- If it does not, fix your program.

Adjust your program

- Make changes to your program so that the cart follows this path.



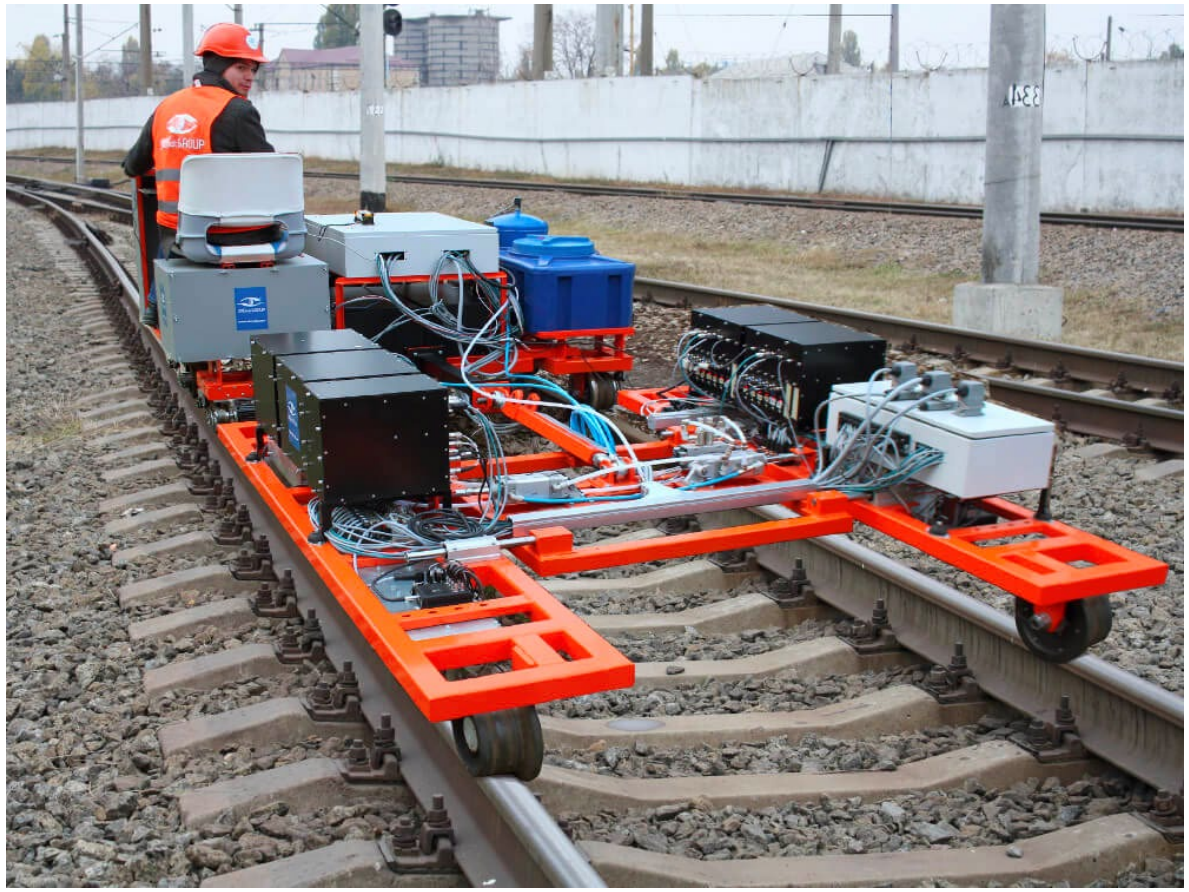


Let's Reflect...

1. What worked for your group? What didn't?
2. What was challenging? How did you deal with those challenges?
3. What are some improvements you would like to make to your robot?
4. Is this a practical application for trains? Why or why not?

Ultrasonic Sensors on the Railway

The ultrasonic non-destructive testing method is the most frequently used in the industry. Ultrasound uses sound waves, or vibrations.



Rail Flaw Detection

Ultrasonic waves are transmitted into the rail at various angles - from the top of the rail head through the web to the bottom of the rail and the entire width of the rail head.

Prepare for Field Trip to High Bay at UTRGV

Field Trip to University of Texas Rio Grande Valley - Center for Railway Safety and High Bay Manufacturing facility.

