Day 1

- Engineering Design Cycle (Process)
- “How Fast Can You Go?”

Welcome Aboard!!!

- Roll Call
- Shirt Distribution
- 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
  - Keep working environment clean

Objectives:

- Understand how engineers work in teams to achieve a common goal.
- Learn about the history and speed of trains
- Explore and experience basic principles of aerodynamics

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.

Characteristics of an Engineer:

- Strong STEM background
- Effective communication
- Effective listening skills
- Team player

Assign Groups

1. Make sure that students are in groups. (4 is preferred)
2. Communication and listening skills are key factors, it is important for you to feel comfortable communicating and listening to each other.

Team Building Challenge

Cup Challenge:

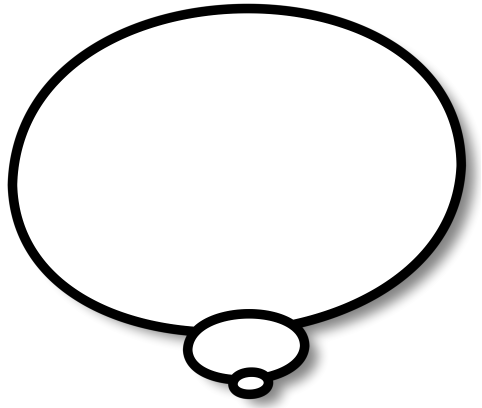
- Your challenge is to build a pyramid of cups by working TOGETHER.
- Tie your string to the rubber band as shown. Team members will *NOT* be allowed to *TOUCH* the cups.
- Using the yarn stretch the rubber band to grab a cup.

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 yarn.**

Let's Reflect...

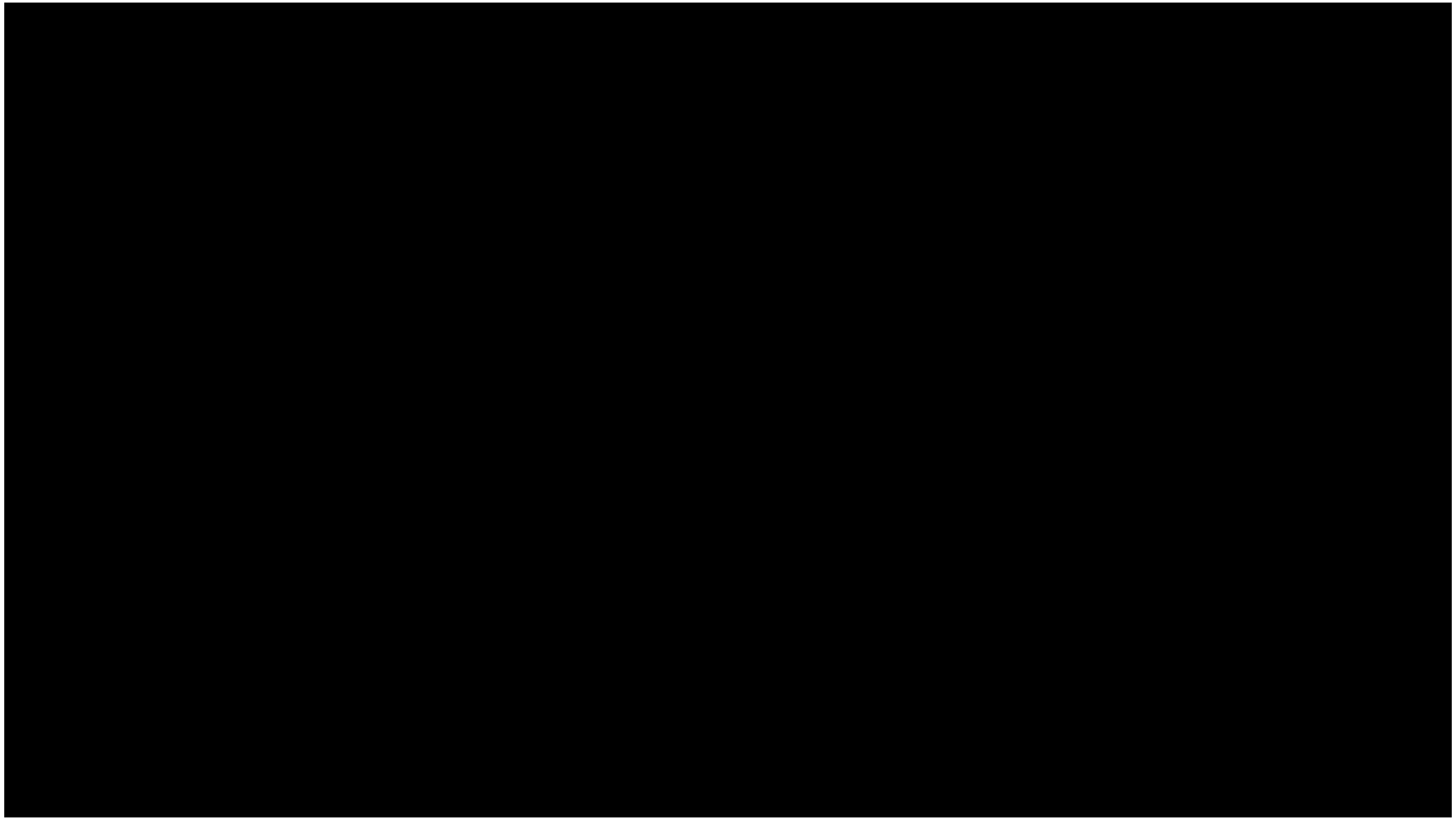


1. What **worked** for your group? What didn't? How did you know?
2. What was **challenging**? How did you deal with those challenges?
3. How do you **feel** about your finished tower?
4. How does this activity **demonstrate how to work in a team**?

Engineering Design Cycle (Process)

- How does the Engineering Design Cycle (Process) apply 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?

What to expect…



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 push 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.
- Most freight is transported by trains, and they are essential to the industry.

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

Railcarts were pulled by people or horses in the early 19th century.

Glacier Express

The **SLOWEST** train 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

A steam locomotive train that runs at **50 miles per hour.**

Train was used in the Harry Potter movie!

Acela Express

Runs at approximately **150 miles per hour.**

This is a tilting train which are designed to counteract the g-force.

Shanghai Maglev

The **FASTEST** train in the world running at **267 miles per hour.**

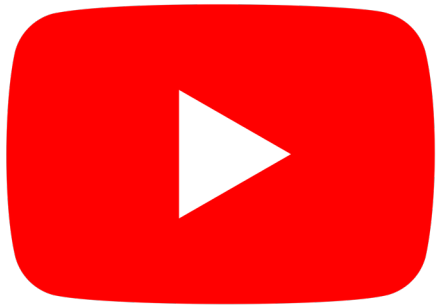
Runs by magnetic levitation.

Newton's Laws

Newton's Laws of Motion in Physics	
Law #1	A body at rest will remain at rest, and a body in motion will remain in motion unless it is acted on by an external force.
Law #2	The force acting on an object is equal to the mass of that objects times its acceleration. F = ma.
Law #3	For every action, there is an equal and opposite reaction.

Newton's Laws

Emphasis on Newton's 3rd Law



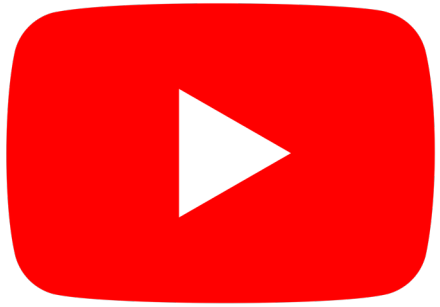
In your own words explain Newton's 3rd law of motion?

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...

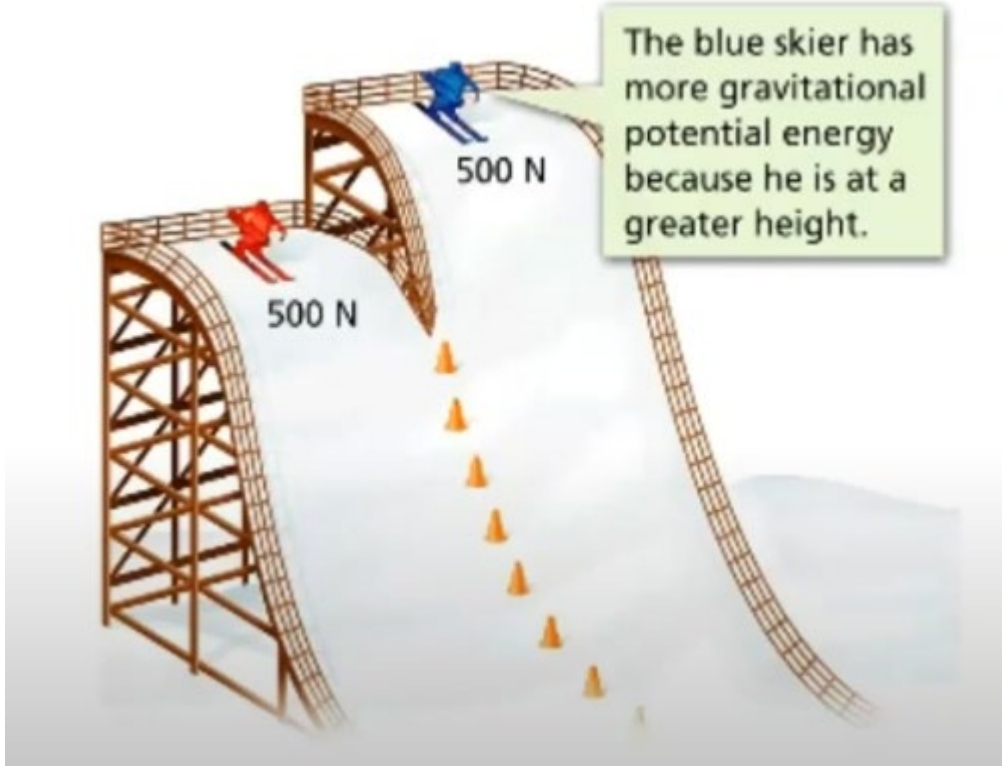
1. What is **Newton's 3rd Law of Motion**?
2. What was demonstrated during the balloon rocket experiment? - How did you know where the forces were applied?
3. What happens if you increase or decrease the size of the balloon?
4. How is this activity **like working on your project with your team**? How did you demonstrate teamwork?

Prior Knowledge:

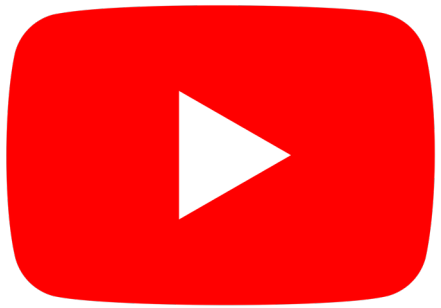
- What is **Potential Energy**?
- How is Gravitational Potential Energy **(GPE)** increased?
- Explain the relationship between GPE and Kinetic Energy.

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?



Potential and Kinetic Energy



Essential Questions

1. **What is potential energy?**

- Potential energy is…

1. **What is kinetic energy?**

- Kinetic energy is…

1. **What increases potential energy?**

- Potential energy increases as…

1. **What increases kinetic energy?**

- Kinetic energy increases as…

Strategy

The strategy will help us remember that Potential energy is greatest at the Top.

POT

TOP

In Summary…

Potential: is stored energy or energy waiting to be used.

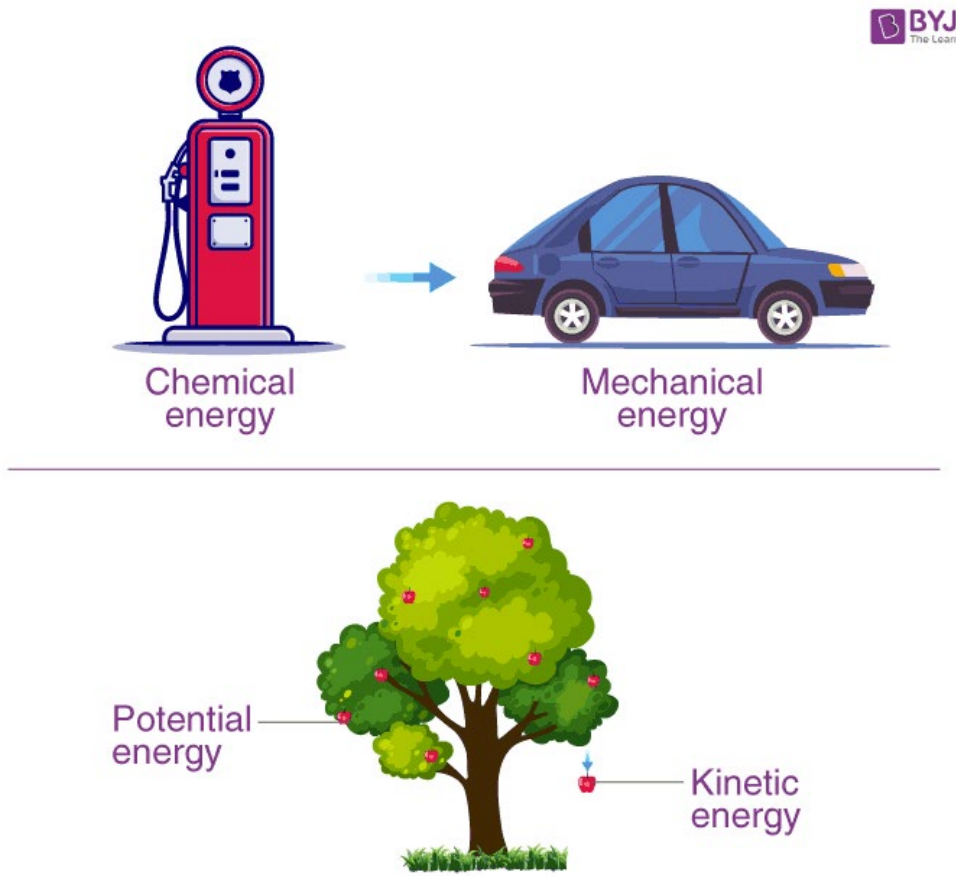
Keep in mind, the higher an object is, the more potential energy it will have.

Kinetic: is energy in motion, or energy in use.

The faster an object moves, the more kinetic energy it has.

Law of Conservation of Energy

According to the **law of conservation of energy**, energy cannot be created nor destroyed. However, it can change forms. **For example:** Our hot wheels activity will demonstrate the transformation of Potential energy into Kinetic Energy.

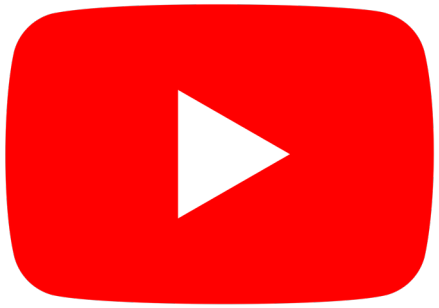


Hot Wheels Lab

Speed by Design

What is Speed?

Understanding Speed



$$speed = \frac{Total\ Distance}{Total\ Time}$$

Let's practice!

1) A train covers a distance of 100 meters in 55 seconds. What is the speed?
2) A car travels for 18 minutes and covers a distance of 865 meters. What is the speed?

Roles Within Your Group

1. **Lead Engineer** - responsible for making sure tasks are completed efficiently on time.
2. **Mechanical Engineer** -
3. **Manufacturing Engineer** - Oversees and leads the building process, make sure that the build is complete and works.
4. **Electrical/Software Engineer**

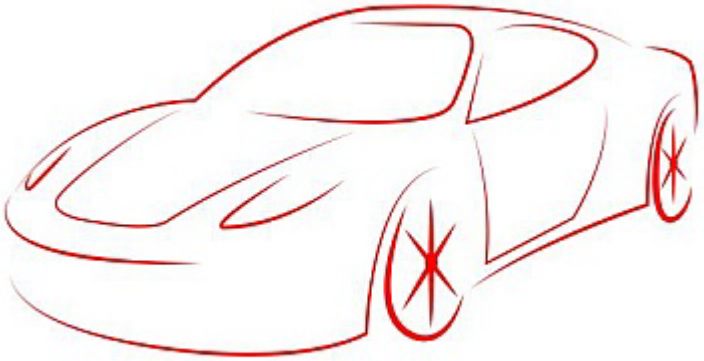
Hot Wheels Lab

Learning Objective:

In this lesson, students explore basic concepts of aerodynamics and the way visual artists and engineers work together to design cars. They experiment with modifications they can make to their cars and determine how these changes influence the speed and distance cars can move.

How Fast Can You Go?

- Make observations
- Think Pair Share:
  - What is speed?
  - Where is the potential and kinetic energy?
  - Do you think the design of a car has any effect on how far and how fast a Hot Wheels car can go?
  - What kinds of things can you change that might change how far and how fast your car might travel?



Materials and Procedures:

In this experience, you will be working in teams to modify Hot Wheel cars to determine what effect the modifications make on the performance of the car.

Materials

1. Stopwatch
2. Hot Wheels car
3. Pieces of Track
4. Calculator

Procedures

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

Explore:

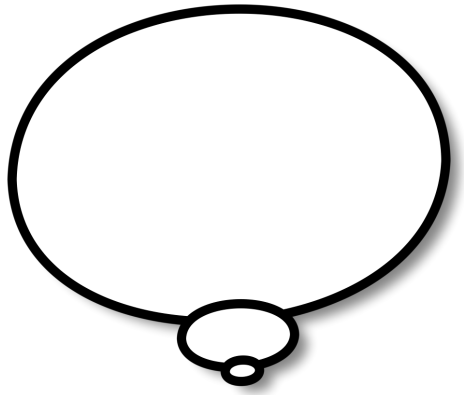
Since you are conducting scientific experiment, you must conduct controlled trials. To do this, as a group you should discuss and agree on variables to keep constant during your tests.

Constants:

1. Where will you start the car on the ramp?
2. How will you put the car in motion?
3. When will you start and stop the stopwatch?
4. How will you measure the distance traveled?

Explore Part 1:

- Record the **distance** traveled and the **time** it took for the car to run the course.
- Conduct 3 trials
- Find the total distance for the 3 trials
- Find the total time for the 3 trials
- Find the estimated Average Speed by dividing the total distance by the total time.



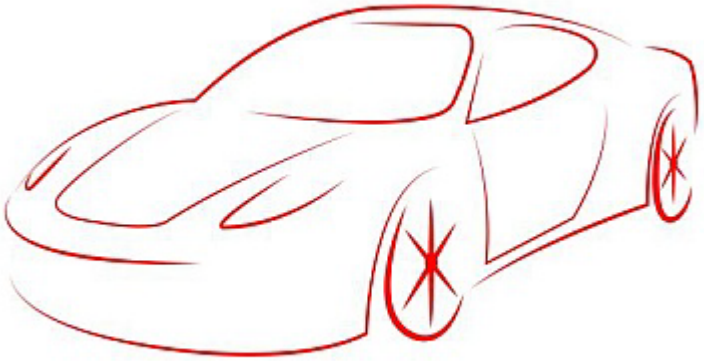
So how do we calculate speed?...

- **Distance:** You will measure in **centimeters** how far your car traveled.
- **Time:** You will record

  much time it takes your car to complete a run.

$$speed = \frac{Total\ Distance}{Total\ Time}$$

Explore Part 2:



- Select a modification and apply it.
- Conduct 3 trials
- Select a second modification and apply it.
- Conduct 3 trials
- Look at the data and decide how the design affected the speed of the car.

Explore:

Team: _____

Modification	Distance Traveled (cm)			Time (s)			Estimated Average Speed (cm/s)
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	
No modification							
Modification #1							
Modification #2							

Note: *Cars should be tested over the same distance for each trial.*

Describe Modification #1: _____

_____

_____

_____

_____

_____

Describe Modification #2: _____

_____

_____

_____

_____

_____

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 car design?
- How does this apply to Newton's Laws?
- What law applies to adding weight on cars and testing speed?

Recap Energies

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

Cleanup

1. Please disassemble and return the following:
   - tracks
   - cars
   - connectors
2. Look around the floor to ensure parts are not damaged or left behind.
3. Lastly, properly dispose of any trash

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?

Any Questions?

End of Day 1

Day 1 References

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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=7SjX7A_FR6g (Slide 37)

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

- Building Basic Bot
- Programming Basics
- Calculating speed

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

Recap Prior Knowledge:

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

Recap Prior Knowledge:

- Is energy created or destroyed?
- What is Law of Conservation of Energy?
- In yesterday's Hot-Wheels™ activity, was there an energy transformation?

Objectives:

- What is Engineering?
- Build the Basic EV3 Lego Bot
- Basic Coding
- Calculating Your Bot's Speed (If sufficient time)

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

Check out the engineering careers at sciencebuddies.org!

LEGO® EV3

What does it mean to be an engineer?

1. Understand how engineers work in teams to **achieve a common 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.**

Robotics Engineer

1. What career did she study?
2. What did she program her robot to do?
3. What type of equipment did she use throughout the video?
4. What motivated her to work with computers?

Pair Programming

Driver: Sits at the computer and controls the main actions of the computer.

Navigator: Helps the driver by answering the driver's questions and points out potential problems or mistakes.

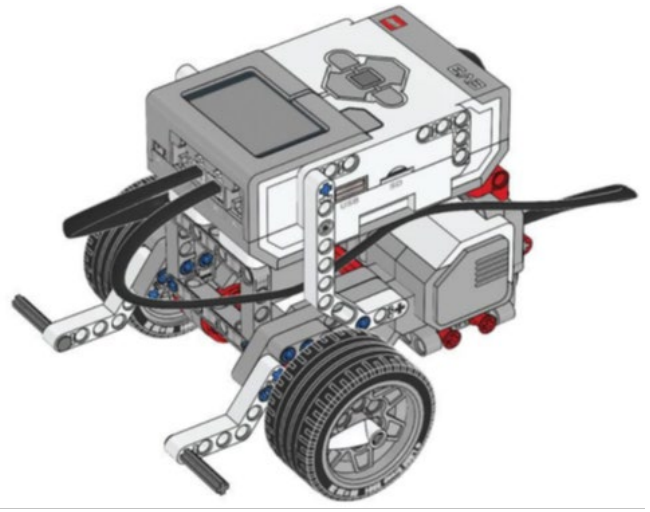
- What does the driver do?
- What is the role of the navigator?
- What worked for them?
- What didn't work?

Assemble LEGO® MINDSTORM® EV3 Basic Robot

Lesson Overview: Students will work in teams modeling real-life engineering working groups, assuming team roles as assigned in Activity #1. Students will follow the basic instructions for building and programming their own robots.

Assemble **LEGO® MINDSTORM®**

EV3 Basic Robot



Materials: (per group)

- One LEGO® MINDSTORM® EV3 basic robotics kit
- LEGO® MINDSTORM® EV3 manual (Found in iPad)
- Laptop or Ipad
- LEGO® MINDSTORM® software installed on the laptop or Ipad
- Meter stick

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® MINDSTORM® EV3 robotics kit using the LEGO® Education EV3 Classroom .