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.

High Bay and Interview Questions

Students will learn about the High Bay located in the Engineering Building. Students will also identify possible higher education and career paths in the STEM field

Engage students in a discussion about higher education and future careers:

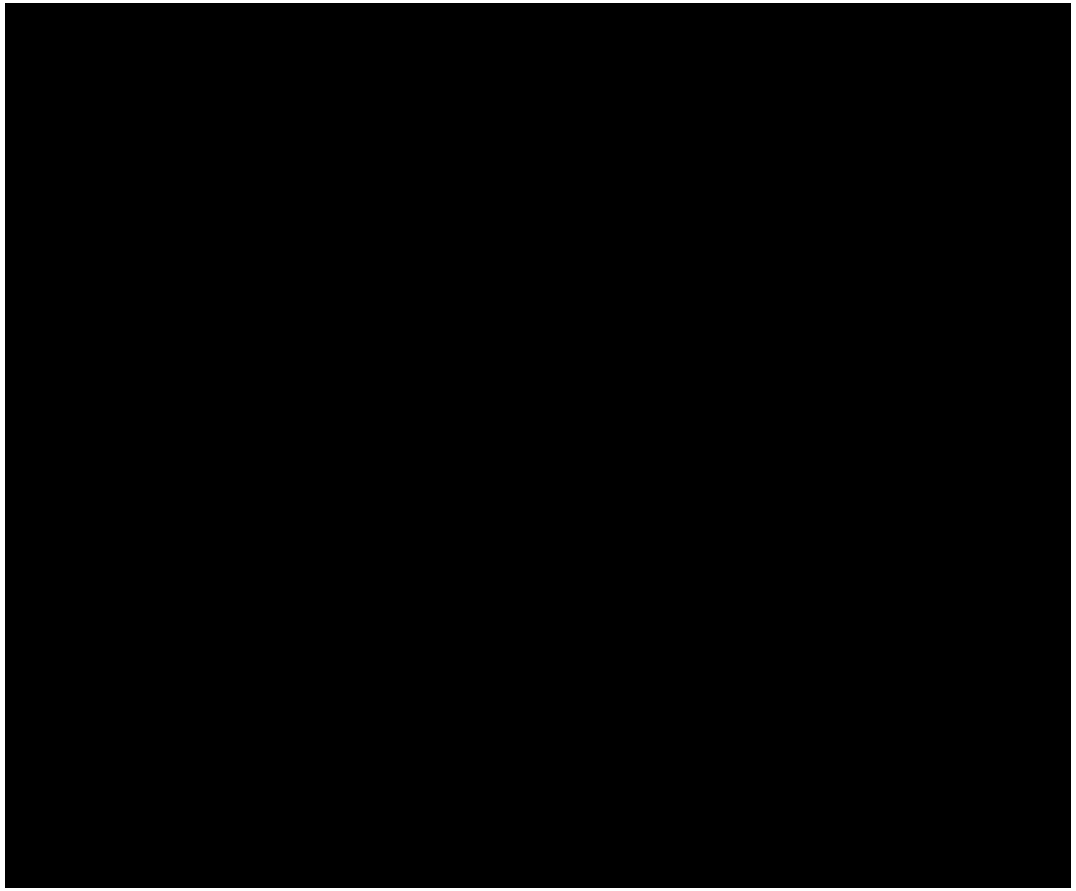
- How many of you know what you want to study in college?
- How many of you are interested in studying for a career in the STEM field?
- It is helpful to start exploring higher education and career options from a young age?

- A career in the STEM field may be the right fit for some you!
- Here at UTRGV there are many opportunities for students to pursue a career in Engineering
- Once you graduate and find a career in Engineering, these are some of the tasks or work you may perform or assist with

Show them “Tour Video” for them to learn what Railway Engineers do (located in Google Drive https://drive.google.com/drive/u/0/folders/11d9wzd0G1a-rGQTBreq9YXJoxFh79rT2).

Additional Videos: https://youtu.be/-dGQxz2uzd4

https://youtu.be/htraayYmKjI



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

Cleanup

Make sure students:

- look around the floor
- count, and put all materials back in the box
- ensure no Lego parts are missing, misplaced, or left behind.