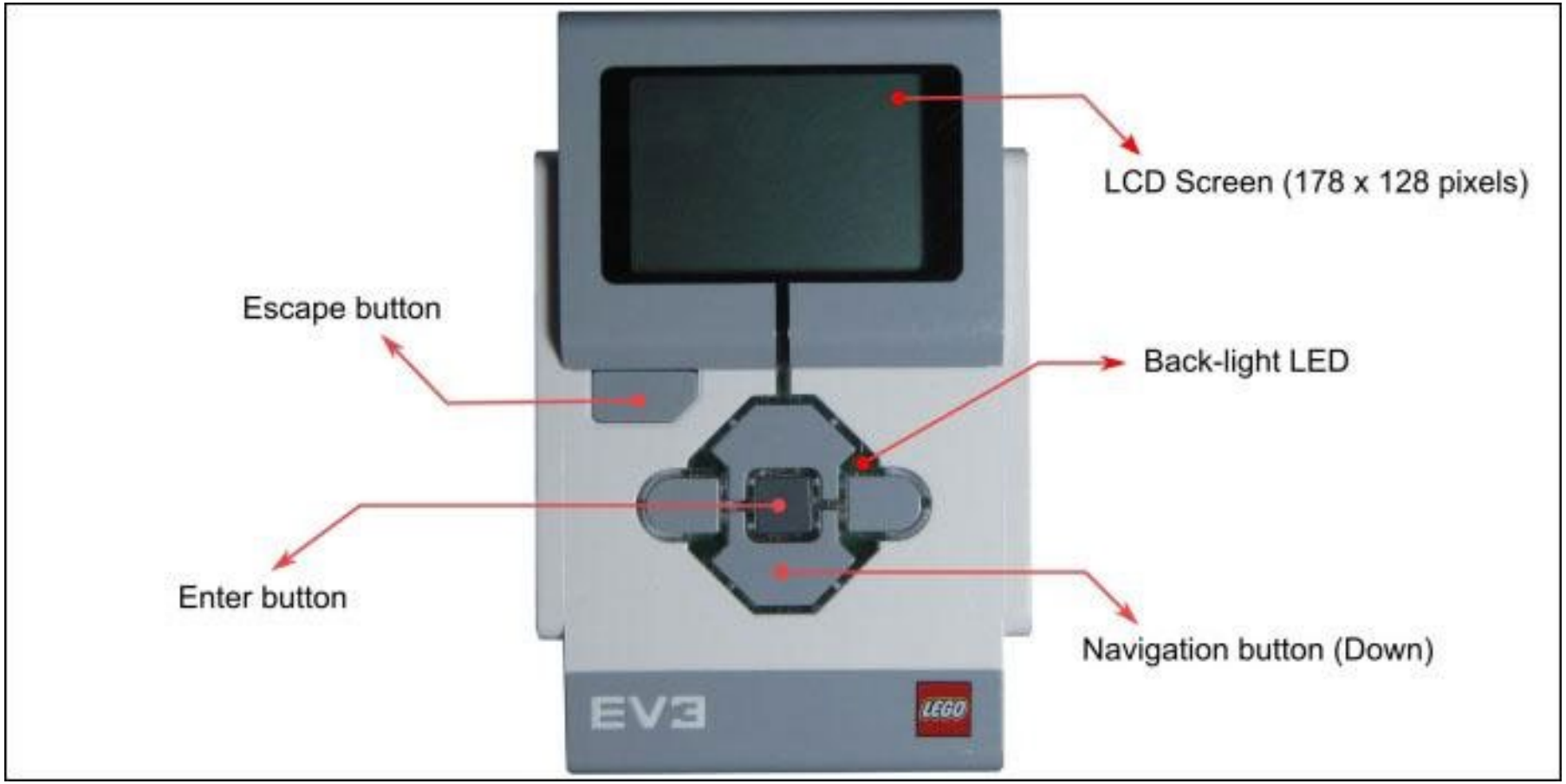
Process and Procedure

➔ 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.

Getting Familiar With Your Equipment

Brick: Main



Ports

PC Port

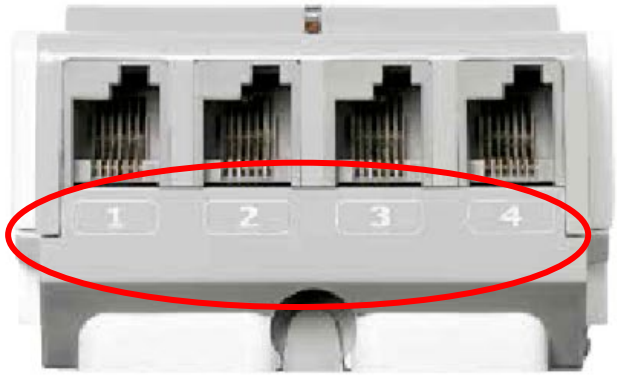
The Mini-USB PC Port, located next to the D port, is used to connect the EV3 Brick to a computer.

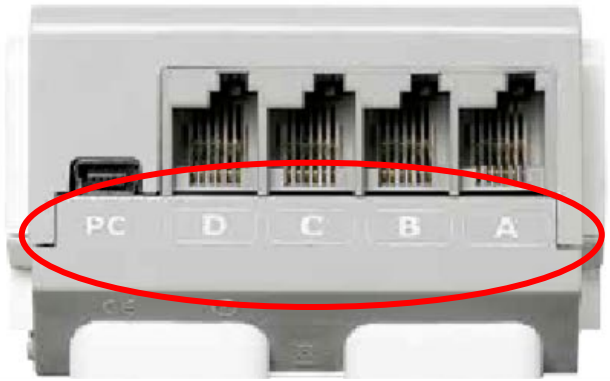
Input Ports

Input Ports 1, 2, 3, and 4 are used to connect sensors to the EV3 Brick.

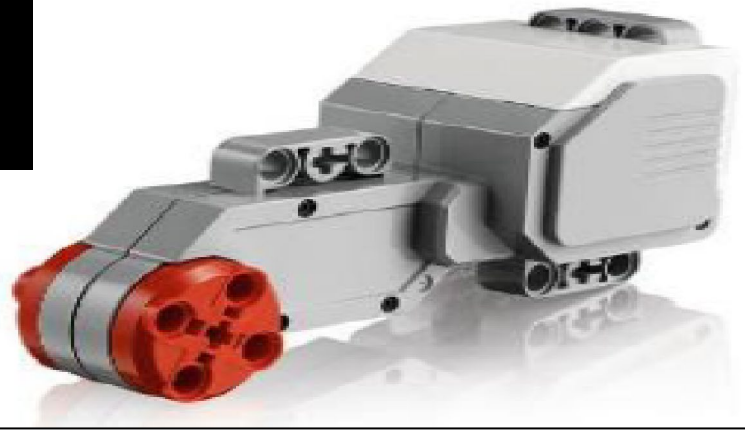
Output Ports

Output Ports A, B, C, and D are used to connect motors to the EV3 Brick.





Motors



Large Motor:

- Receives programmed instructions from the Brick.
- Heavy duty with lower gearing for mobility Requirements.

Medium Motor:

- Receives programmed instructions from the Brick.
- Used primarily for moving parts of a robot.
- Light duty with higher gearing for quick response; Not suitable for mobility.

Sensors

Ultrasonic Sensor:
Detects distance to an object and sends that data to the brick for possible action according to programmed parameters.

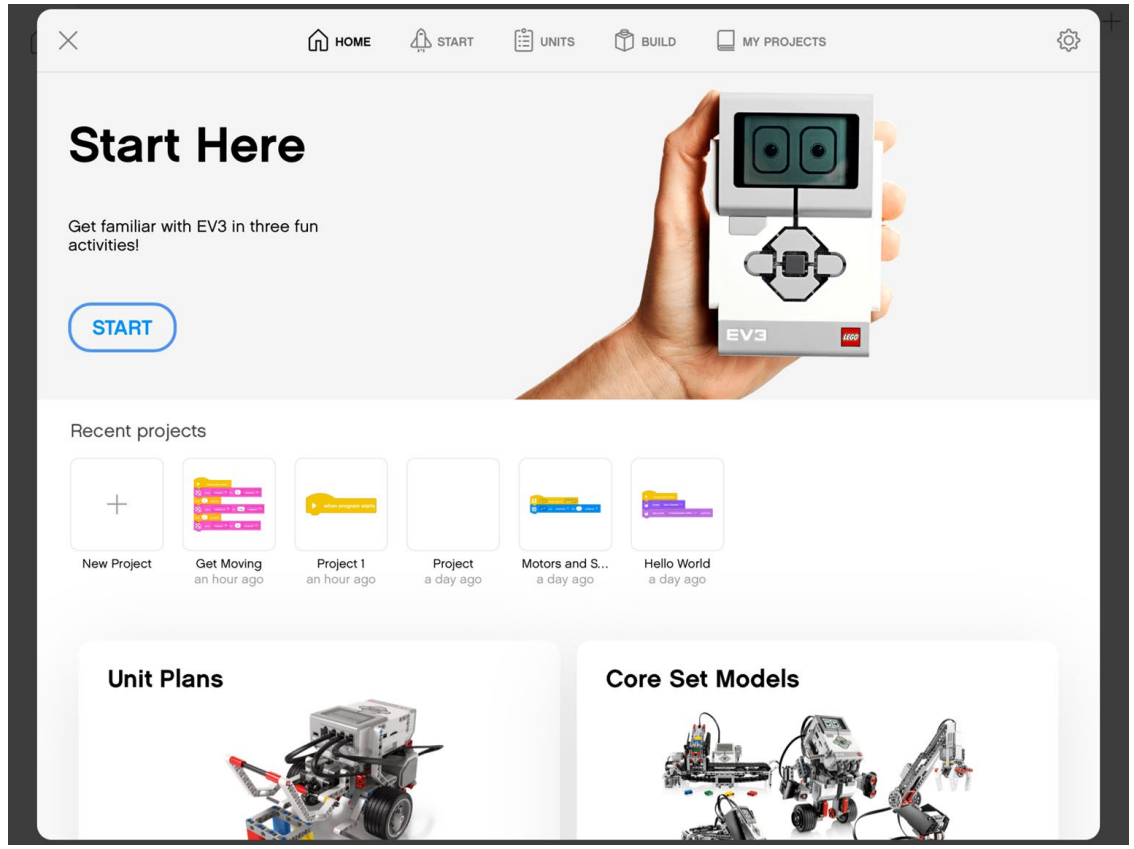
Touch Sensor:
- Sends the state of either being pressed, not pressed, or bumped (pressed, then not pressed to the Brick for possible action according to programmed parameters.
- Often used to determine if the robot has physically bumped into something.

Color Sensor:
- Detects color differences and send that data to the Brick for possible action according to programed parameters.
- Emits a set of color wavelengths. The color wavelength that is reflected back, and not absorbed, determines the color of the surface.

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



HOME START UNITS BUILD MY PROJECTS

Recent projects

New Project | Angles and P... a few seconds ago | The Factory R... a minute ago | Moves and Tu... 2 minutes ago | Project 22 days ago

Unit Plans

All of the EV3 Classroom lessons are grouped into themed units to actively engage middle school students in STEM learning.

Core Set Models

These models will inspire you and challenge your robotics skills. Take LEGO® MINDSTORMS® Education EV3 to the next level!

HOME START UNITS BUILD MY PROJECTS

Unit Plans

Grades 6-8

Robotics, Engineering, Computer Science, STEAM

Robot Trainer

Ready to train your robotics skills? Take the Driving Base, configure its extensions, and write programs to...

Grades 6-8

Engineering, Science, STEAM

Engineering Lab

Are you interested in machines? Get ready to work like a real engineer! Build exciting models and conduct yo...

HOME START UNITS BUILD MY PROJECTS

Robotics, Engineering, Computer Science, STEAM

Robot Trainer

Developing Robotics Skills Using a Driving Base

LESSONS TEACHER RESOURCES

Ready to train your robotics skills? Take the Driving Base, configure its extensions, and write programs to complete challenging tasks!

Update available

Moves and Turns

Making Controlled Movements

The factory manager has ordered a wheeled robot to help automate some tasks. The Driving Base has arrived, and it's

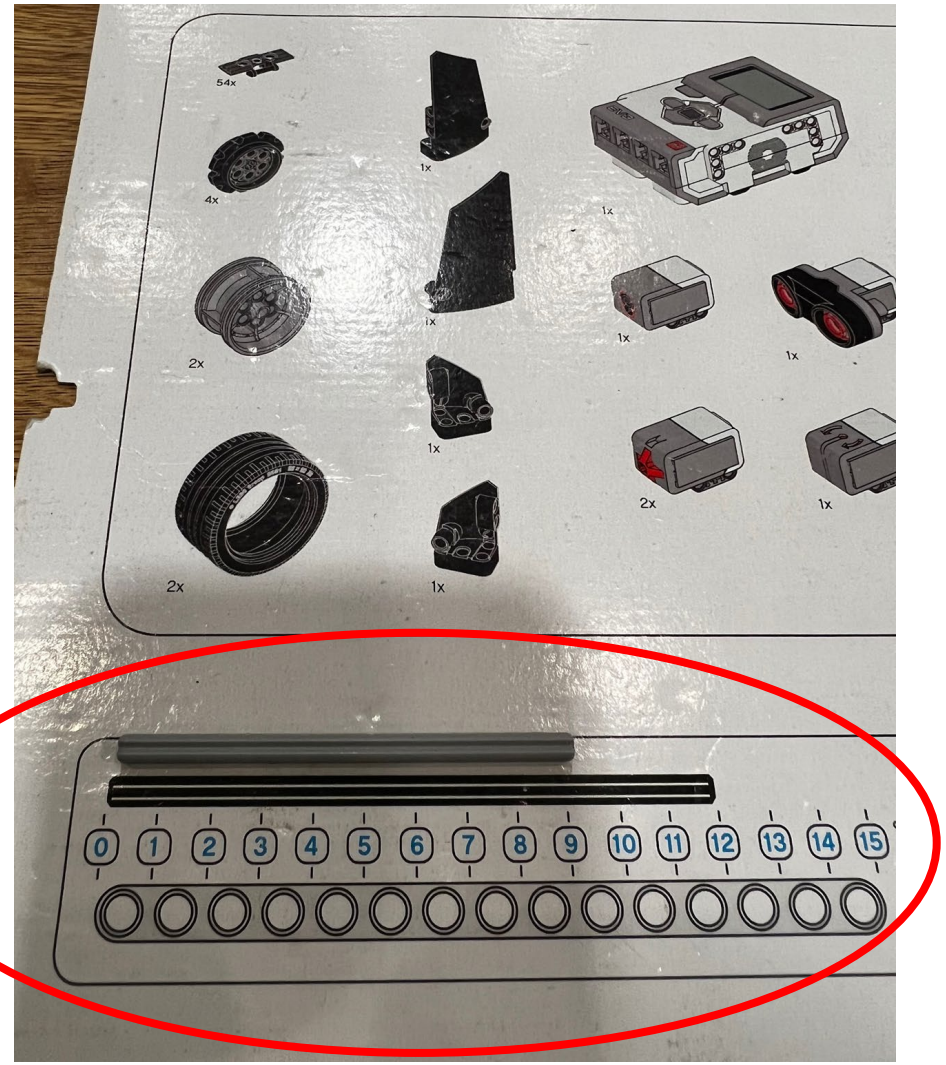
MORE

START

45-90 min.

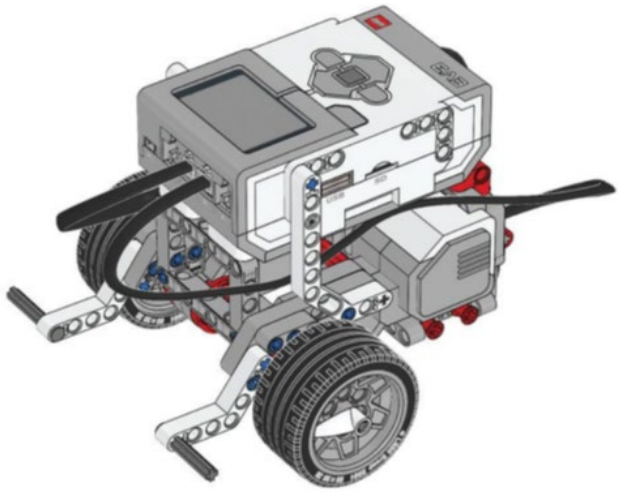
How to identify pieces…

Place the piece you want to measure as shown in the picture. The number will indicate which piece of equipment you have.



Let's Build!

1:30:00



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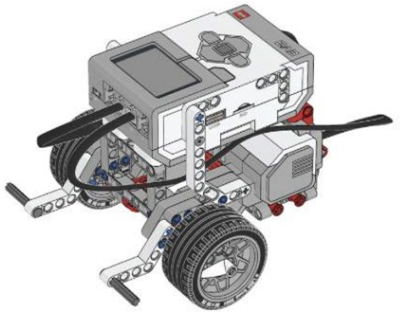


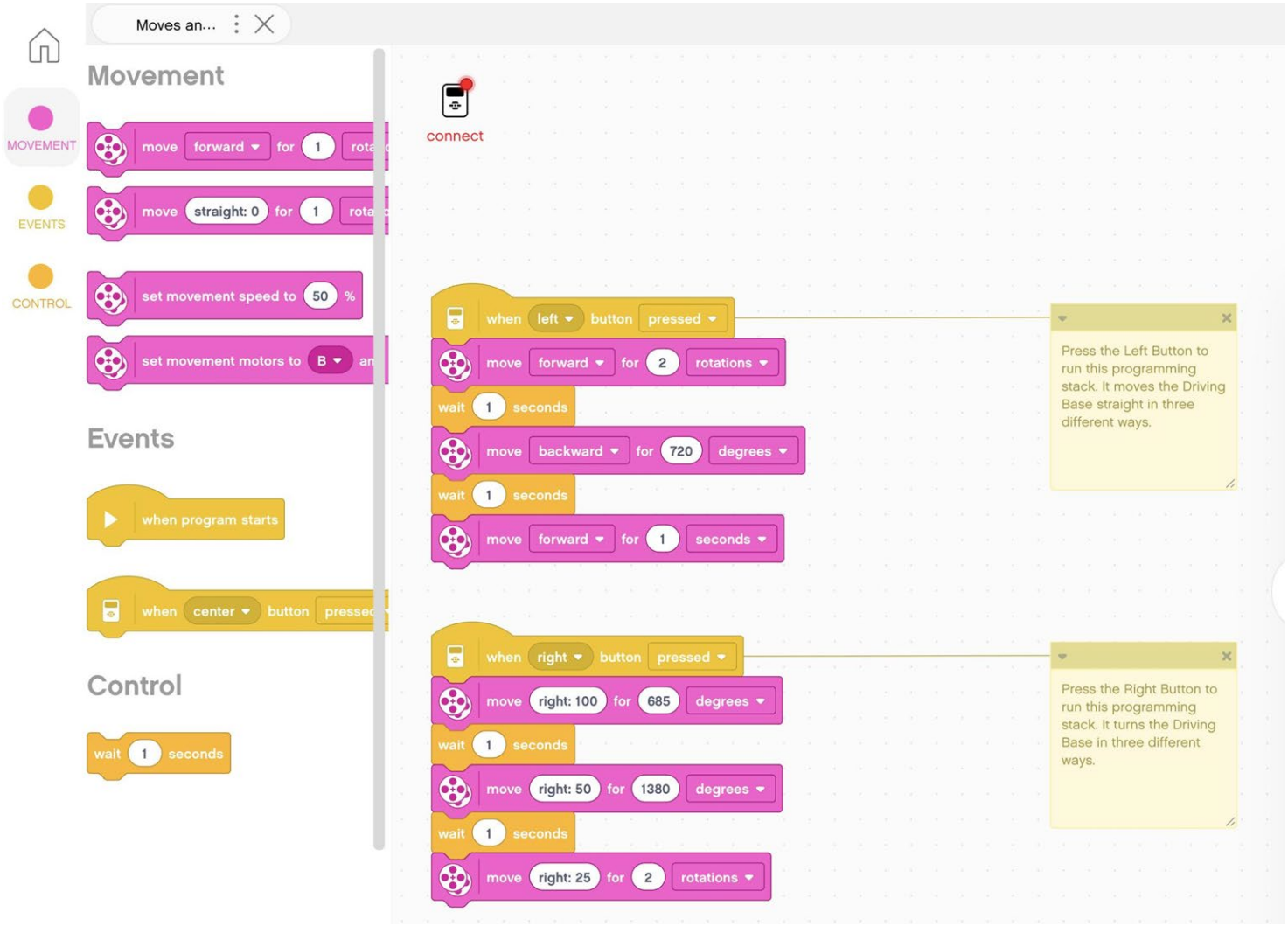
This is the Driving Base.

We'll use it throughout this unit. If you haven't already built it, build it now!

BUILD

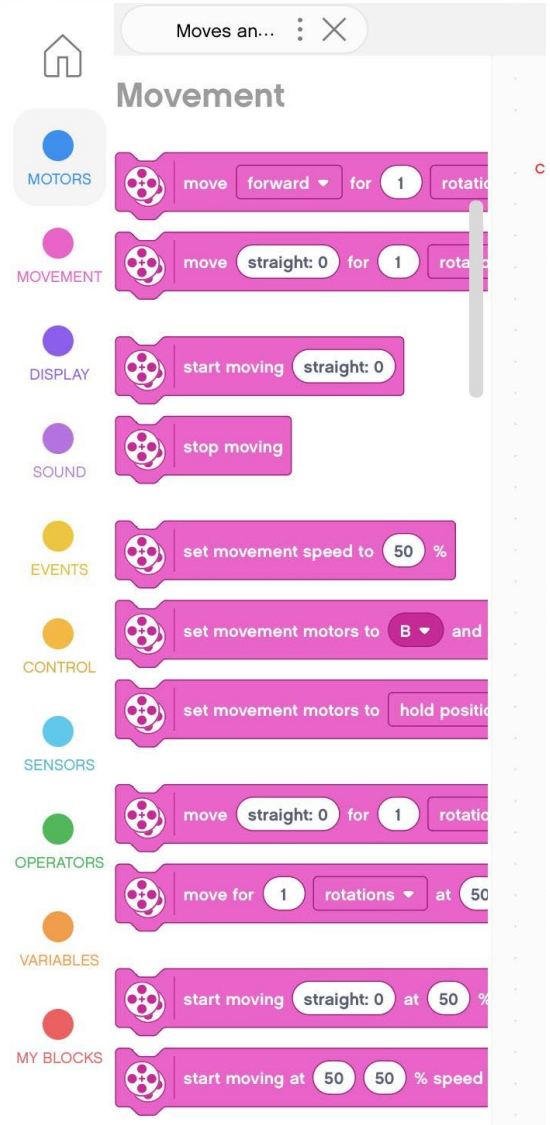
Pairing and Observations

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



Introduction to the rest of the blocks

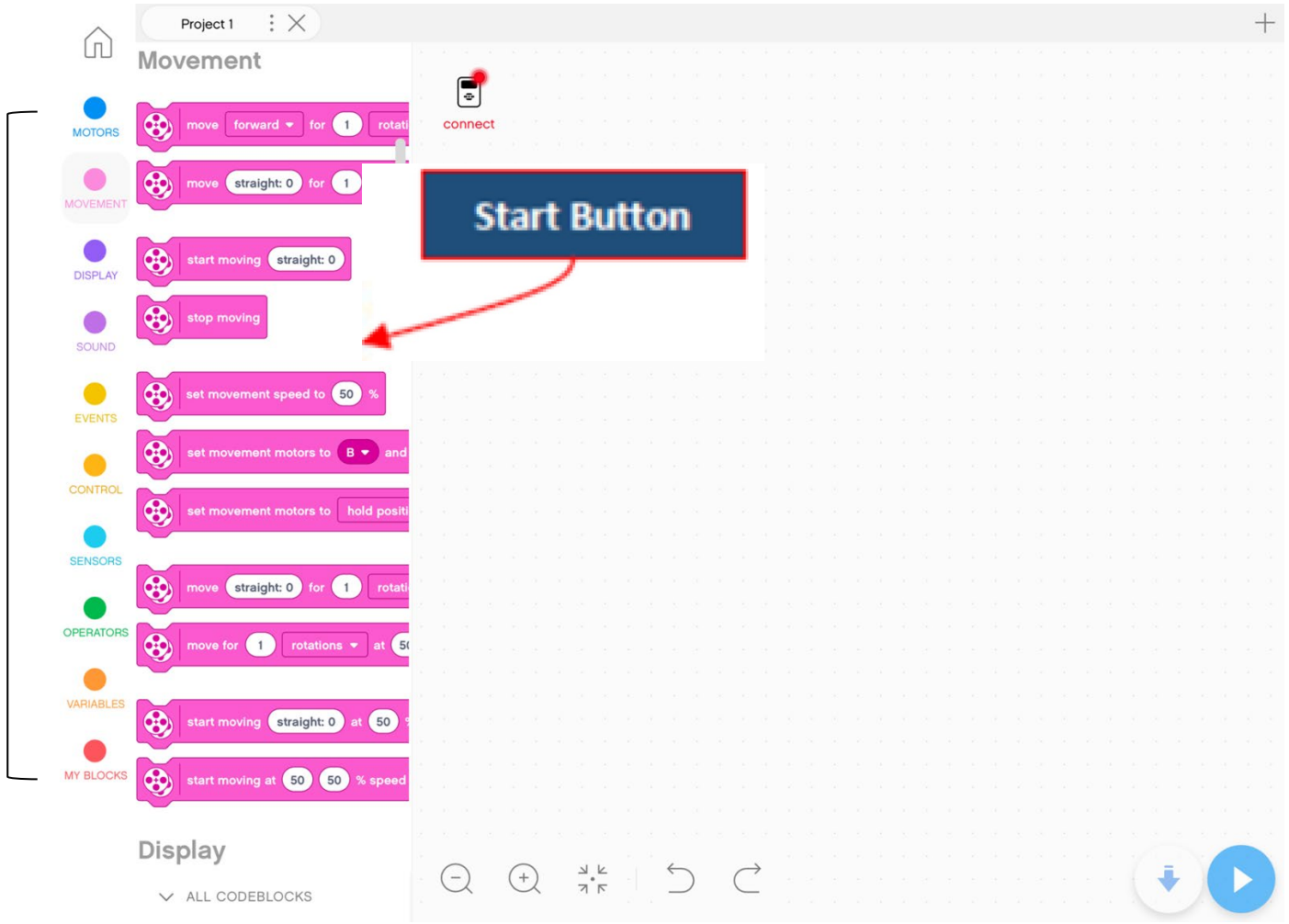
- The program you just tried provided you limited blocks.
- Let's take some time to get familiar with the rest of the move blocks.



WORK SPACE

All programs must start with the Start command. It is the yellow arrow.

Programming Blocks

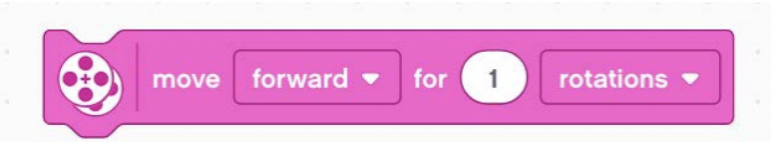


MOVEMENT BLOCKS

Movement Blocks

Movement blocks enable you to run two motors in a synchronized motion. They're primarily used to move Driving Bases around. Only motors of the same type (e.g., two Medium Motors) can be synchronized.

Move for Duration



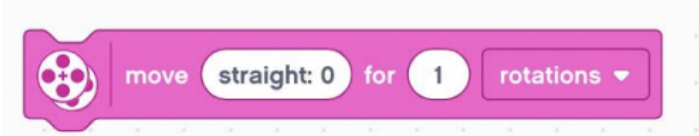
Moves a model forward or backward for a specified number of seconds, degrees or rotations.

Use the Set Movement Motors Block to match the Ports on your model that are connected to Large Motors. The default Ports are B (left) and C (right).

The speed of the motors is set by the Set Movement Speed Block. The default speed is 50%.

MOVEMENT BLOCKS

Move with Steering for Duration



Moves a model forward the specified number of seconds, degrees, or rotations with the specified steering. the possibility of steering.

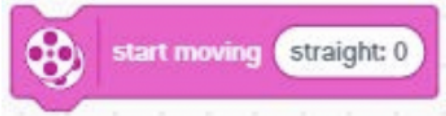
Higher steering values (i.e. +99 and -99) will make the arc path of the Driving Base sharper.

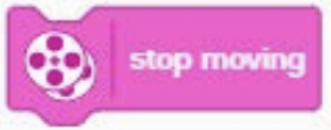
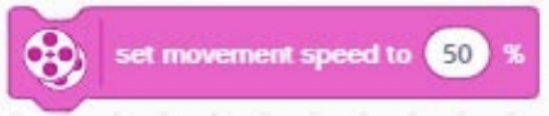
Use a value of "0" to drive in a straight line. Using the values 100 and -100 will make the Driving Base pivot on itself.

Use the Set Movement Motors Block to match the Ports on your model that are connected to Large Motors. The default Ports are B (left) and C (right).

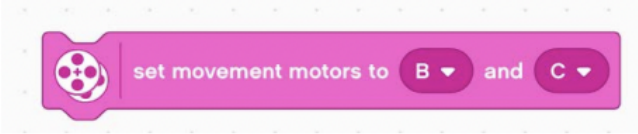
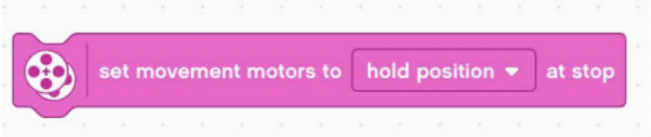
The speed of the motors is set by the Set Movement Speed Block. The default speed is 50%.

MOVEMENT BLOCKS

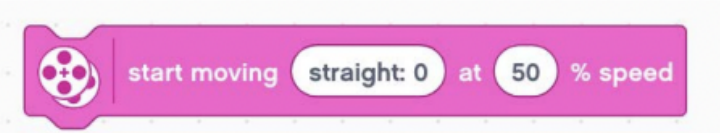
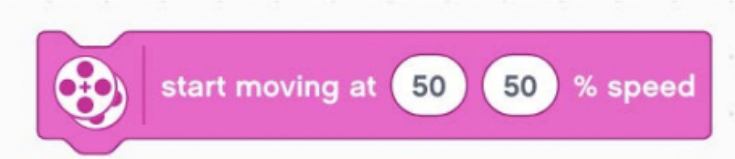
Start Moving with Steering 	Starts moving a model forward with the possibility of steering forever. Higher steering values (i.e. +99 and -99) will make the arc path of the Driving Base sharper. Use a value of "0" to drive in a straight line. Using the values 100 and -100 will make the Driving Base pivot on itself.

Stop Moving 	Stops all movement. Use the Set Movement Motors Block to match the Ports on your model that are connected to Large Motors. The default Ports are B (left) and C (right).
Set Movement Speed 	Sets the speed of a moving Driving Base. The speed range is -100 to 100. Negative values change the direction of the movement. The default value is 75%

MOVEMENT BLOCKS

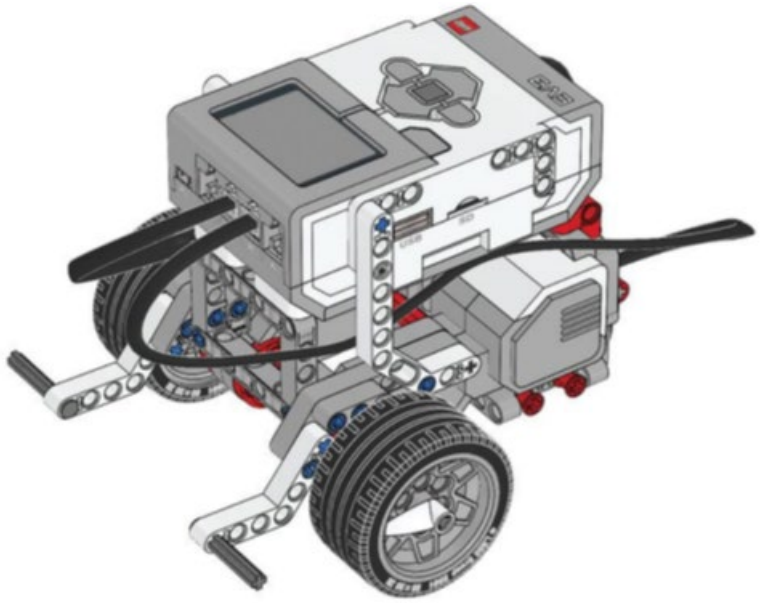
Set Movement Motors 	Sets the movement motors for the Movement Blocks. The first specified Port sets the left motor, and the second specified Port sets the right motor. The default Ports are B (left) and C (right).
Set Movement Motors to Hold Position at Stop 	Sets the action that the movement motors will perform when their current command completes. It can be set to either float or actively hold the current position when the motors stop.
Move with Steering for Duration at Speed 	Moves a model the specified number of seconds, degrees, or rotations at the specified speed, with the specified steering. Use the Set Movement Motors Block to match the Ports on your model that are connected to Large Motors. The default Ports are B (left) and C (right).

MOVEMENT BLOCKS

Start Moving with Steering at Speed 	Starts moving a model at the specified speed, with the specified steering until the motors are told to do something else or the program stops. Use the Set Movement Motors Block to match the Ports on your model that are connected to Large Motors. The default Ports are B (left) and C (right).
Start Moving at Speed 	Starts moving a model at the specified speed for each motor until the motors are told to do something else or the program stops. The first speed value sets the speed of the left motor, and the second speed value sets the speed of the right motor.

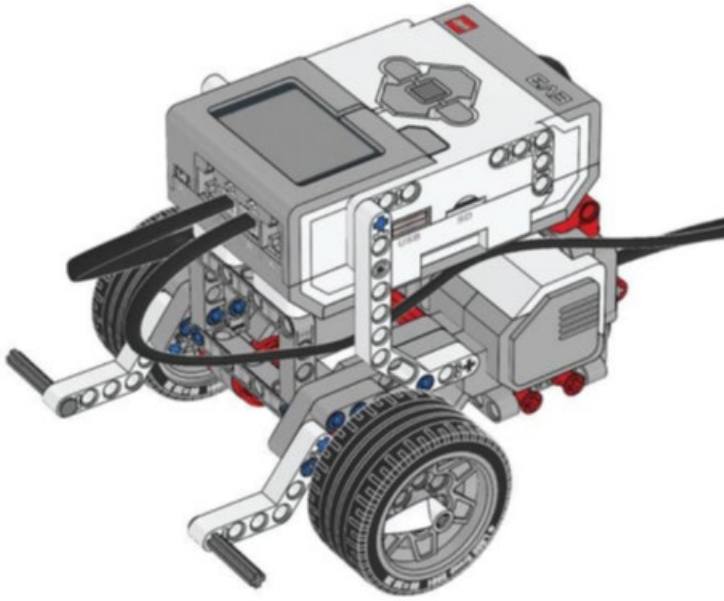
It's Time for a Challenge!

LEGO education

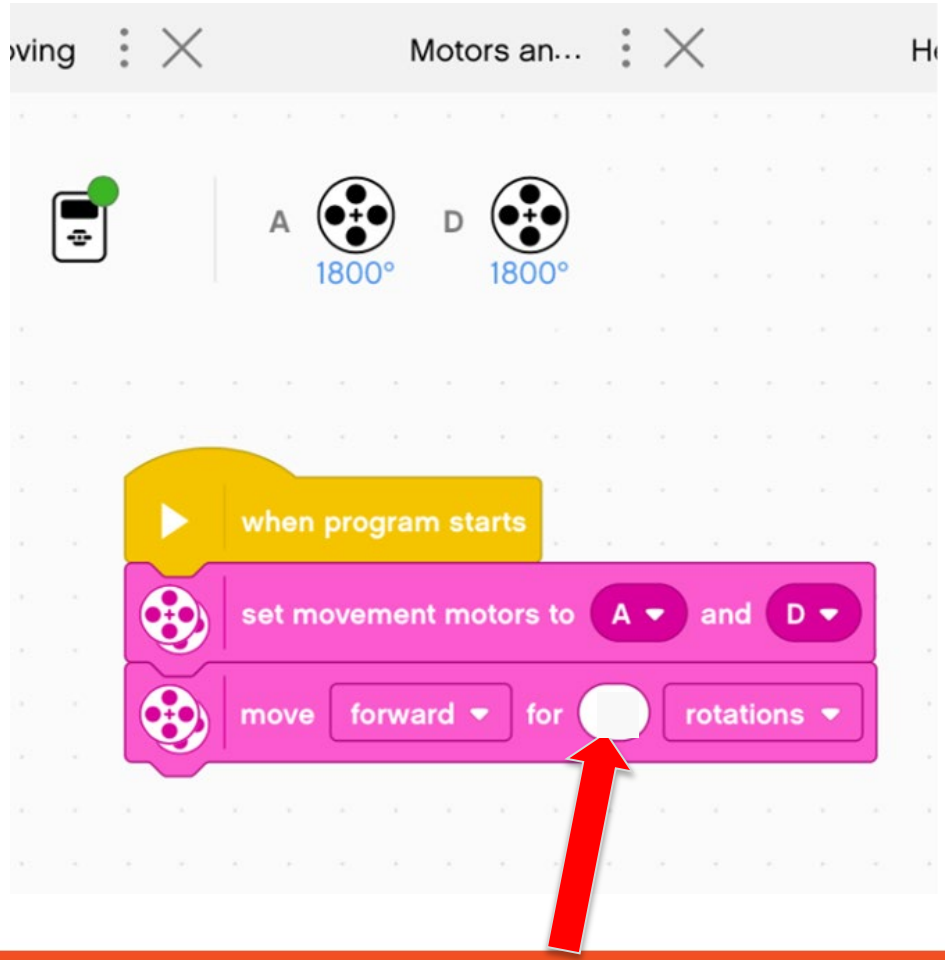


Pairing Your Robot

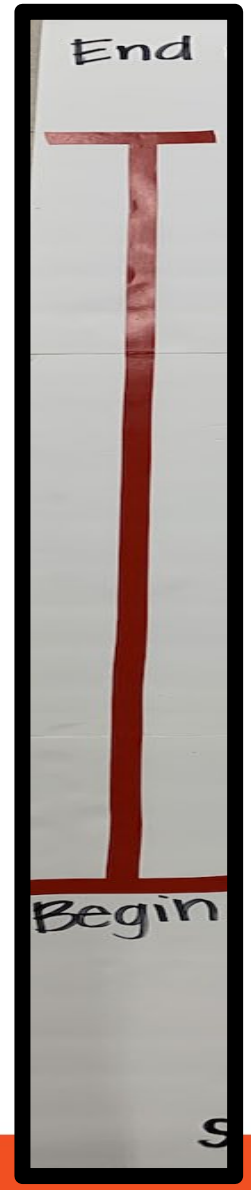
Before programming the commands, Sync the robot to the iPad using Bluetooth. Press the button in the middle of the block to turn it on.



Program Your Robot to...



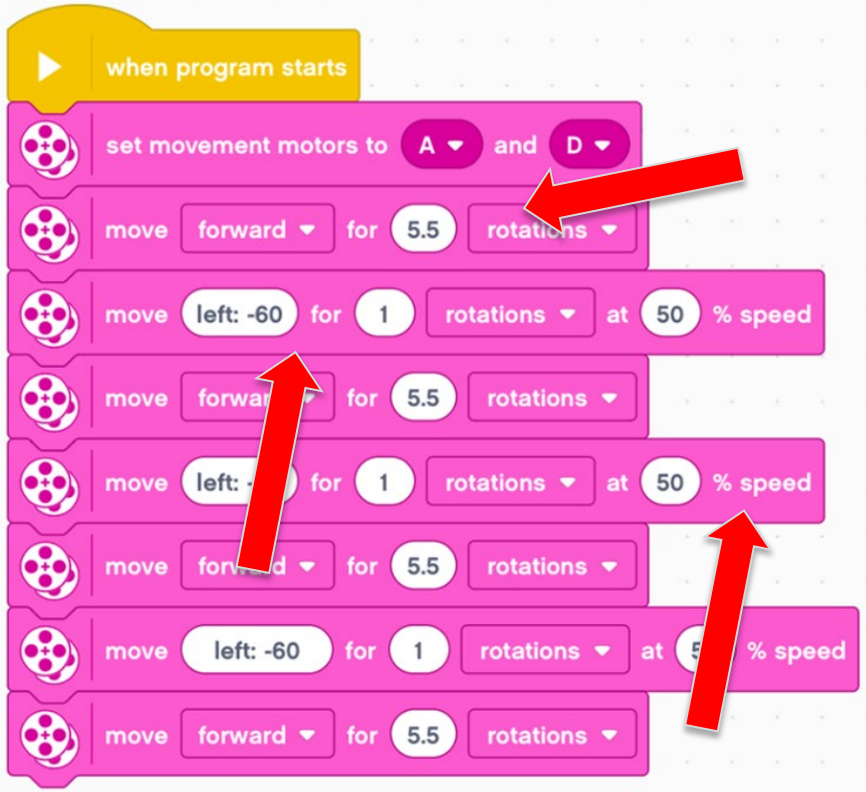
1. Set movement motors to correct motors.
2. The goal is to program your Robot to move forward an entire meter.
3. Use the engineering design process to determine the number of rotations needed to complete the distance of 1 meter.
4. You will need to alter the number of rotations to fit your measurements.



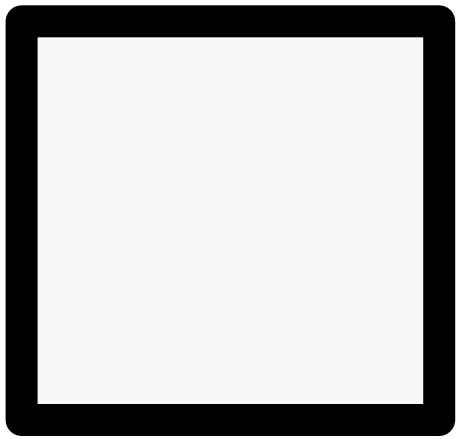
Create a New Program

- Save your program on moving your robot 1 meter. You will need this shortly.
- Open a new program for the next challenge.
- Title your programs.

Program your robot to move in a square.



1. Set movement motors to correct motors.
2. The goal is to program your Robot to move in a square.
3. Use the engineering design process to determine the number of rotations or degrees needed to complete the distance.
4. You will need to alter the number on the red arrows to fit your measurements.

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Award Number: 69A3552348340


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

Day 2: Part 2

So how do we calculate speed?...

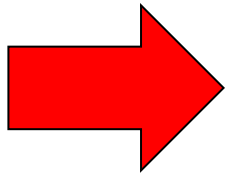
- **Distance:** You will measure in **centimeters** how far your robot traveled.
- **Time:** You will record much time it takes your robot to complete a run.

$$Speed = \frac{Total\ Distance}{Total\ Time}$$

Example:

My robot traveled **150 centimeters in 20 seconds.**

$$Speed = \frac{Total\ Distance}{Total\ Time}$$



$$Speed = \frac{150\,cm}{20\,sec}$$

$$Speed = 7.5\,cm\,per\ \text{sec}$$

Calculating Speed

Use the proper units:

Distance = centimeters

Time = seconds

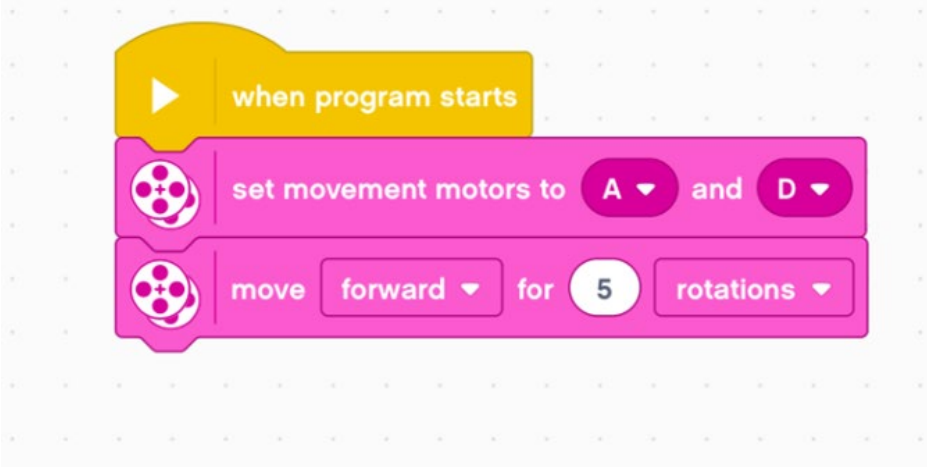
Formula for Calculating Speed

$$Speed = \frac{Total\ Distance}{Total\ Time}$$

Trial	Distance	Time	Speed
1	cm	(s)	(cm/s)
2	cm	(s)	(cm/s)
3	cm	(s)	(cm/s)

Average Speed:

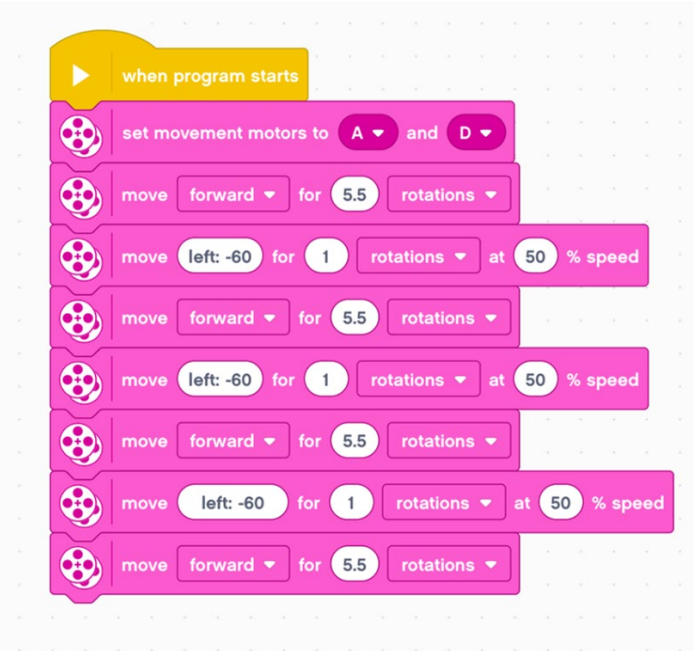
Let's Calculate Your Bot's Speed!



1. Your distance traveled is 1 meter.
2. What other information do you need in order to calculate your speed?

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

Let's Calculate Your Bot's Speed!

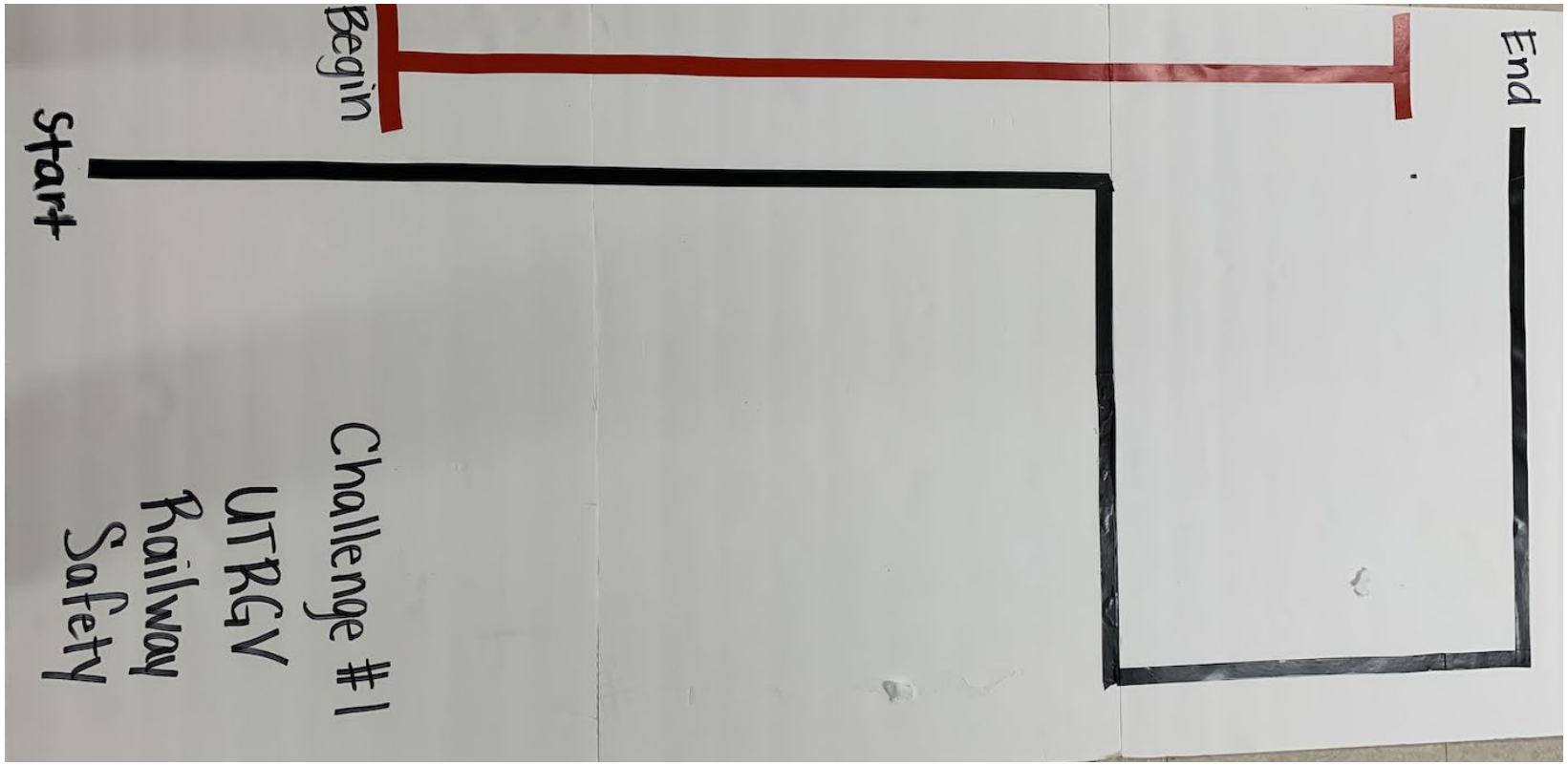


1. Let's calculate speed of traveling in a square.
2. What other information do you need in order to calculate your speed?