Plug your block in to charge.

Cleanup and Closing Discussion

1. How was today's challenge applicable to Railway Engineering?
2. What are some real challenges engineers face?
3. What are some of your team's strengths and weaknesses?

End of Day 4

Day 4 References

(2020). Houston County train wreck did $5 million-plus in damage, posed hazmat risk. 13WMAZ. Retrieved October 7, 2024, from https://www.13wmaz.com/article/news/local/central-georgia-houston-county-norfolk-southern-train-wreck-derailment-crash-5-million-dollars-cleanup/93-5434e4d4-cb94-498d-b528-9b98a65eb087 (Slide 4)

(n.d.). Solving problems with trains! How are train faults fixed: (Britain's Digital Railways). Solving Problems With Trains! How are Train Faults Fixed: (Britain's Digital Railways). Retrieved October 7, 2024, from https://cdn.jwplayer.com/previews/EL3QWC4I (Slide 5)

Jing, G., Qin, X., Wang, H., & Deng, C. (2022). Developments, challenges, and perspectives of railway inspection robots. Automation in construction, 138, 104242. (Slide 6)

(n.d.). EV3 – Basic Characteristics and Components. EV3 – Basic Characteristics and Components. Retrieved October 7, 2024, from https://petlja.org/sr-Latn-RS/biblioteka/r/lekcije/BlockBasedProgMakeCodeEng/makecode-and-ev3 (Slides 6 & 7)

Earth Bondhon (n.d.). Ultrasonic Distance Sensor. Ultrasonic Distance Sensor. Retrieved October 7, 2024, from https://earthbondhon.com/ultrasonic-distance-sensor/#google_vignette (Slide 12)

(n.d.). OKOSCAN 73HS High-Speed Rail Testing System. OKOSCAN 73HS High-Speed Rail Testing System. Retrieved October 7, 2024, from https://alffpetrongltd.com/ultrasonic-flaw-detectors/ (Slide 31)

(2024). *Lego Spike Prime*. Welcome to our Teacher Resources. https://education.lego.com/en-us/

UNIVERSITY TRANSPORTATION CENTER FOR
RAILWAY SAFETY
Award Number: 69A3552348340
Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)
Award Number: 2112650

Day 5

- Final Challenge

Objectives:

- Investigate Cargo and Freight Trains
- Go Over Final Challenge Rules and Expectations
- Initiate Final Challenge

Reminders and Procedures:

- Roll Call
- Housekeeping Rules
  - Must wear shirt everyday
  - Restroom only when accompanied by an adult
  - NO Electronic devices unless instructed
  - Be active, engaged and participate in your group
  - Be respectful and leave room organized

What Do Cargo Trains Carry?