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

Additional Maze Challenge

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



Debriefing Questions:

Concept review:

1. What are you measuring?
   a. Units for distance?
   b. Units for time?
   c. 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?

Cleanup

Make sure students:

- Look around the floor for any parts
- Pick up any trash and dispose of it properly
- Put all materials back in the box
- Ensure no Lego® parts are missing, misplaced, or left behind.

DO NOT DISASSEMBLE ROBOT.

Ensure everything is put away.

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?
4. What can you do tomorrow to improve your driving base/coding?

End of Day 2

Day 2 References

Eyler, S. (2021). *Gravitational Potential Energy*. PS2L3 1b Gravitational Potential Energy. Retrieved October 7, 2021, from https://www.youtube.com/watch?v=1Ix4Ey2CTJ0 (Slide 3)

Eyler, S. (n.d.). Day at Work: Robotics Engineer. Day at Work: Robotics Engineer. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=7trO3sQzmf8 (Slide 10)

Code.org (n.d.). Pair Programming. Pair Programming. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=vgkahOzFH2Q (Slide 11)

Pintarič, M. (n.d.). *01-port-view-ev3*. 01-Port-View-Ev3. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=bqdiL9V57D4 (Slide 17)

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

Day 3

- **Wheel and Axle**
- **Forklift Challenge**

Objectives:

- Team Building Exercise
- Investigating the Wheel and Axle
- Define trial and error in your own words
- Medium Motors and Forklifts
- Safety Procedures in the HIgh-Bay
- Tour of High-Bay

Team Building Activity

Directions:

1. You will first compete with members in your group.
2. The winner from each duo, will then compete with another winner from a different duo.
3. Those that have lost will follow a winner and cheer him/her on.
4. Once all members in the group have played, we can then move on to compete with other winners from different groups.
5. Last person to win will be considered the classroom champion!

Let's Reflect...

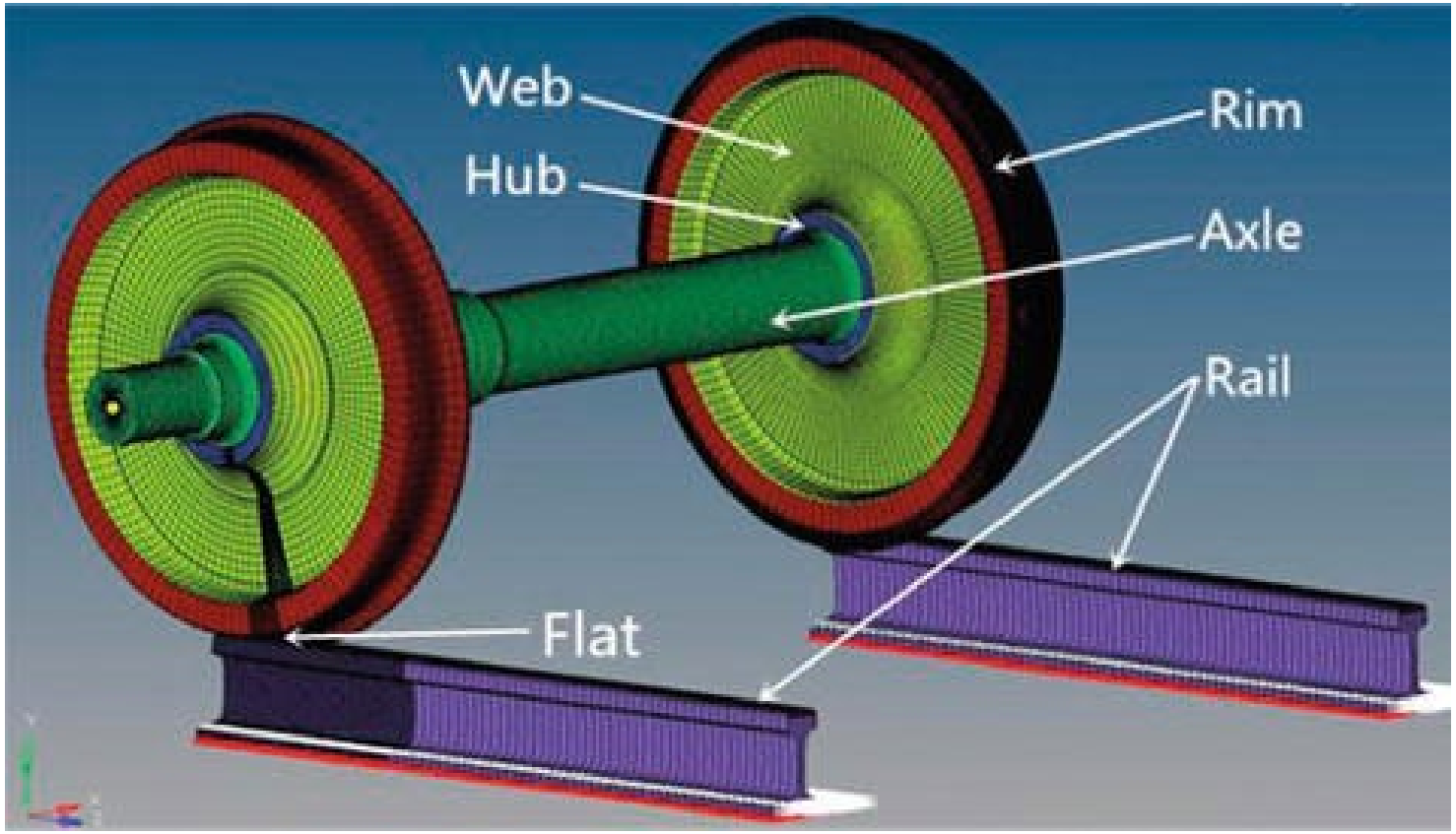
1. How did you feel as a supporter/winner?
2. How is support important in a team?

Wheel and Axle

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

Approximately weighs 2,000 pounds (depending on size & material)

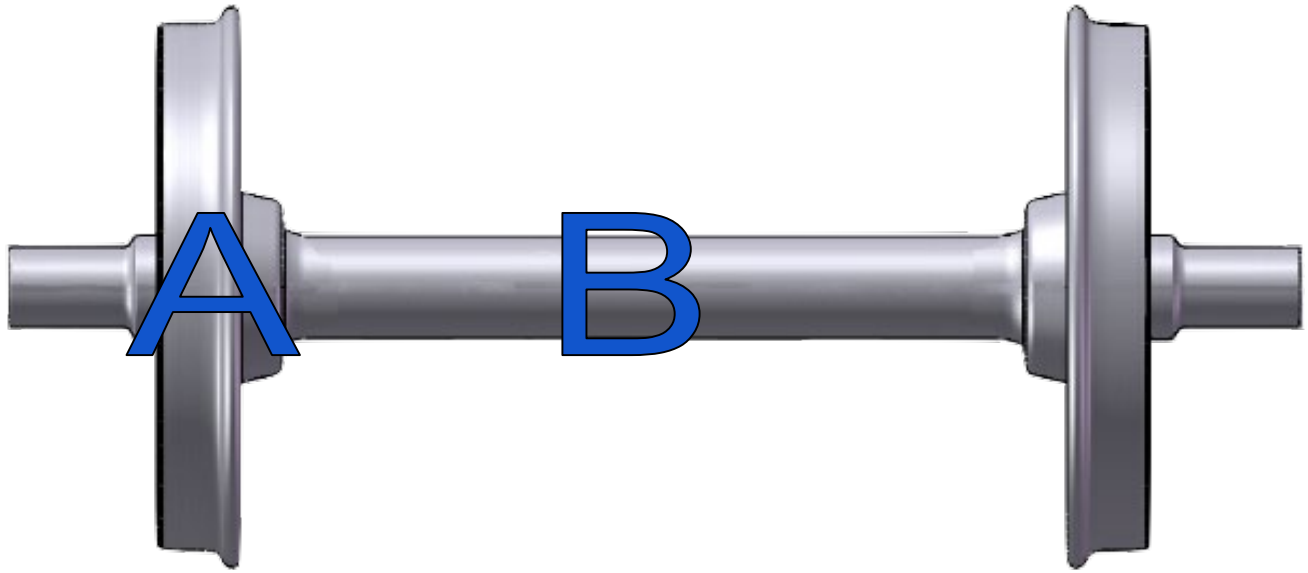
(Wheel-Axle Assembly)



(Wheel-Axle Assembly)

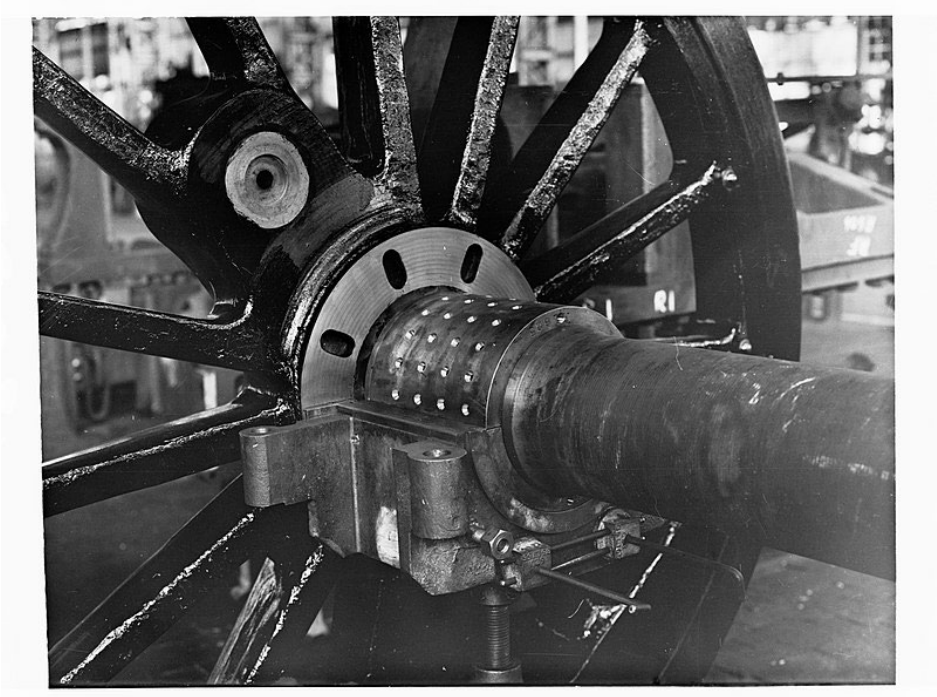
Which letter points to the axle?

Which letter points to a wheel?

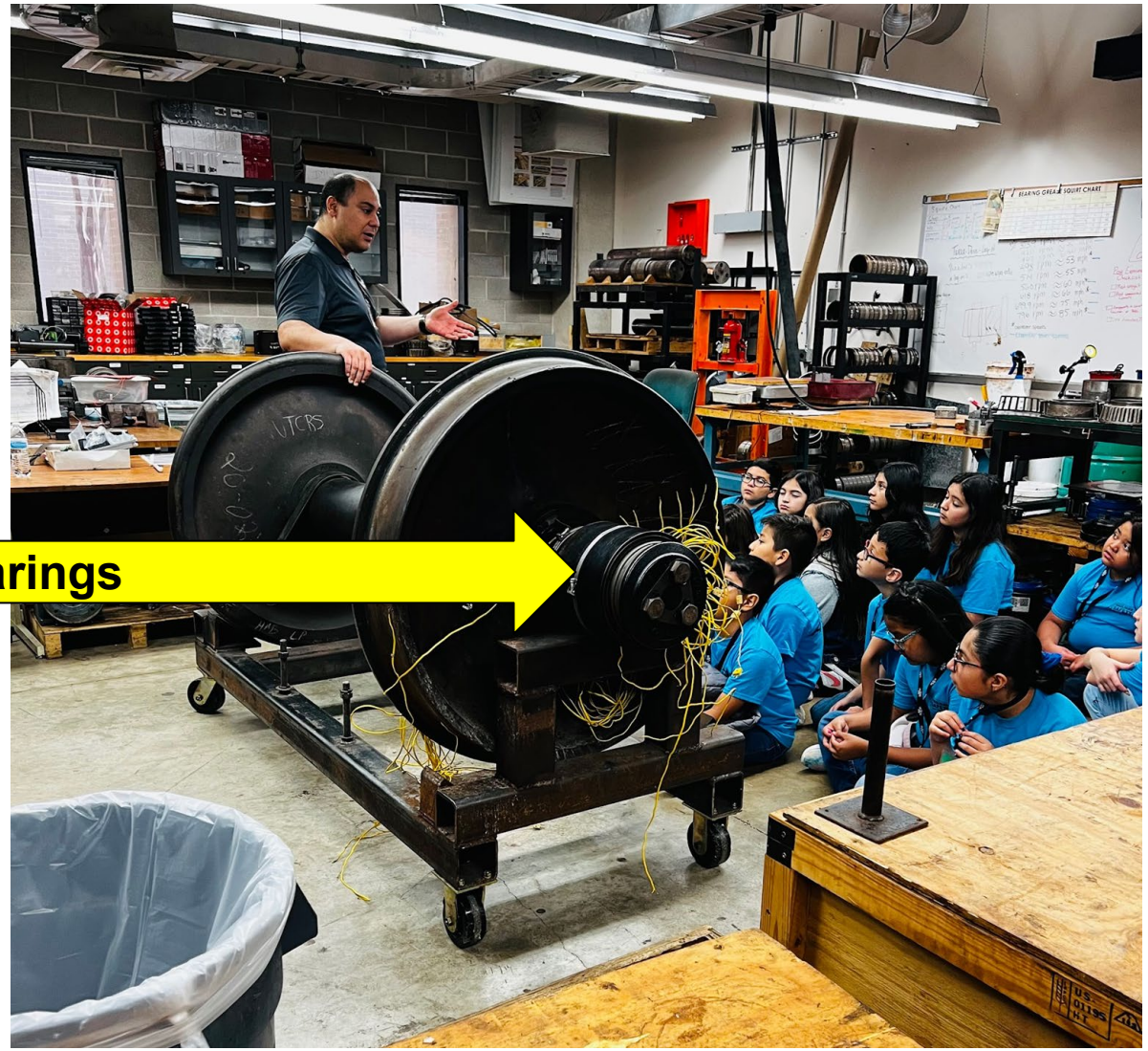


Wheel Bearings

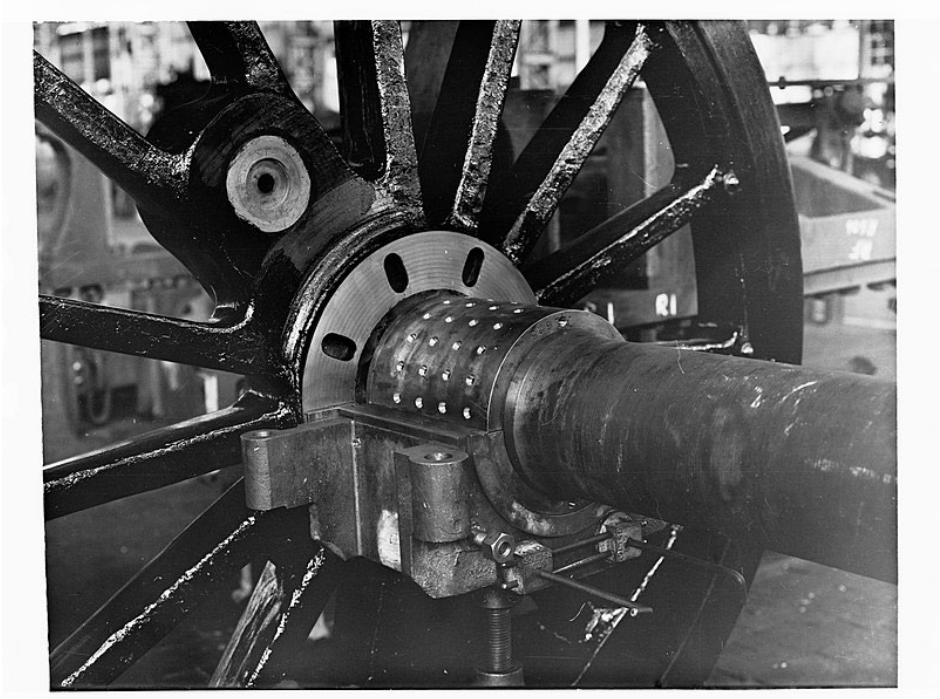
Axle Bearings: A Series of Wise Decisions from Manufacturing to Monitoring. The first and most important function of a train wheel bearing is to reduce friction and allow for smoother rotation between the rotating shaft and the part that supports the rotation.



Bearings



Demonstration of the wheel and axles in use.

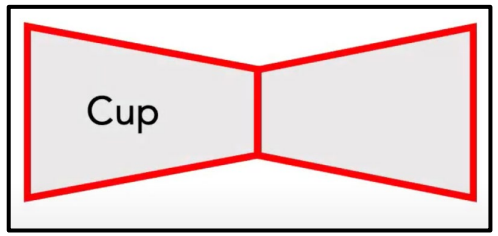


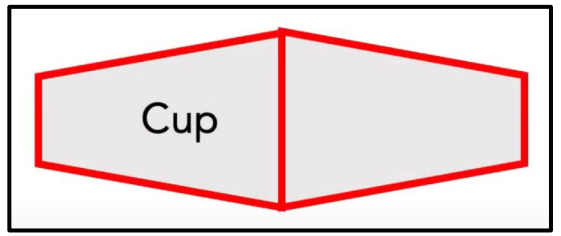
Materials

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

Procedure

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





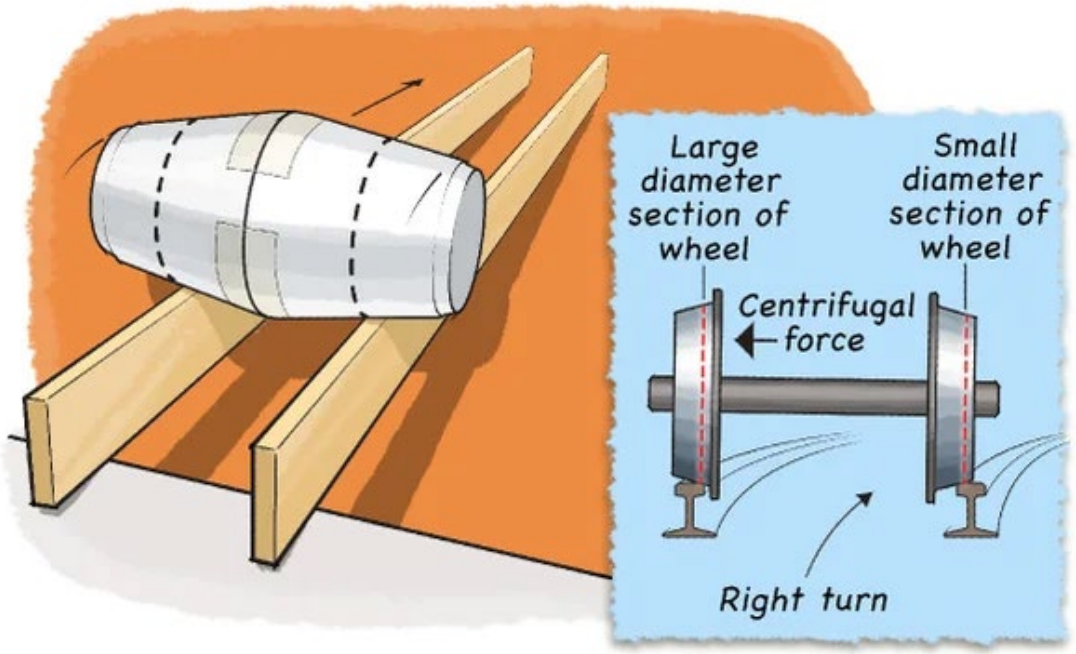
1. Set up the two yard sticks into an inclined plane and tape them in place.
2. Place your cups (wheels) at the top and let it drop.

Set up...

Place two ends of the meter sticks on the chair as shown. Ensure to tape both ends as well to avoid the sticks from falling.

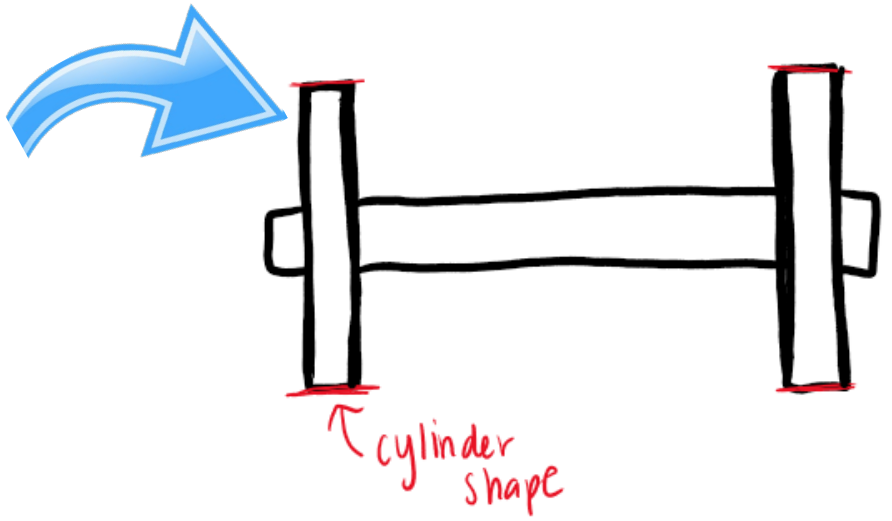
REMEMBER: Each group member needs to try both models once.

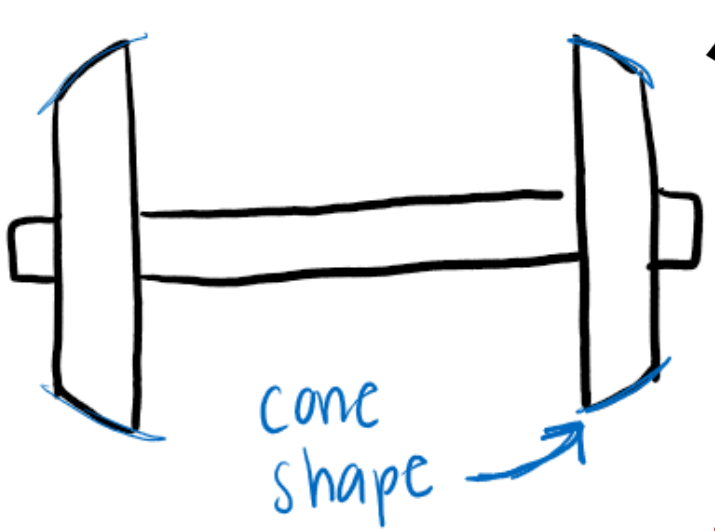
A Glance of how cone-shaped wheels adjust to turns & errors



Shape of Wheel

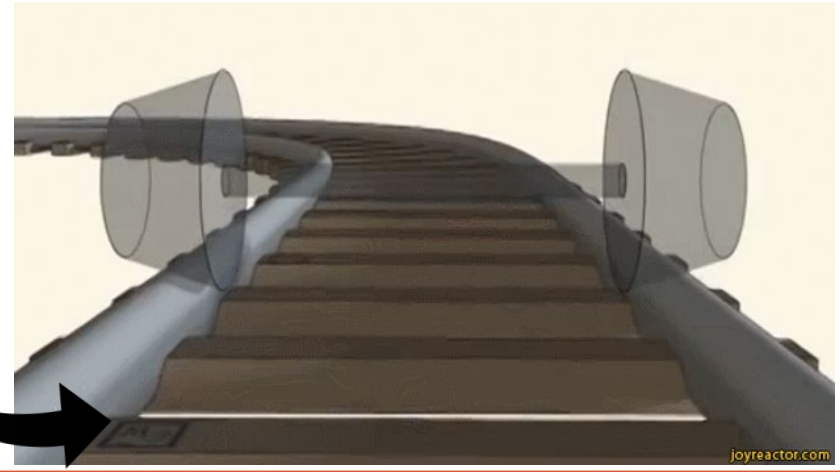
Wheels are **NOT** completely cylindrical.





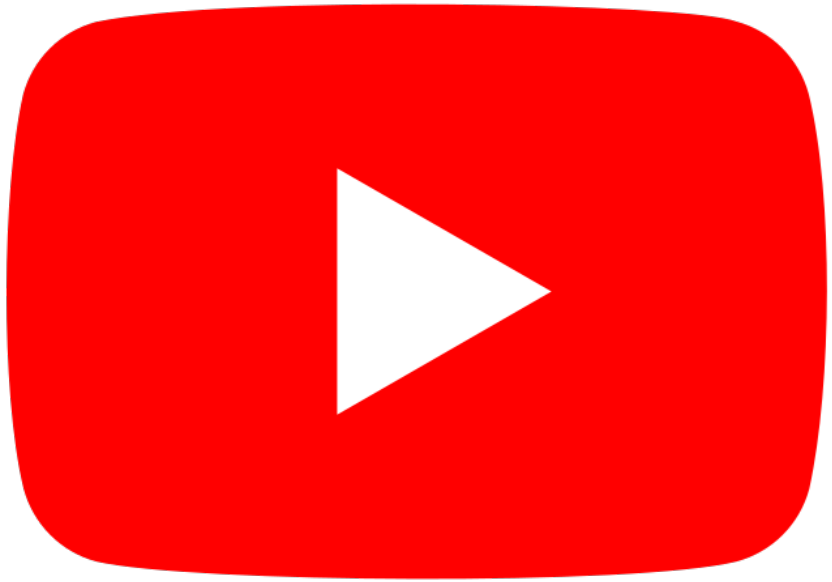
They are **cone shaped**.

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 (cone shaped) wheel is superior to other designs.



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

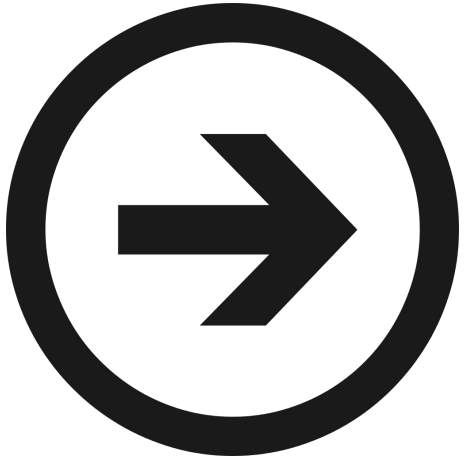
What caused the train derailment in Ohio? Could it have been prevented?

Causes of Train Derailments

- Train derailments can occur as a result of elevated friction between the train wheels and rails, leading to significantly increased temperatures that can induce metals to fuse together.
- Another frequent cause of train derailments arises from undetected broken rails, resulting in the displacement of the wheel from its designated track.

What can we do?

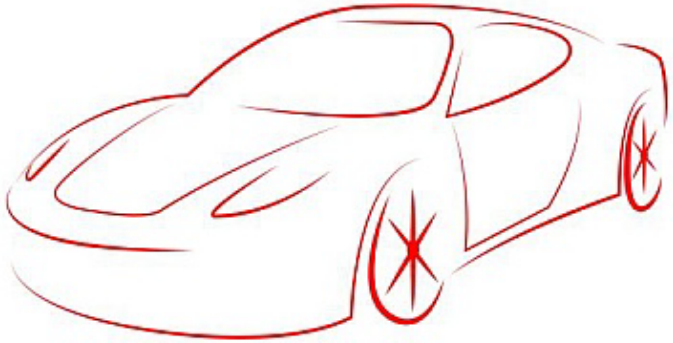
Severe braking over time can cause **fractures, scrapings & deterioration of the wheel & axle**...which can then cause **accidents**.



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

Also…

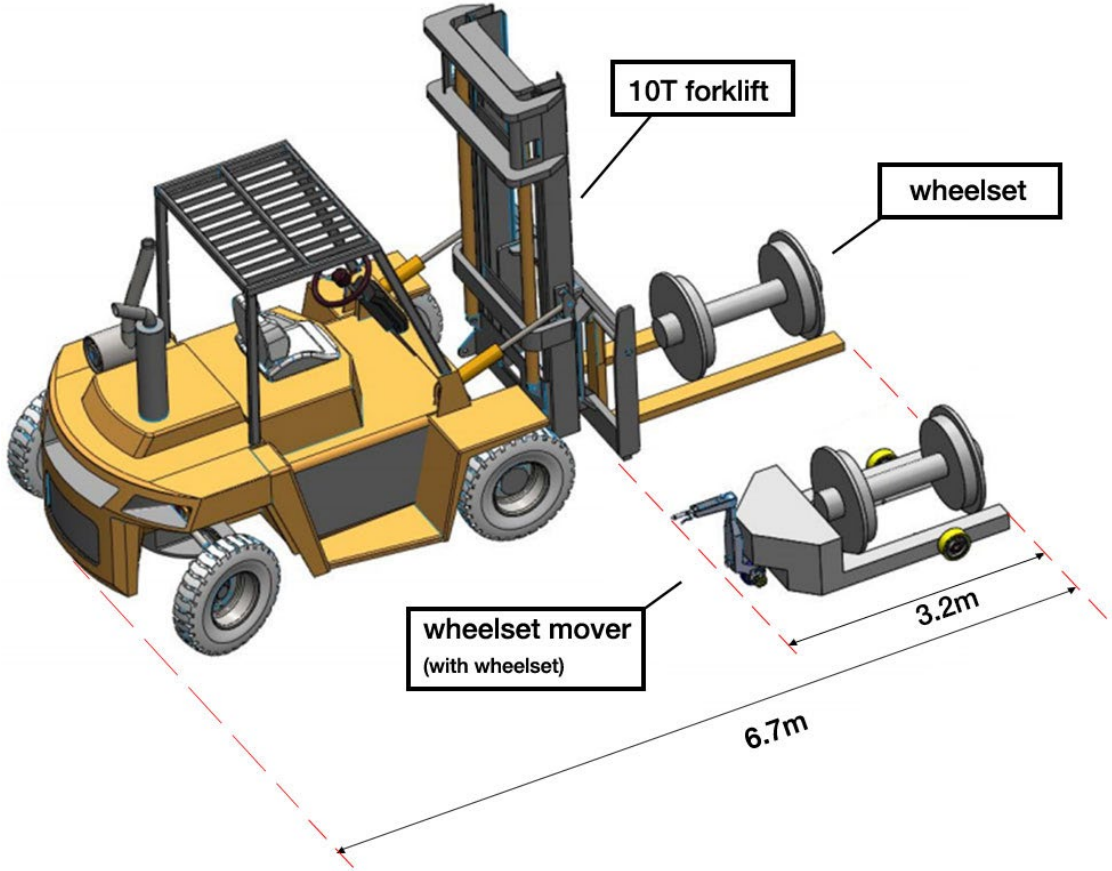
Just like we change the wheels of our cars very often (for every 50,000 miles traveled)…..



….Freight trains need an exchange of wheels & axles for every 500,000 miles as well.

How Are They Moved?

Wheels & axles are moved by **forklifts** to make the process more **efficient (easy)**. Helps place wheels & axles at a desirable spot as well.



Show "Tour Video" to learn what Railway Engineers do.

The importance of a forklift regarding the replacement of the wheel and axle.

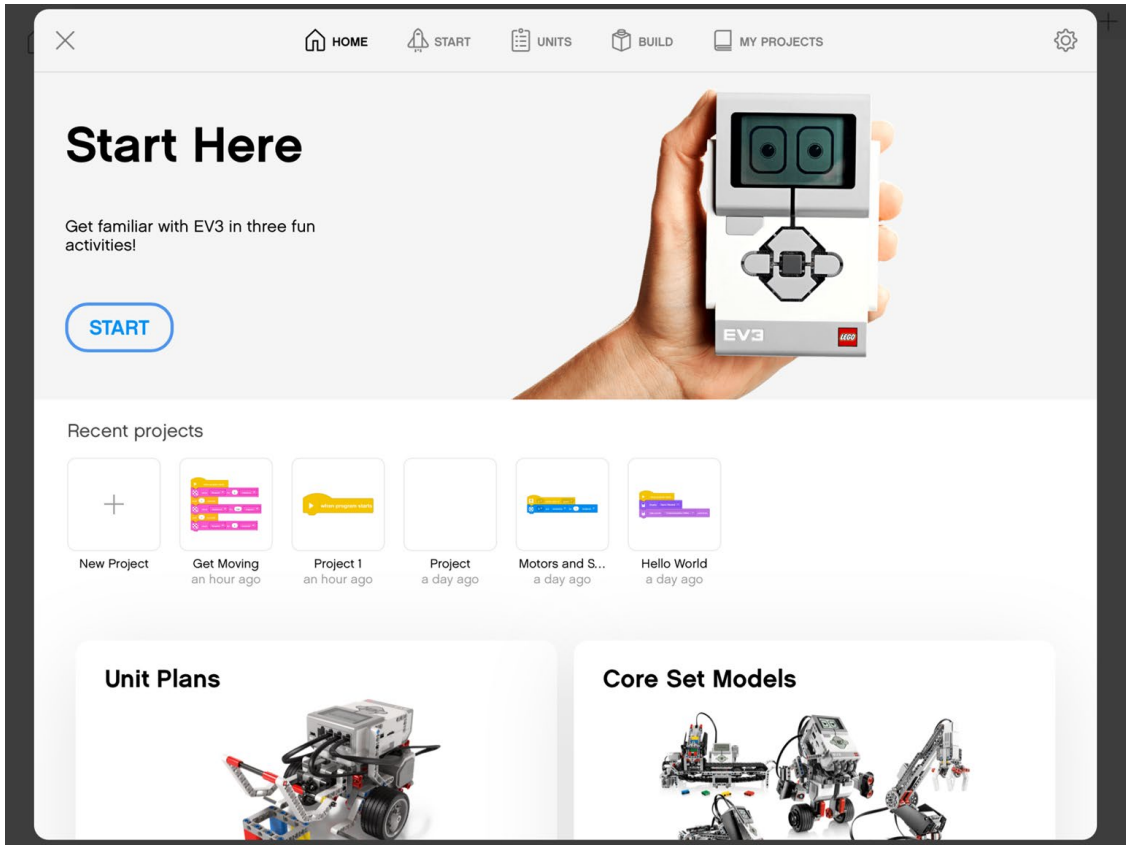
Roles Within Your Group

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.

Medium Motor

Using the Medium Motor, we will build a functioning forklift.
We are going to use the medium motor to lift and drop off objects.

Programming Basics



HOME START UNITS BUILD MY PROJECTS

Recent projects

New Project | Angles and P... a few seconds ago | The Factory R... a minute ago | Moves and Tu... 2 minutes ago | Project 22 days ago

Unit Plans

All of the EV3 Classroom lessons are grouped into themed units to actively engage middle school students in STEM learning.

Core Set Models

These models will inspire you and challenge your robotics skills. Take LEGO® MINDSTORMS® Education EV3 to the next level!

HOME START UNITS BUILD MY PROJECTS

Unit Plans

Grades 6-8

Robotics, Engineering, Computer Science, STEAM

Robot Trainer

Ready to train your robotics skills? Take the Driving Base, configure its extensions, and write programs to...

Grades 6-8

Engineering, Science, STEAM

Engineering Lab

Are you interested in machines? Get ready to work like a real engineer! Build exciting models and conduct yo...

HOME START UNITS BUILD MY PROJECTS

MORE

Objects and Obstacles

Using the Ultrasonic Sensor

The Driving Base moves like a charm, but there's a problem. It keeps bumping into walls, and there have been near

START

45-90 min.

Grab and Release

Using a Motorized Tool

The Driving Base is moving around autonomously without causing any accidents. Now it's time to use it to perform

MORE

START

45-90 min.

Colors and Lines

Using the Color Sensor

The Driving Base is turning into a quite capable robot that's useful around the factory! However, at the moment, each of

MORE

START

45-90 min.

Angles and Patterns

Using the Gyro Sensor and My Blocks

The Driving Base is getting some serious work done, but it needs to drive repeatedly in the same patterns, and its

MORE

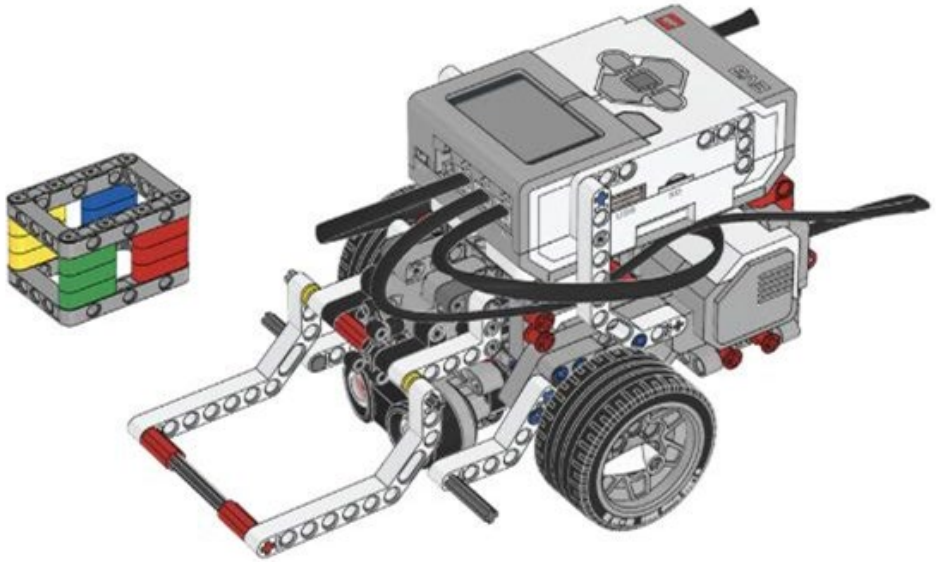
START

45-90 min.

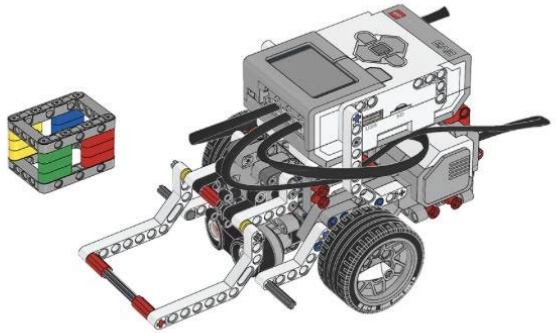
The Factory Robot

Mastering the Driving Base

Let's Build!



02 /06



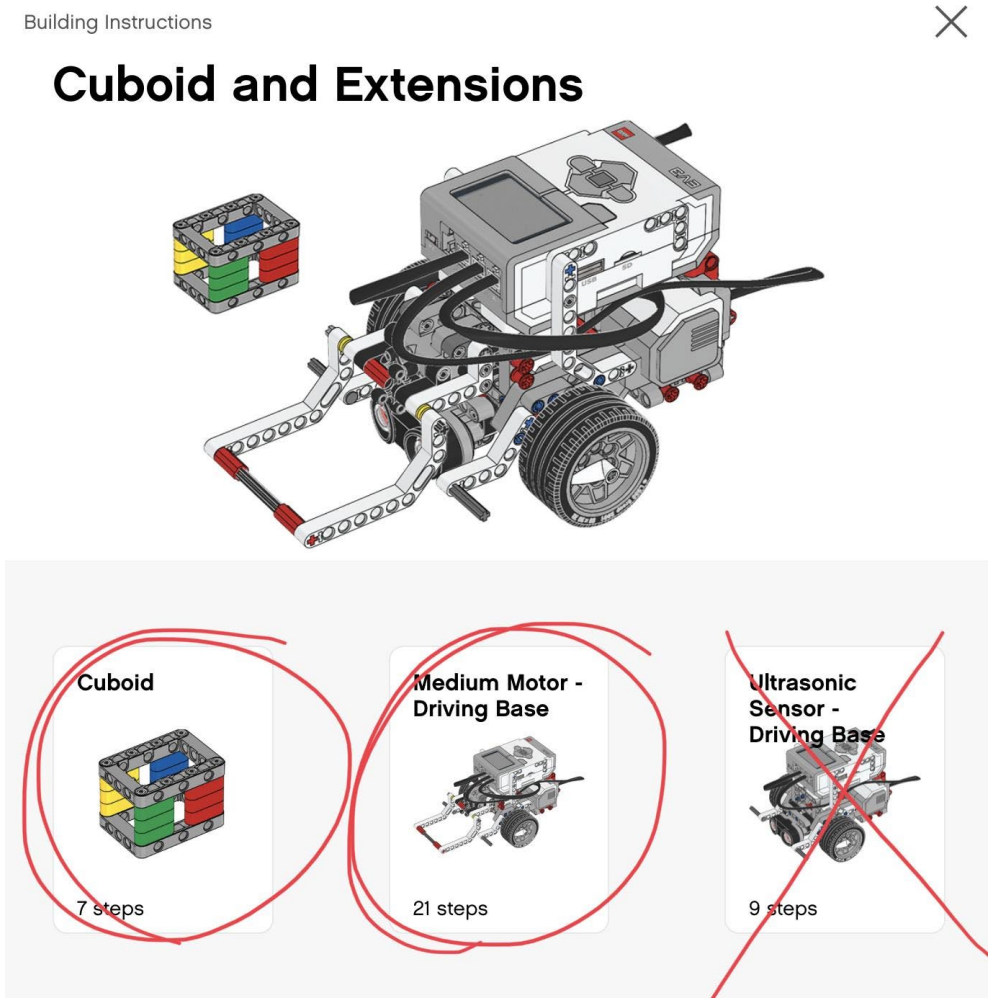
Build the Cuboid and these extensions.

We'll use the Medium Motor extension to grab and release the Cuboid. You'll also need the Ultrasonic Sensor extension from the last lesson. Build the Cuboid, then build the extensions onto the Driving Base.

BUILD

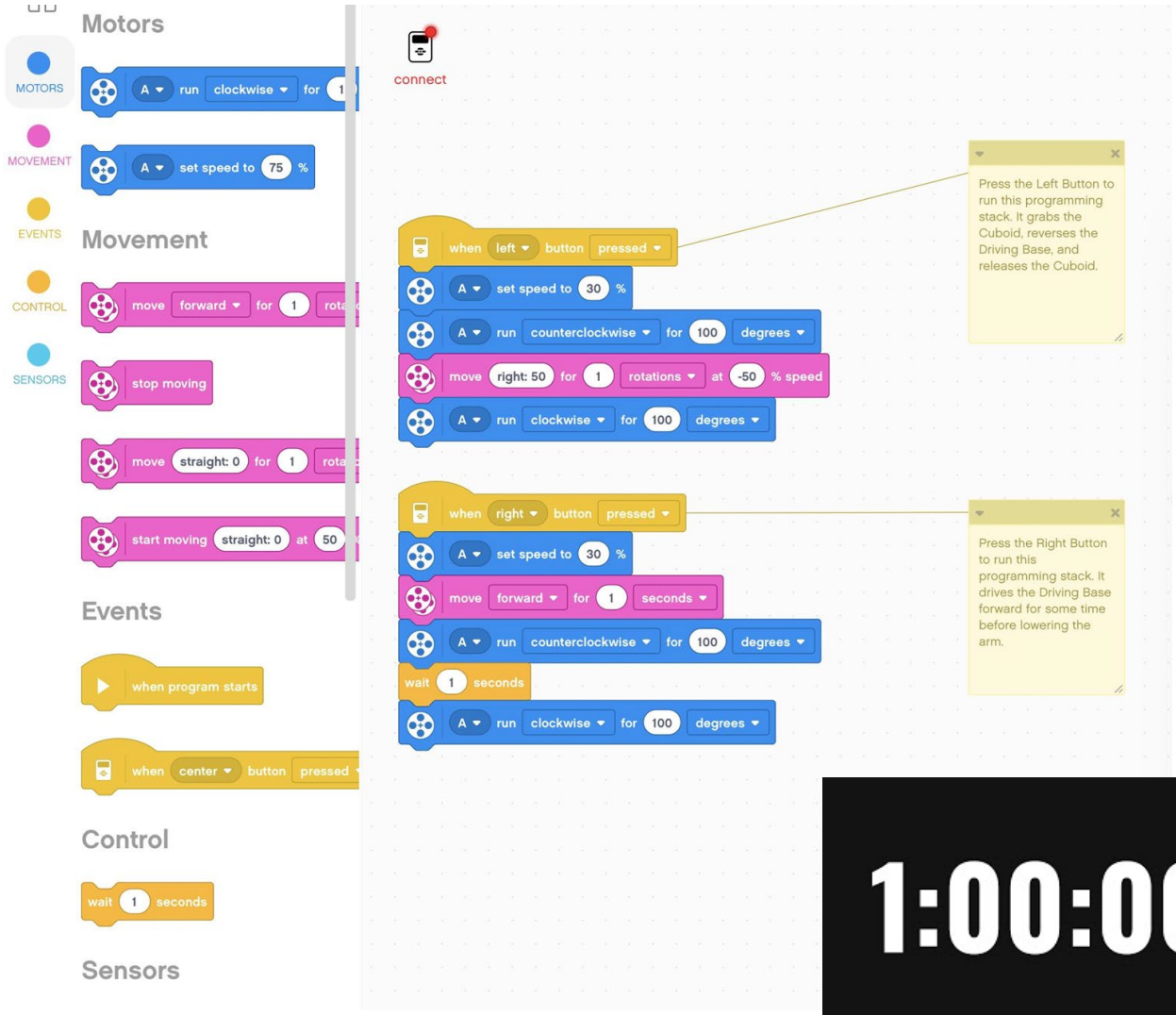
Cuboid and Extensions

- For now, you will only build the
  - Cuboid
  - Medium Motor-Driving Base
- Follow the instructions on your screen.



Pairing and Observations

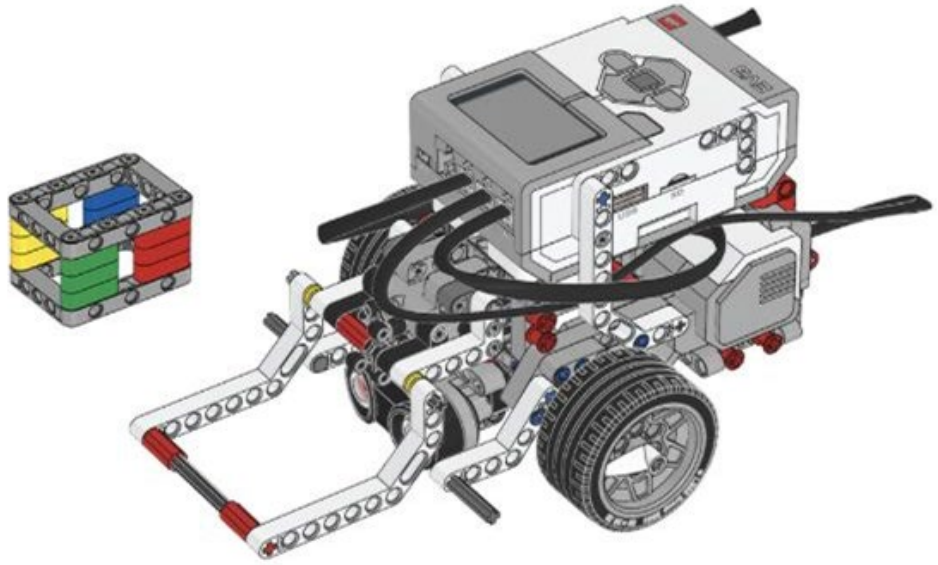
- Follow the instructions prompted on your screen.
- Pair your robot.
- Press play and make observations.
- Make sure you read the yellow block.



1:00:00

It's Time for a Challenge!