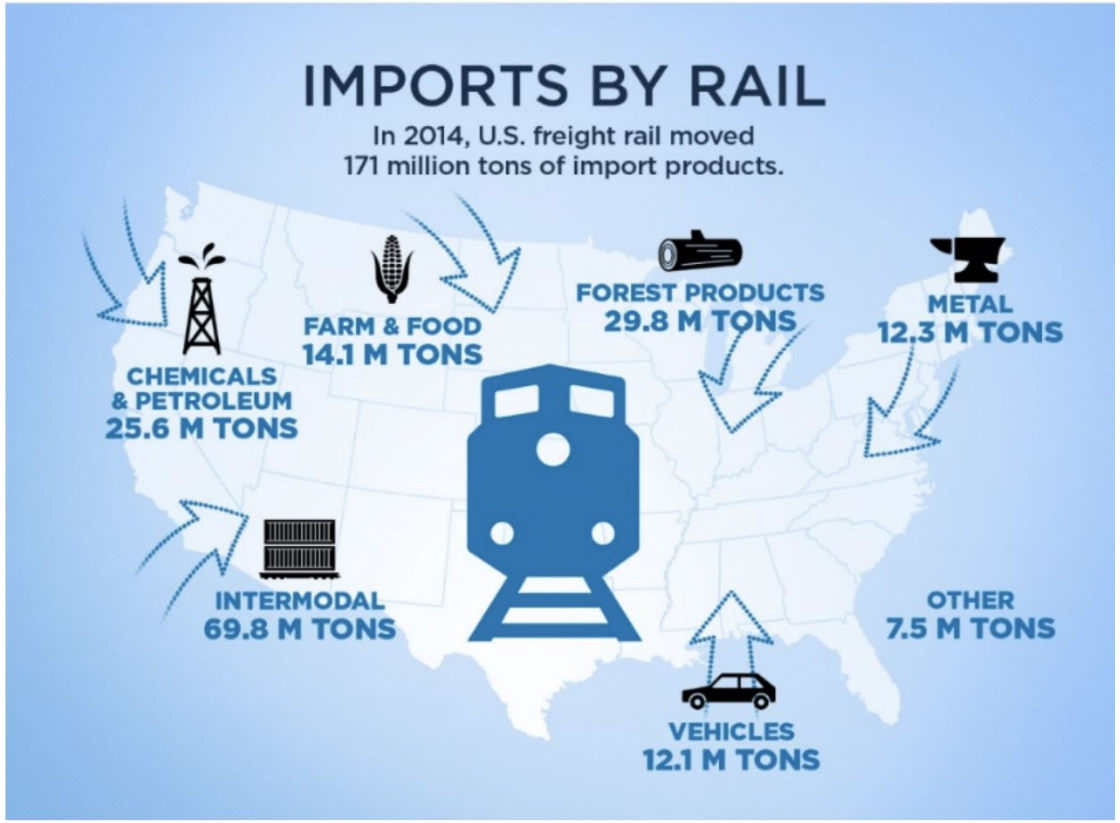
According to the US Bureau of Transportation, the freight industry moves between 1.5 to 2 million ton-miles of goods annually in the US alone.

https://www.bts.gov/topics/rail-transportation

What Do Cargo Trains Carry?

A large number of industries heavily rely on trains for transport as their primary supply because of:

- affordability
- high level of security
- multimodal compatibility
- punctuality
- eco-friendliness



It's Time for the Final Challenge!

https://youtube.com/shorts/QYg7R[illegible]
82s7U2feature=share

Cargo Delivery Races

You will compete to deliver cargo.
The Engineers that deliver the most cargo wins!

Axle Delivery Races

- Design your own robot (you may use building instructions from other lessons)
- The objective is to use a forklift to pick up an wheel axle, drop it off and park.
- Use what you have learned throughout the week.
- Remember to follow the Engineering Design Process.

Remember, the Forklift that delivers the axle and returns to start the quickest wins!

Debriefing Questions:

1. Concept review:
   a. What are you measuring?
      i. Units for distance?
      ii. Units for time?
      iii. Units for speed?
2. After the challenge,we will review the time each group took to get from one end to the other.
3. What are some coding or other challenges you faced?

Photos courtesy of and copyright Free Range Stock

Cleanup

Make sure students:

- look around the floor
- count, and put all materials back in the box
- ensure no Lego parts are missing, misplaced, or left behind.

Completely Disassemble and

Take a FULL Inventory of Your Kit!

Cleanup and Closing Discussion

1. How was today's challenge applicable to Railway Engineering?
2. What are some challenges real engineers face?
3. What are some of your team's strengths and weaknesses?

End of Day 5

Day 5 References

FRA 101: Getting to know Fra - Federal Railroad Administration. FRA 101: Getting to Know FRA. (2021). https://railroads.dot.gov/sites/fra.dot.gov/files/2021-12/20210824-FRA101.pdf (Referenced in slide 4)

Freight Railroads & International Trade. (n.d.). https://www.aar.org/wp-content/uploads/2017/12/AAR-Freight-Railroads-International-Trade-Report-March-2017.pdf (Referenced in slide 5)

Allain, R. (2011, May 6). *How efficient is a freight train?*. Wired. https://www.wired.com/2011/05/how-efficient-is-a-freight-train/ (Referenced in slide 7)

robot_man. (n.d.). *Lego Spike Prime Drag racers using Force Sensors*. YouTube. https://youtube.com/shorts/QYg7Pv82s7U?si=PNUBURB-NWiGyUU5 (Referenced in slide 7)

(2024). *Lego Spike Prime*. Welcome to our Teacher Resources. https://education.lego.com/en-us/