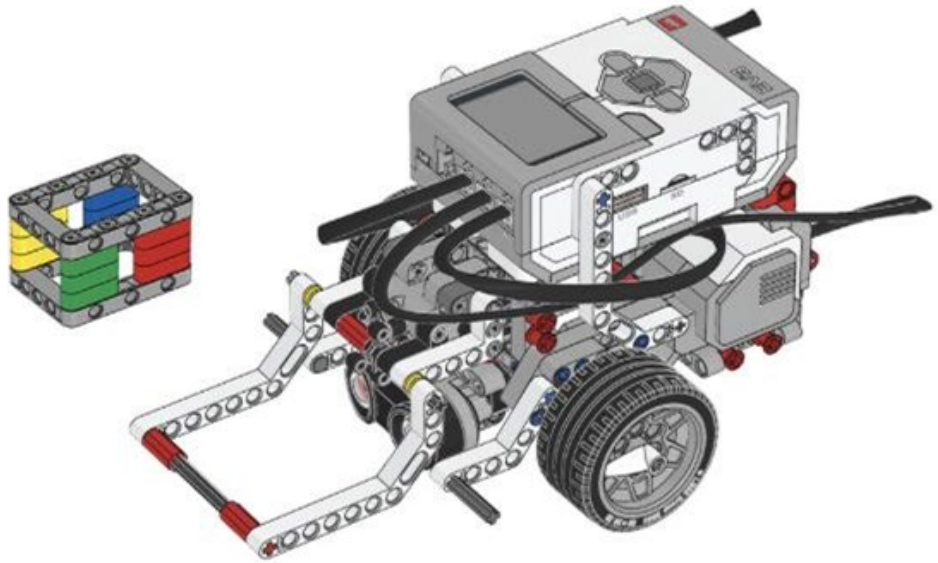
LEGO education



Build and Program a Forklift

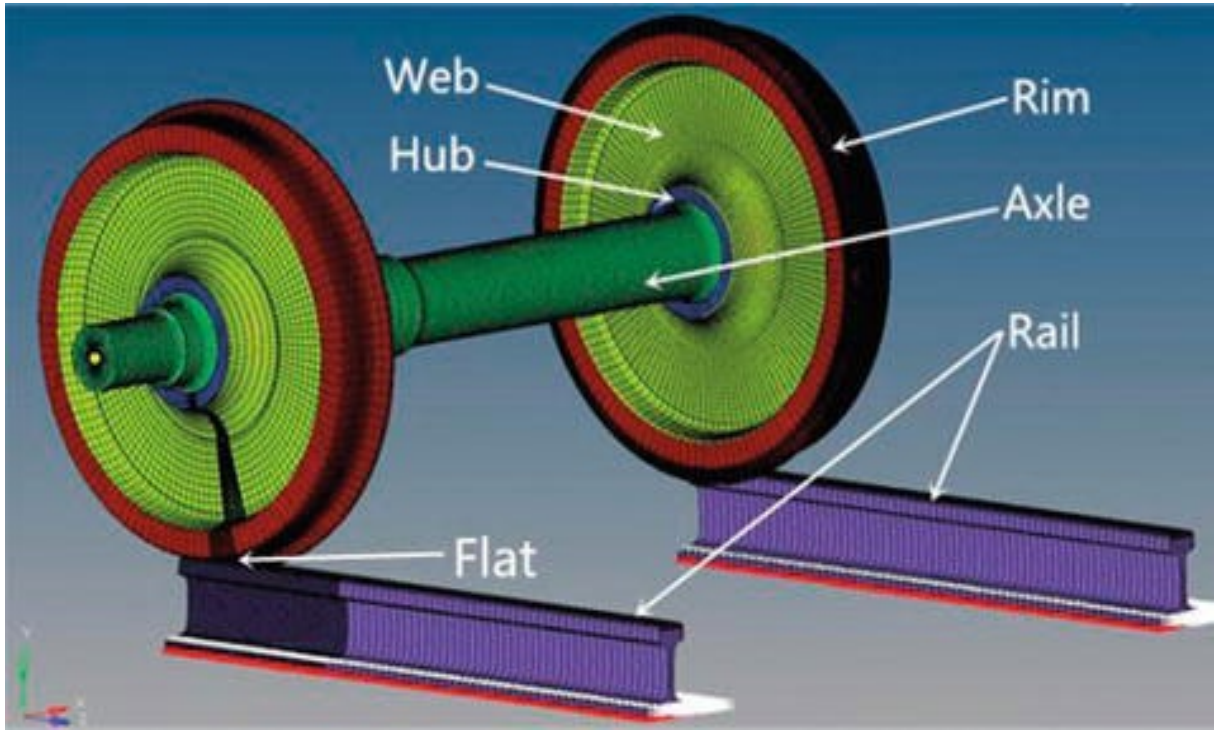
Using the Medium Motor, we will build a functioning forklift.

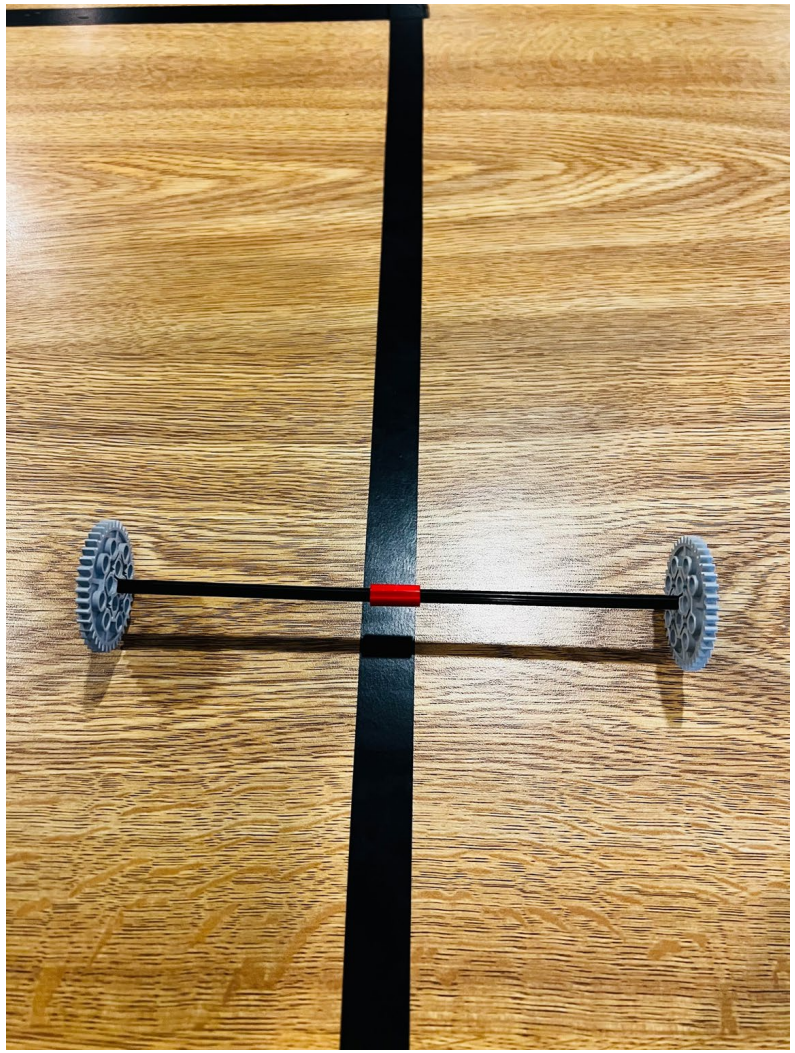
We are going to use the medium motor to lift a “wheel and axle” and drop it off at the drop off section of the board. Once you are done, park your bot at the “UTRGV Transportation Center for Railway Safety.”



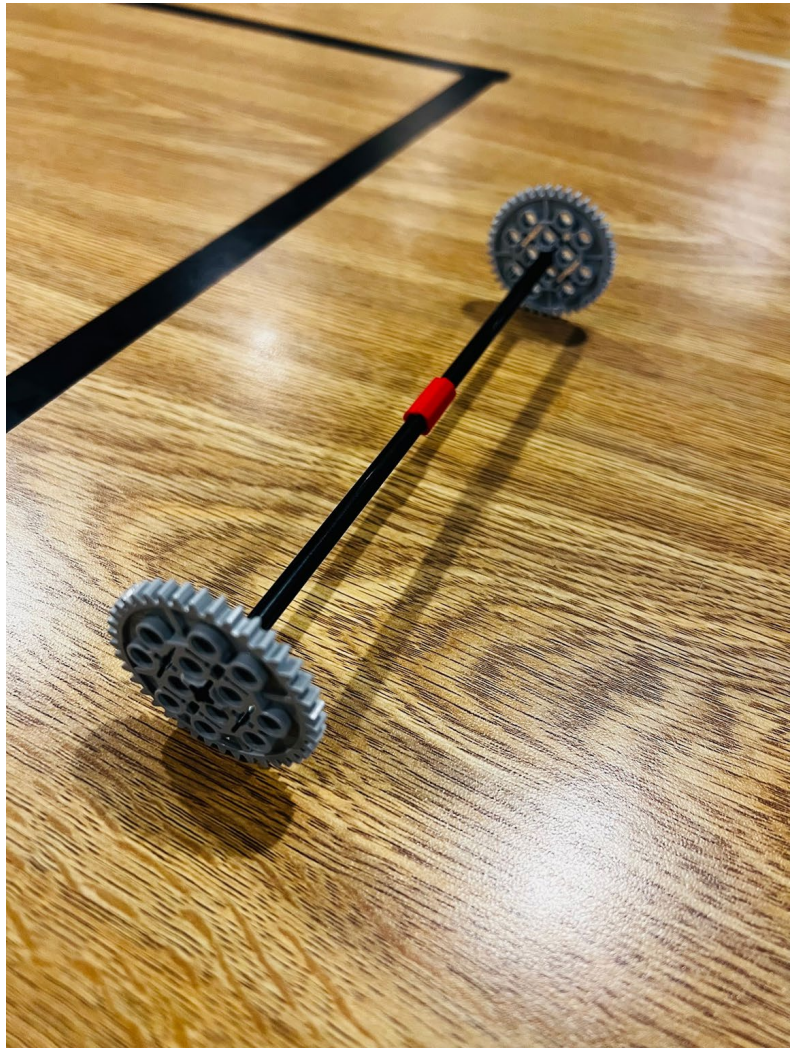
Wheel-Axle Assembly Activity

Directions: Use the Lego pieces to build a model, build a wheel-axle assembly





Examples



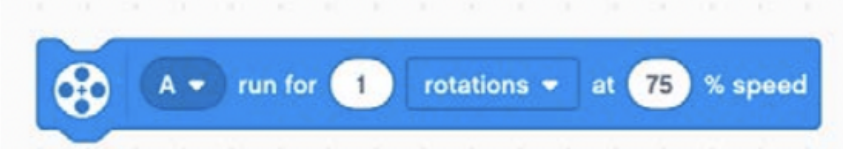
Challenge 1

Program your robot to move up 2 tiles. The axle will be placed on the second tile. The robot will then “lift” the axle.

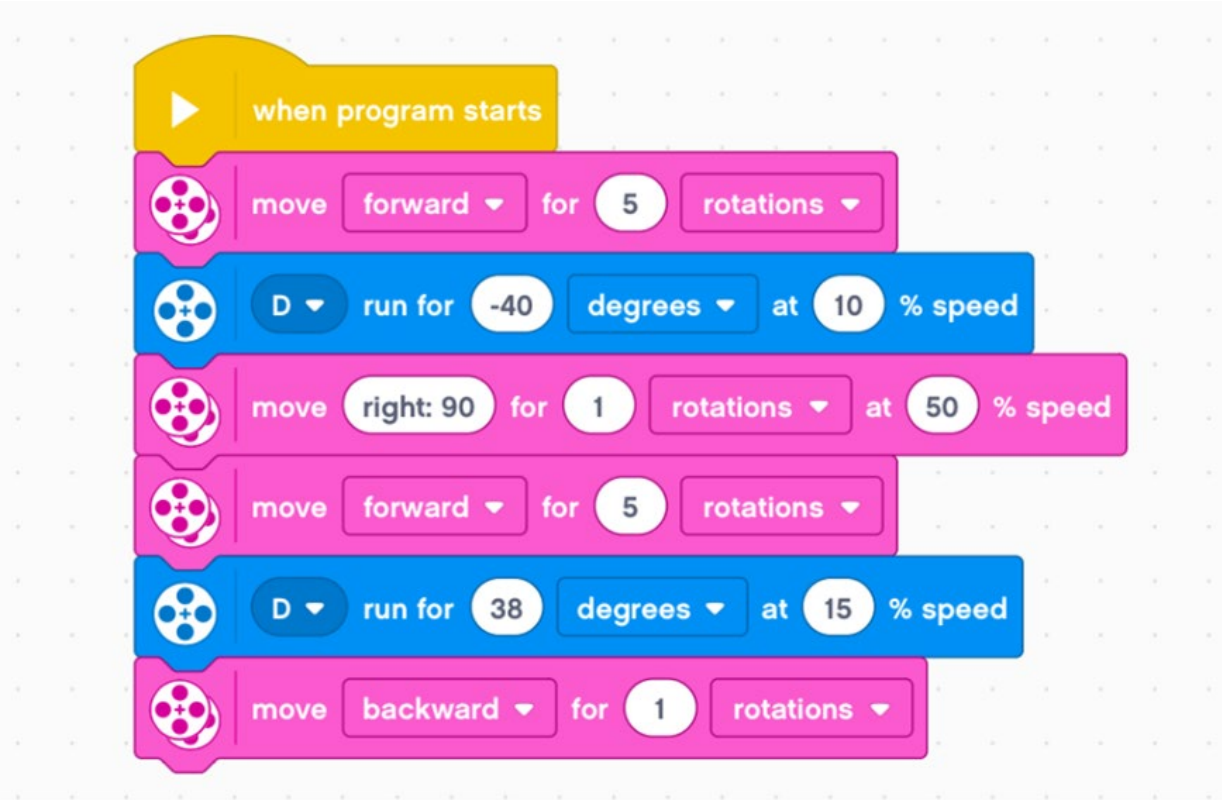
Challenge 2

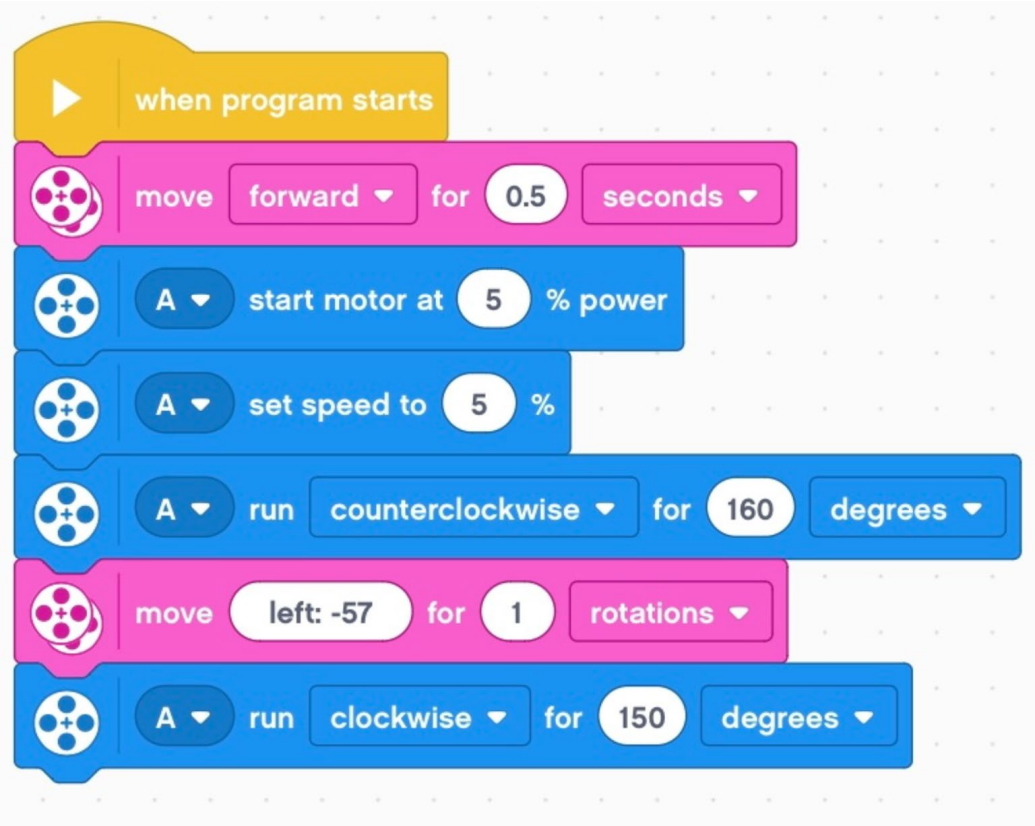
Program your robot to move two more tiles and “drop off” the axle.

Motor Blocks

Run Motor for Duration 	Runs one motor clockwise or counterclockwise for a specified number of rotations, seconds, or degrees. The motor speed is set by the Set Speed Block. The default speed is 75%.
Run Motor for Duration at Speed 	Runs one motor for a specified number of rotations, seconds, or degrees at a specified speed. A negative speed value runs the motor counterclockwise.

Sample Programs





Challenge #3

Using the Medium Motor, we will build a functioning forklift.
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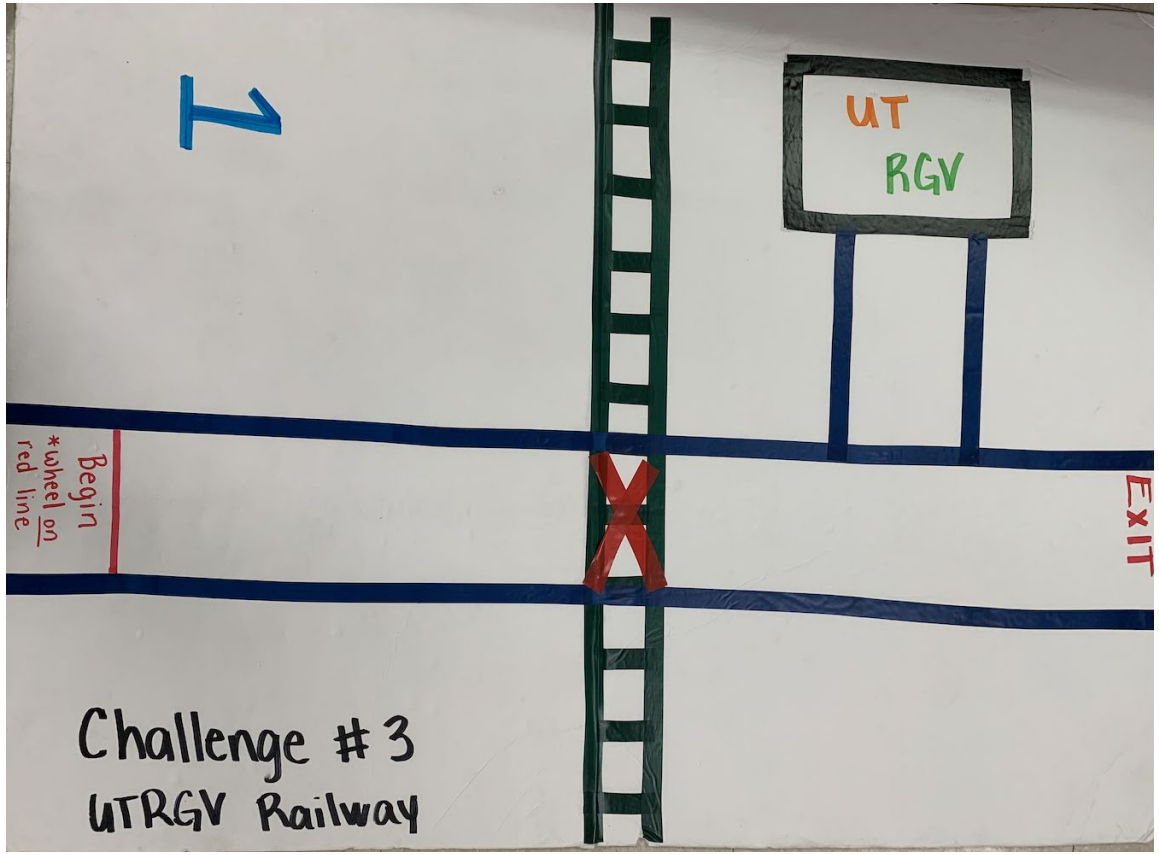


Let's Reflect...

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?

Cleanup

Make sure students:

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

DO NOT DISASSEMBLE ALL OF YOUR ROBOT.

Return battery pack to teacher for charging.

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?
4. What did you learn today?

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

End of Day 3

Day 3 References

Jing, L. (2018). Wheel-Rail Impact by a Wheel Flat. InTech. doi: 10.5772/intechopen.70460 (Slide 7)

Science Buddies (n.d.). Train Wheel Science. Scientific American. Retrieved October 7, 2024, from https://www.scientificamerican.com/article/train-wheel-science/ (Slide 14)

(2023, September 1). Rail wheel Market Forecast 2023 to 2032 By Xcellent Insights. Open PR. Retrieved October 7, 2024, from https://www.civilengineeringnews.tk/2013/07/coning-of-wheels.html#google_vignette (Slide 15)

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 16)

(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 17 & 22)

(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 18)

Electrodrive (n.d.). Electrodrive Bogie Mover - Rail Wheelset Mover. Electrodrive Bogie Mover - Rail Wheelset Mover. Retrieved October 7, 2024, from https://www.youtube.com/watch?v=iF7yrFU5dW0 (Slide 22)

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

Day 4

- Rail Flaw Detection
- Tour

Recap:

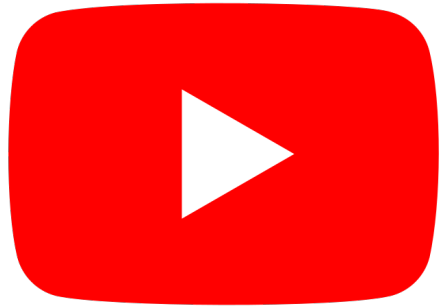
- What causes train derailment?
- How can we prevent derailment in trains?
- How are train wheels replaced?
- Is the wheel design/shape critical in trains?

Objectives:

- Train Track Maintenance
- Rail Flaw Detection and Ultrasonic Sensors
- Review wheel and axle maintenance and replacement, sensors that can be used for preventive maintenance.

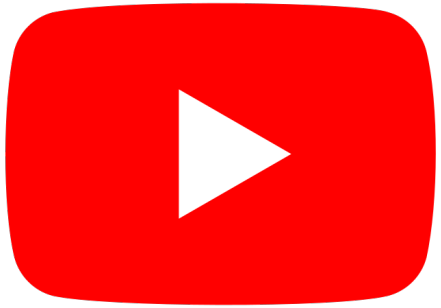
Rail Flaw Detection

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

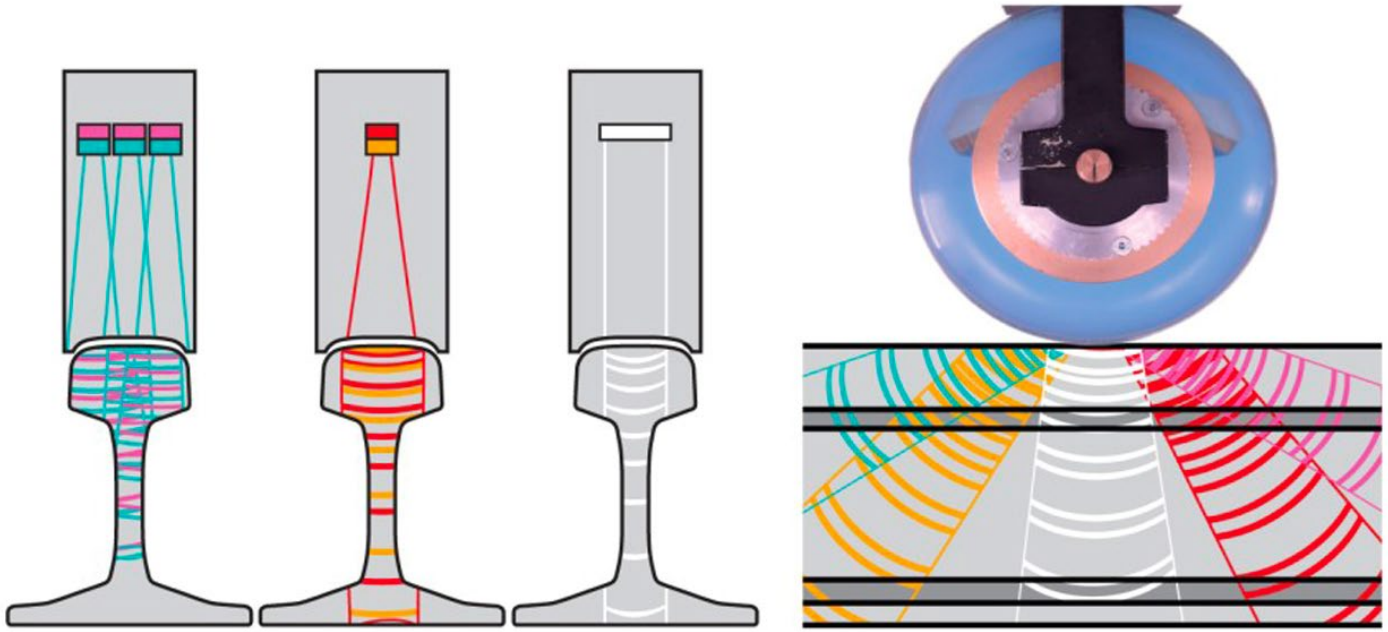


Rail Flaw Detection

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.

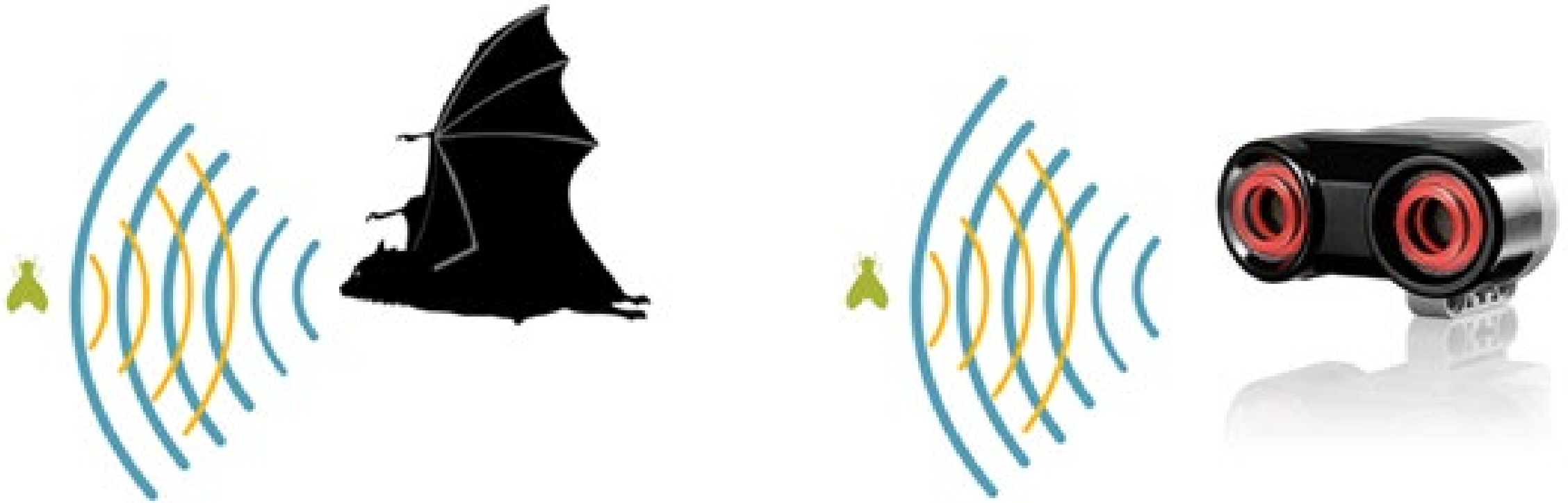


Ultrasonic Sensor



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

Ultrasonic Sensor



Transmit

Sensor

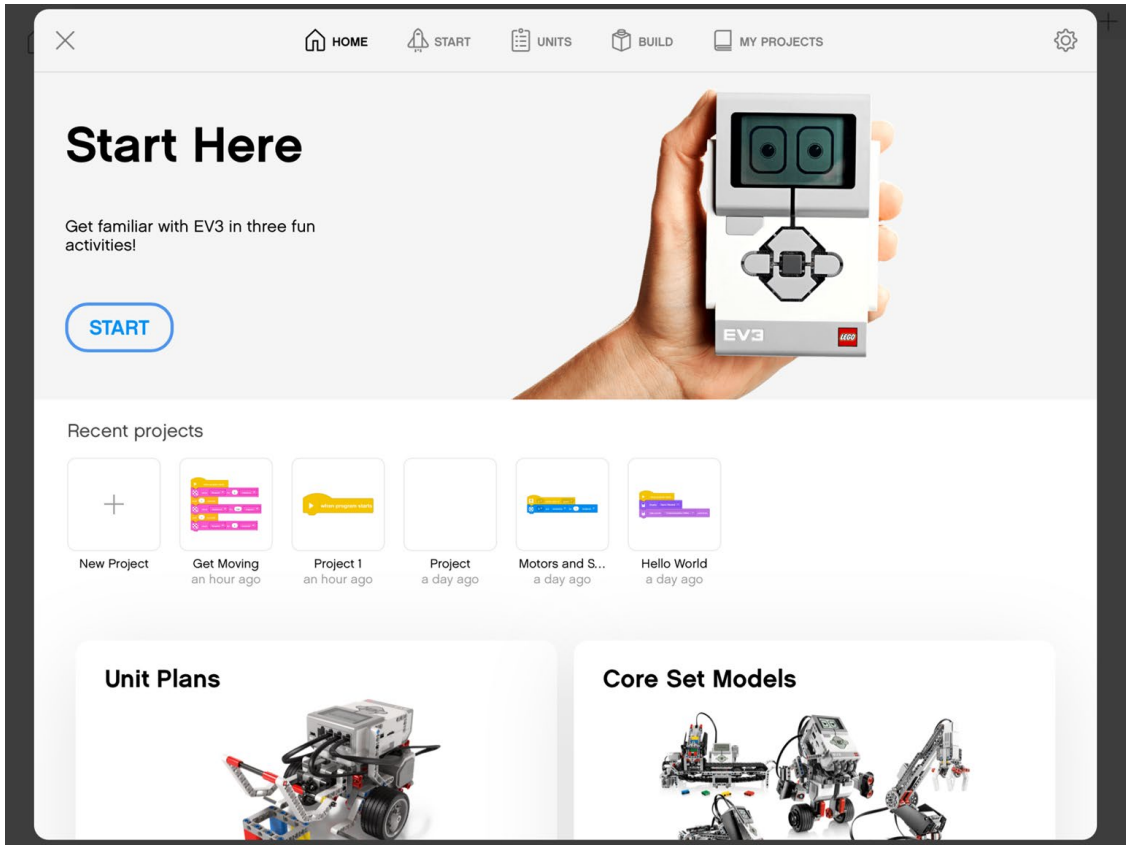
Let's Discuss

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.

Programming Basics



HOME START UNITS BUILD MY PROJECTS

Recent projects

New Project | Angles and P... a few seconds ago | The Factory R... a minute ago | Moves and Tu... 2 minutes ago | Project 22 days ago

Unit Plans

All of the EV3 Classroom lessons are grouped into themed units to actively engage middle school students in STEM learning.

Core Set Models

These models will inspire you and challenge your robotics skills. Take LEGO® MINDSTORMS® Education EV3 to the next level!

HOME START UNITS BUILD MY PROJECTS

Unit Plans

Grades 6-8

Robotics, Engineering, Computer Science, STEAM

Robot Trainer

Ready to train your robotics skills? Take the Driving Base, configure its extensions, and write programs to...

Grades 6-8

Engineering, Science, STEAM

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HOME START UNITS BUILD MY PROJECTS

LESSONS TEACHER RESOURCES

Ready to train your robotics skills? Take the Driving Base, configure its extensions, and write programs to complete challenging tasks!

Moves and Turns

Making Controlled Movements

The factory manager has ordered a wheeled robot to help automate some tasks. The Driving Base has arrived, and it's

MORE

START

45-90 min.

Objects and Obstacles

Using the Ultrasonic Sensor

The Driving Base moves like a charm, but there's a problem. It keeps bumping into walls, and there have been near

MORE

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Grab and Release

Using a Motorized Tool

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MORE

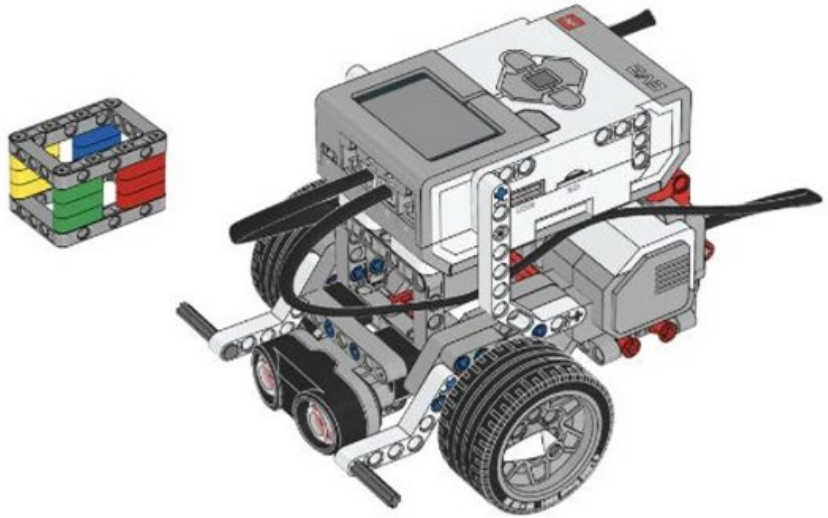
START

45-90 min.

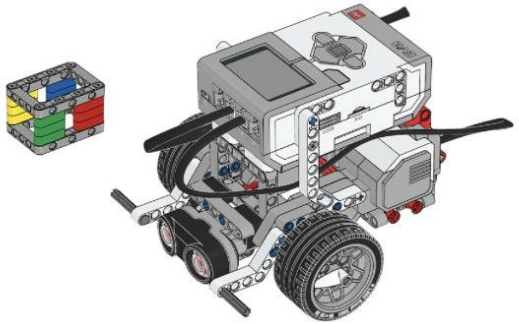
Colors and Lines

Let's Build!

1:00:00



02 /06

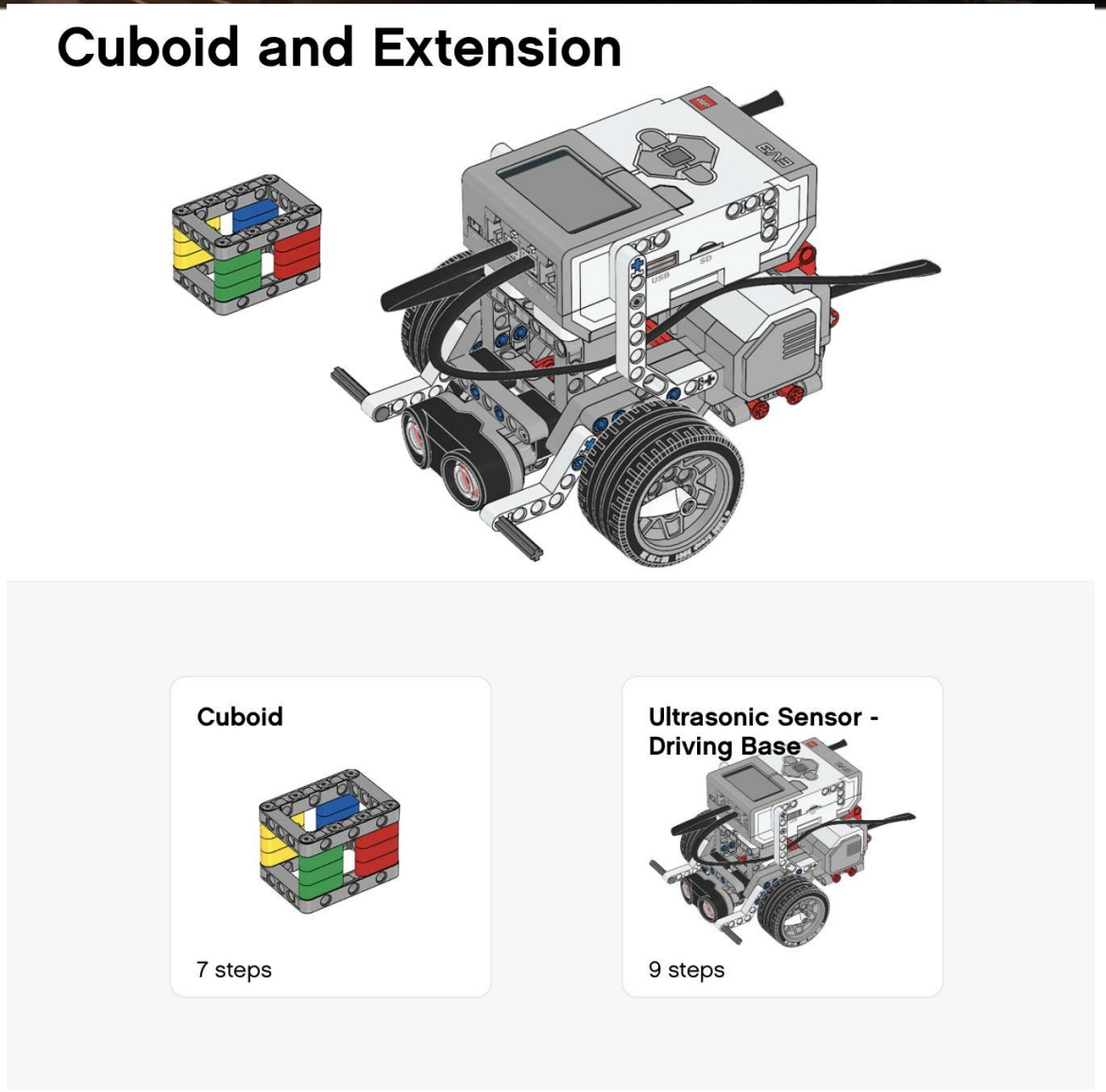


Build the Cuboid and this extension.

You'll need the Ultrasonic Sensor extension in order to detect objects and obstacles. Build the Cuboid, then build the extension onto the Driving Base.

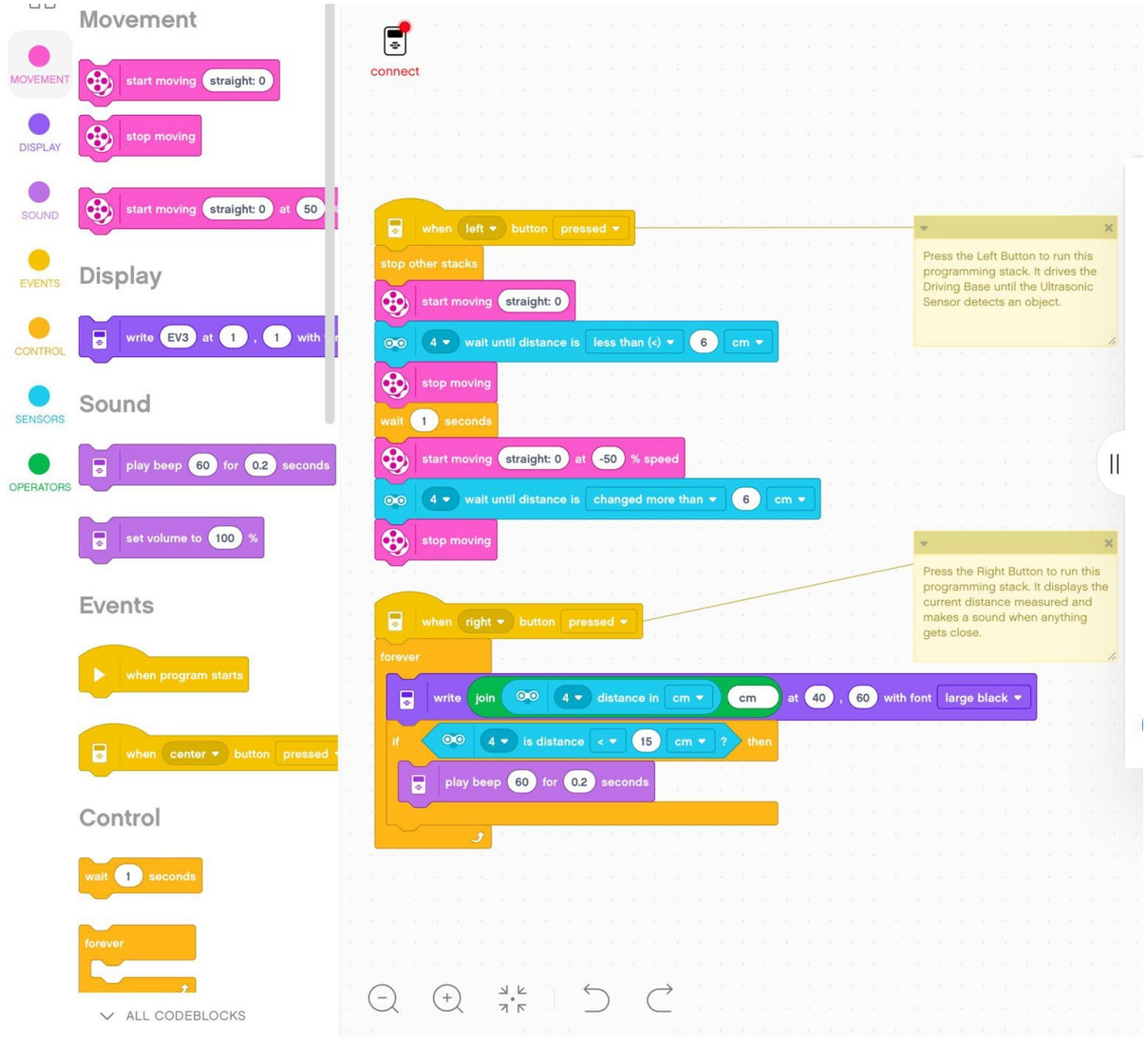
BUILD

Ultrasonic Sensor

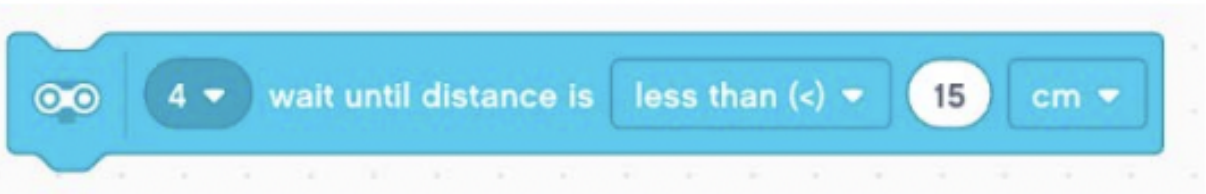


Pairing and Observations

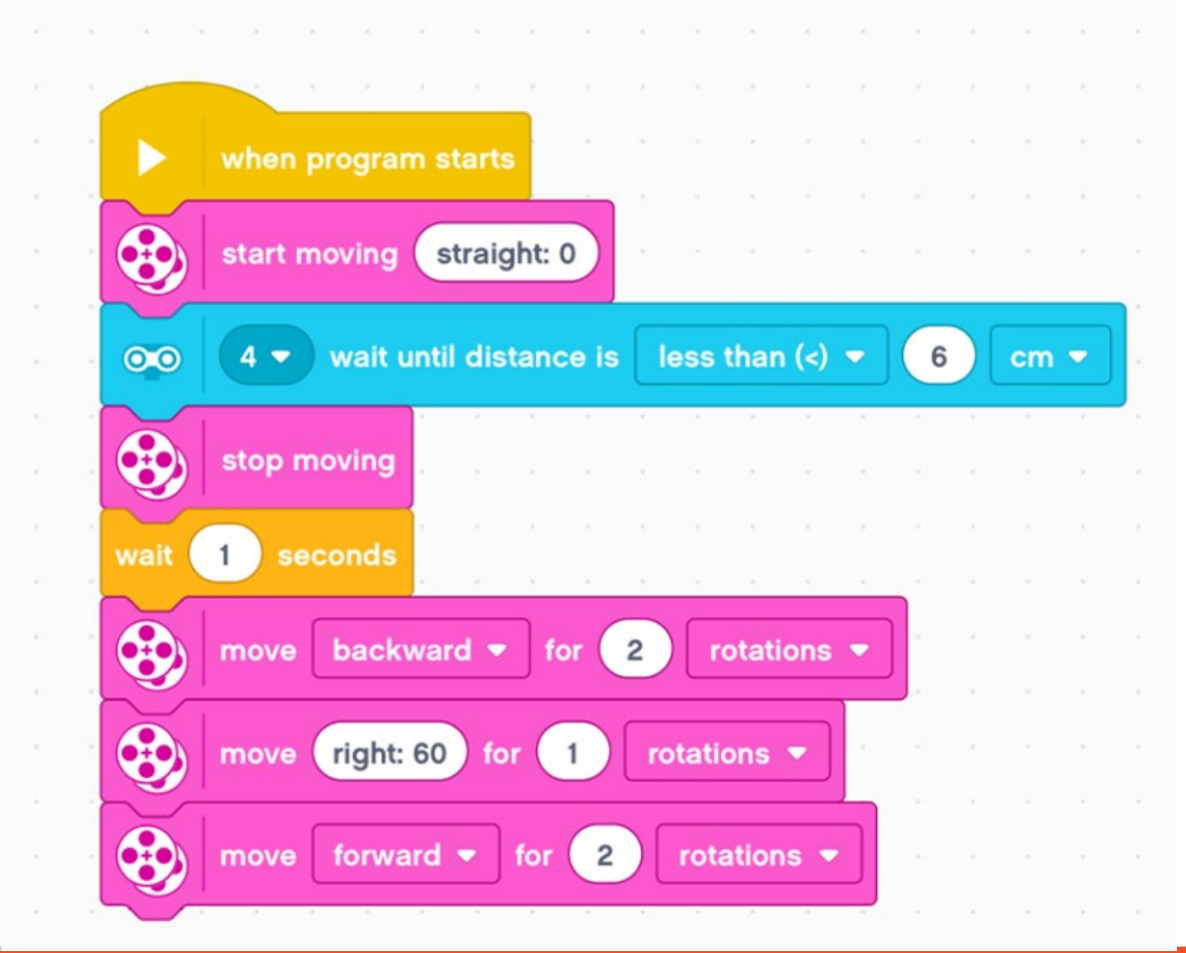
- Follow the instructions prompted on your screen.
- Pair your robot.
- Press play and make observations.
- Make sure you read the yellow block.



Sensor Block

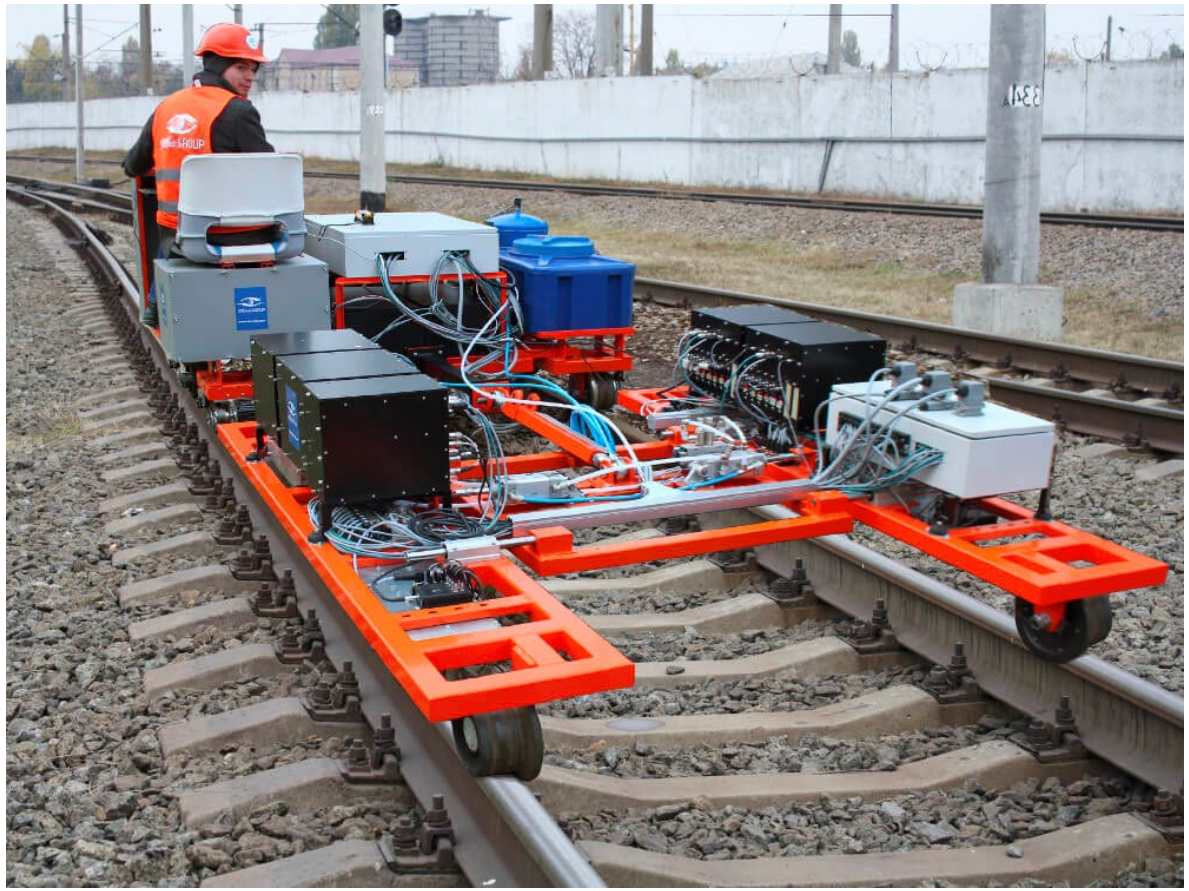
Wait Until Distance Is	Pauses the programming stack until the Ultrasonic Sensor's distance to an object is less than, greater than, equal to, or changed more than the specified distance in centimeters or inches.
	

Sample Program



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.



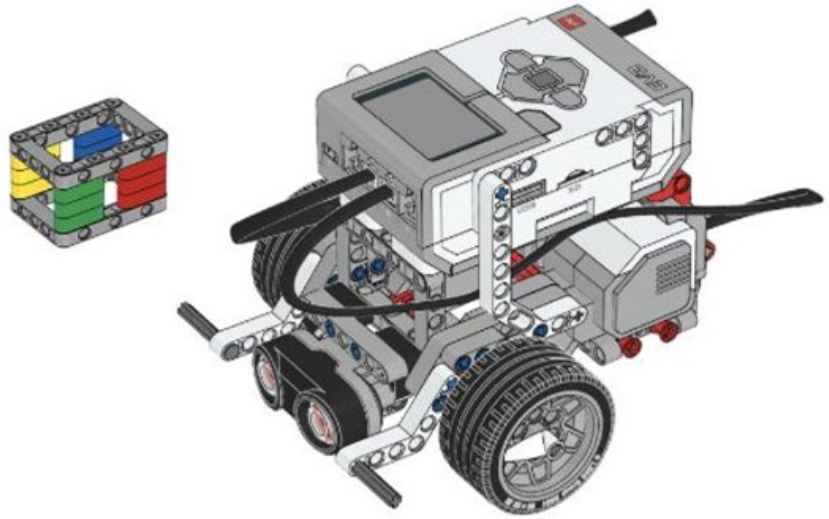
Rail Flaw Detection

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.

Day 4 Part 2

Adding the Medium Motor

LEGO education



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MORE

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45-90 min.

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Mastering the Driving Base

Cuboid and Extensions

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  - Medium Motor-Driving Base
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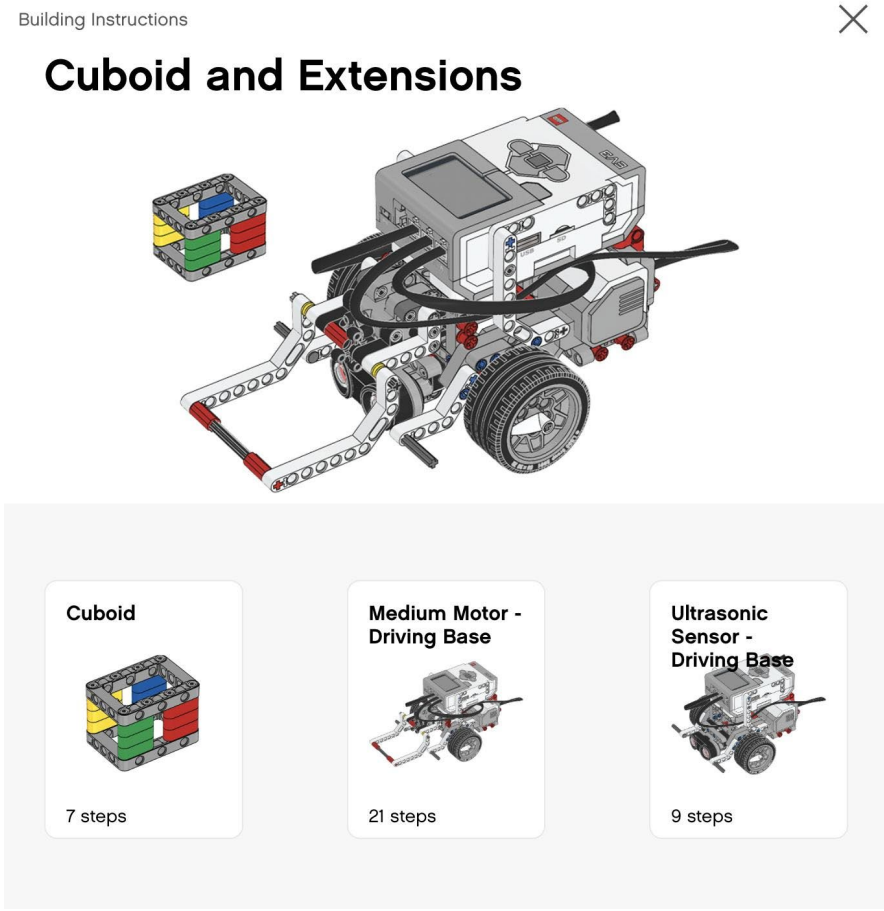
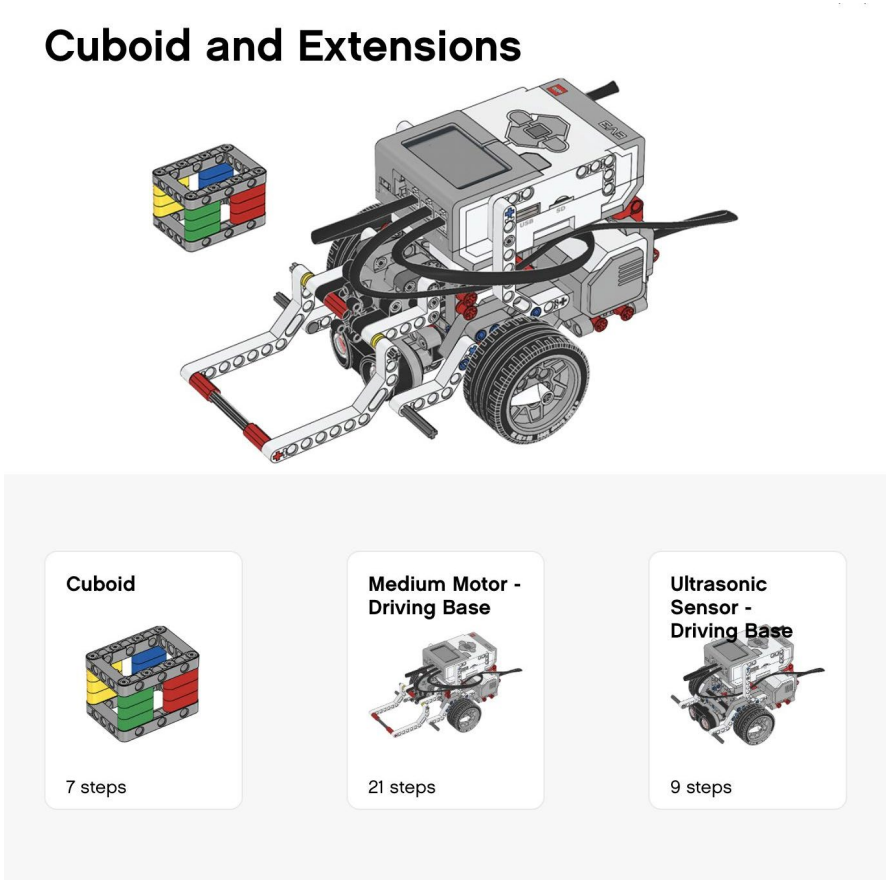


Medium Motor and Ultrasonic Sensor

Program the Driving Base to use the Ultrasonic Sensor to:

- Stop near the Cuboid
- Lower the arm to collect
- Move the Cuboid 90 degrees to the left.



Let's Reflect...

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

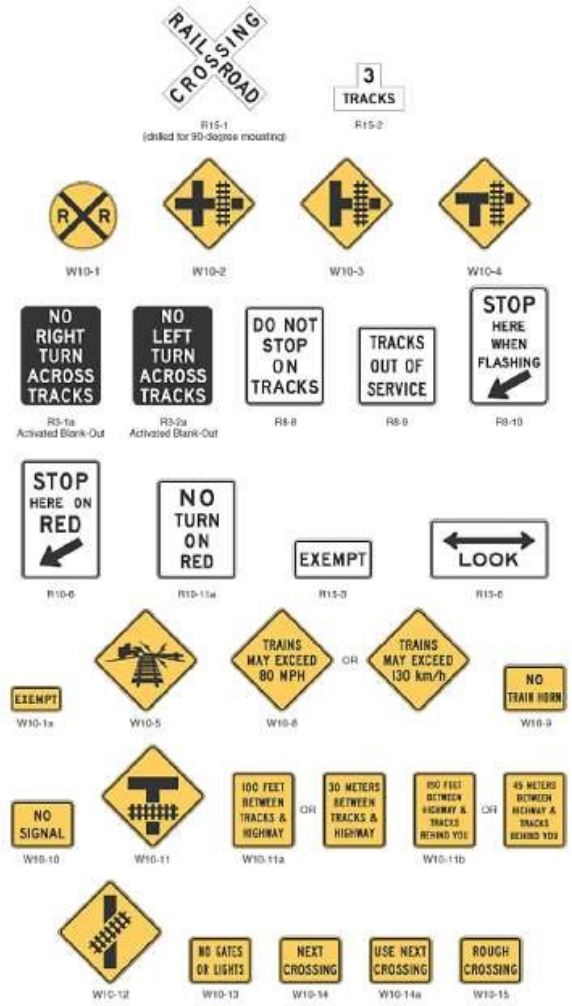
06 /06

How did you do?

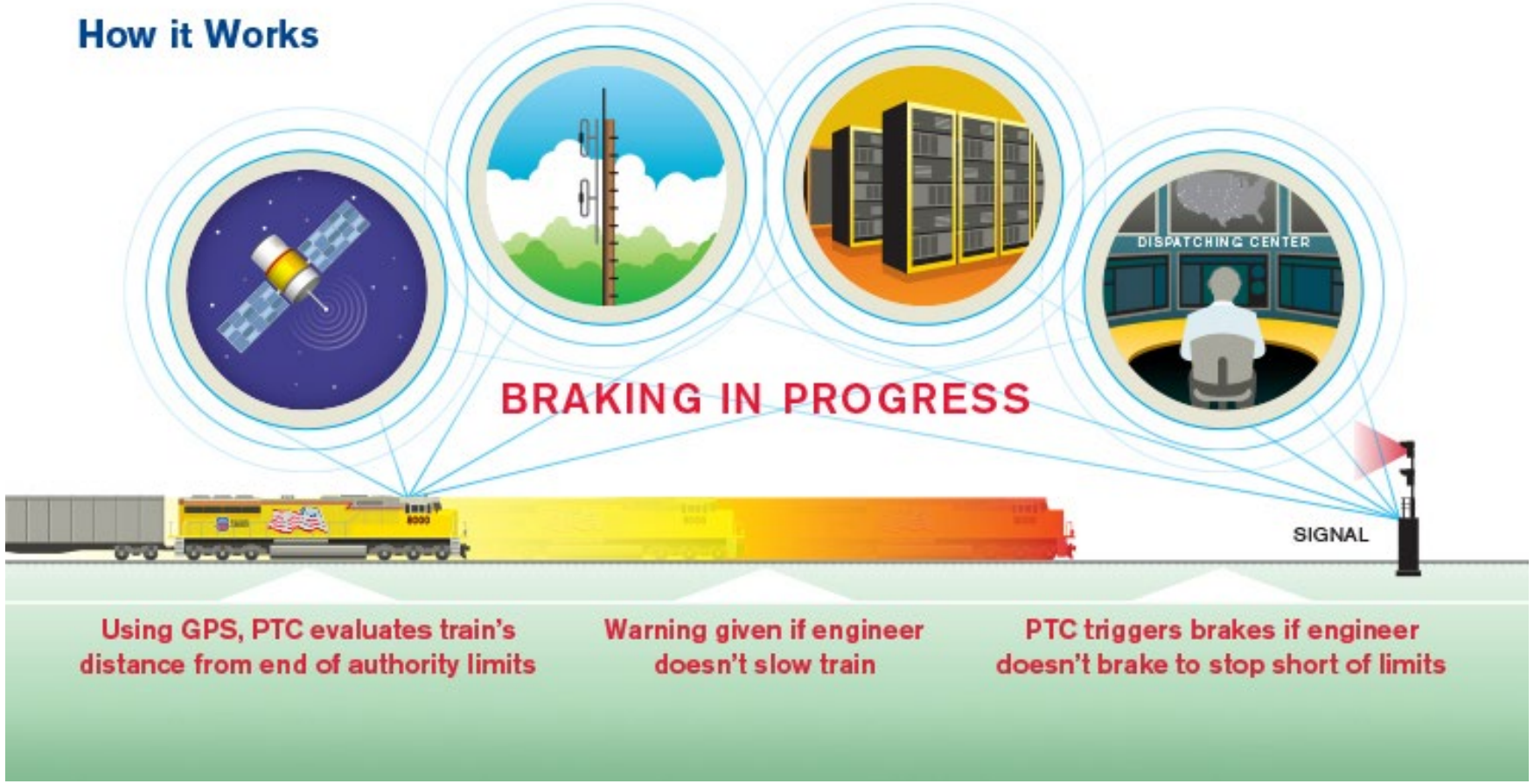
What did you do well? Is there anything you could've done better?

You've got this! You can grab and release objects, moving them wherever you want.

Railway Safety

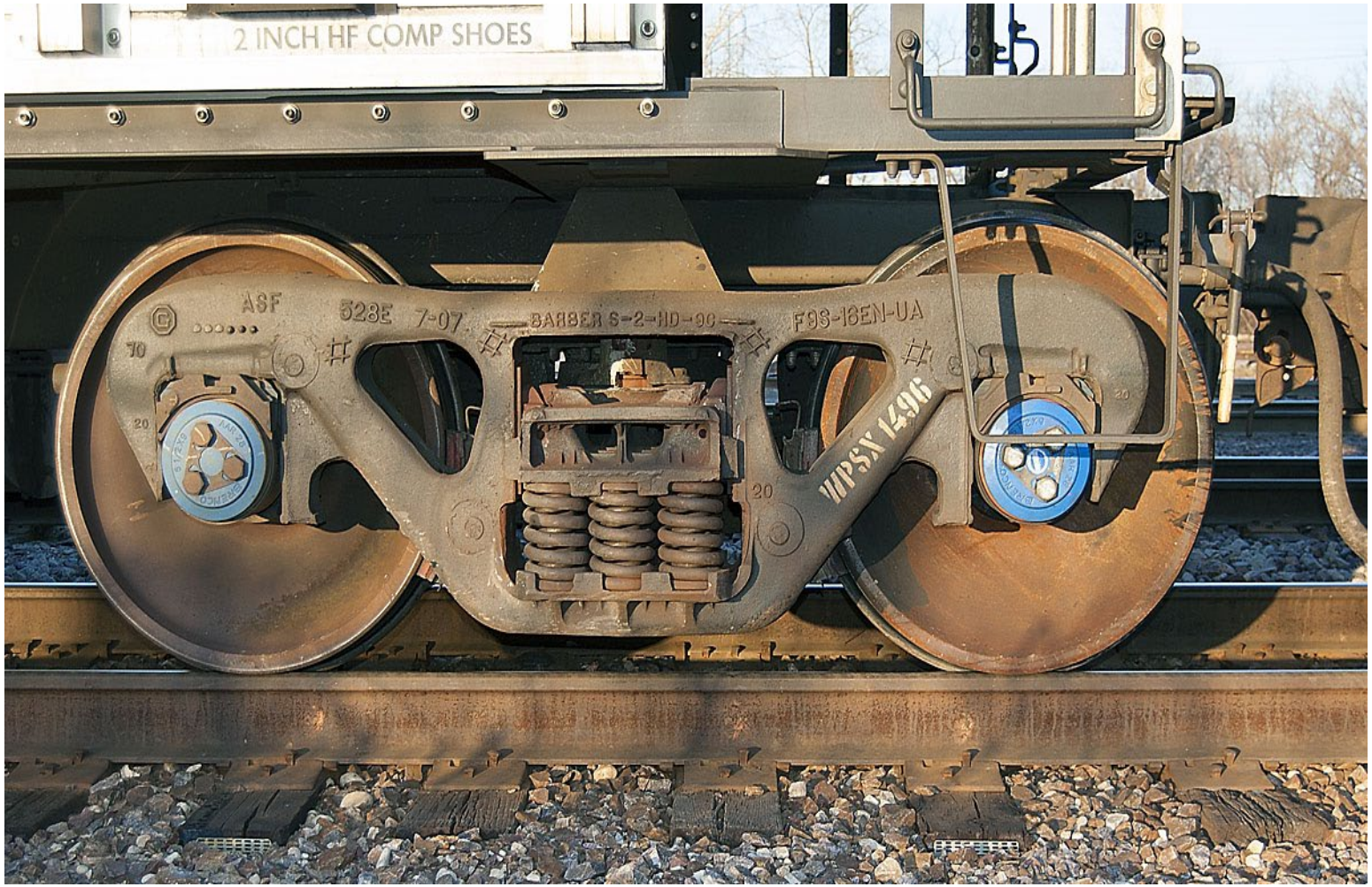


PTC: Positive Train Control

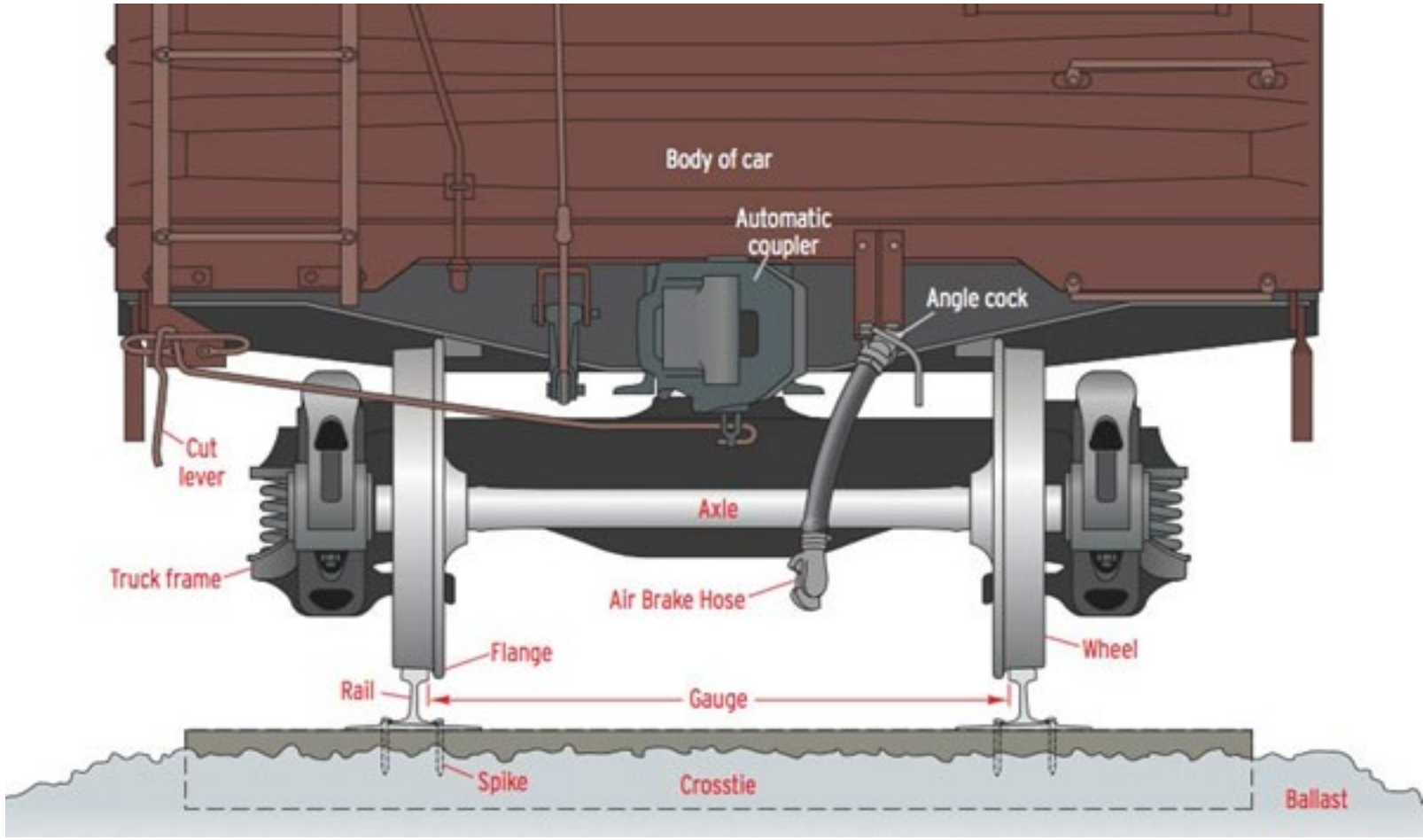


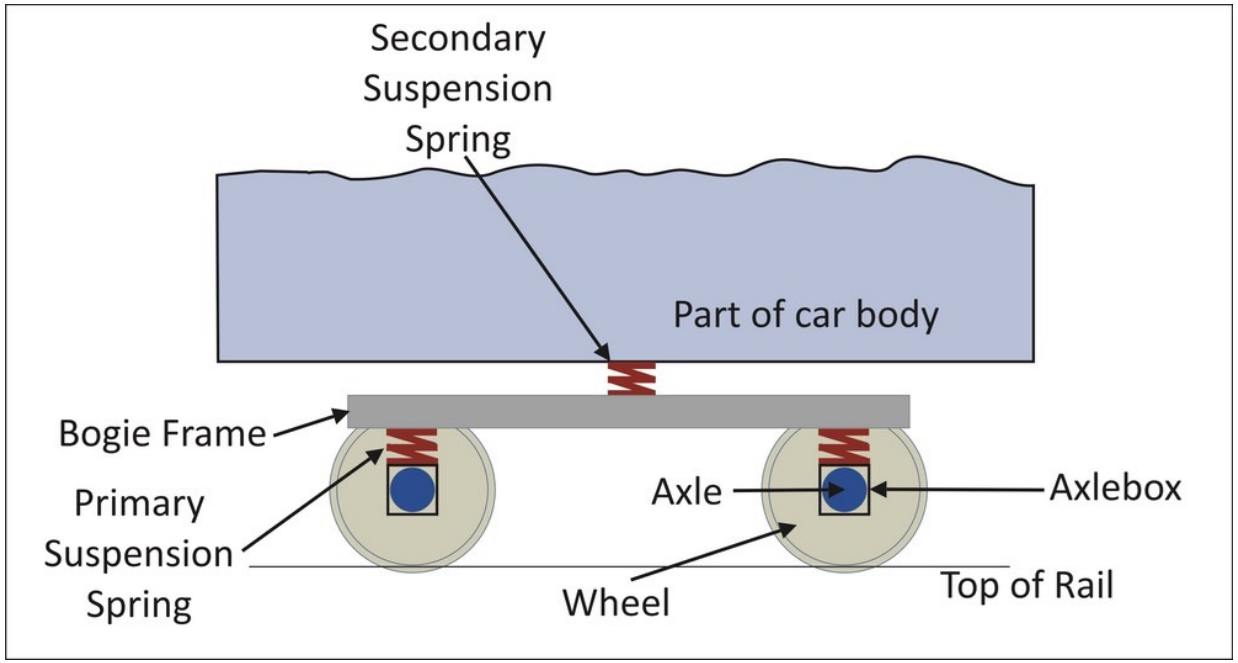
https://youtu.be/7fDRazEWAKU

Side View


2 INCH HF COMP SHOES
ASF
528E
7-07
BARBER S-2-HD-90
F9S-16EN-UA
WPSX 1496

Rear View


Body of car
Automatic coupler
Angle cock
Cut lever
Axle
Truck frame
Air Brake Hose
Flange
Wheel
Rail
Gauge
Spike
Crosstie
Ballast


Secondary
Suspension
Spring
Part of car body
Bogie Frame
Primary
Suspension
Spring
Axle
Axlebox
Wheel
Top of Rail

Wheel-Axle Assembly

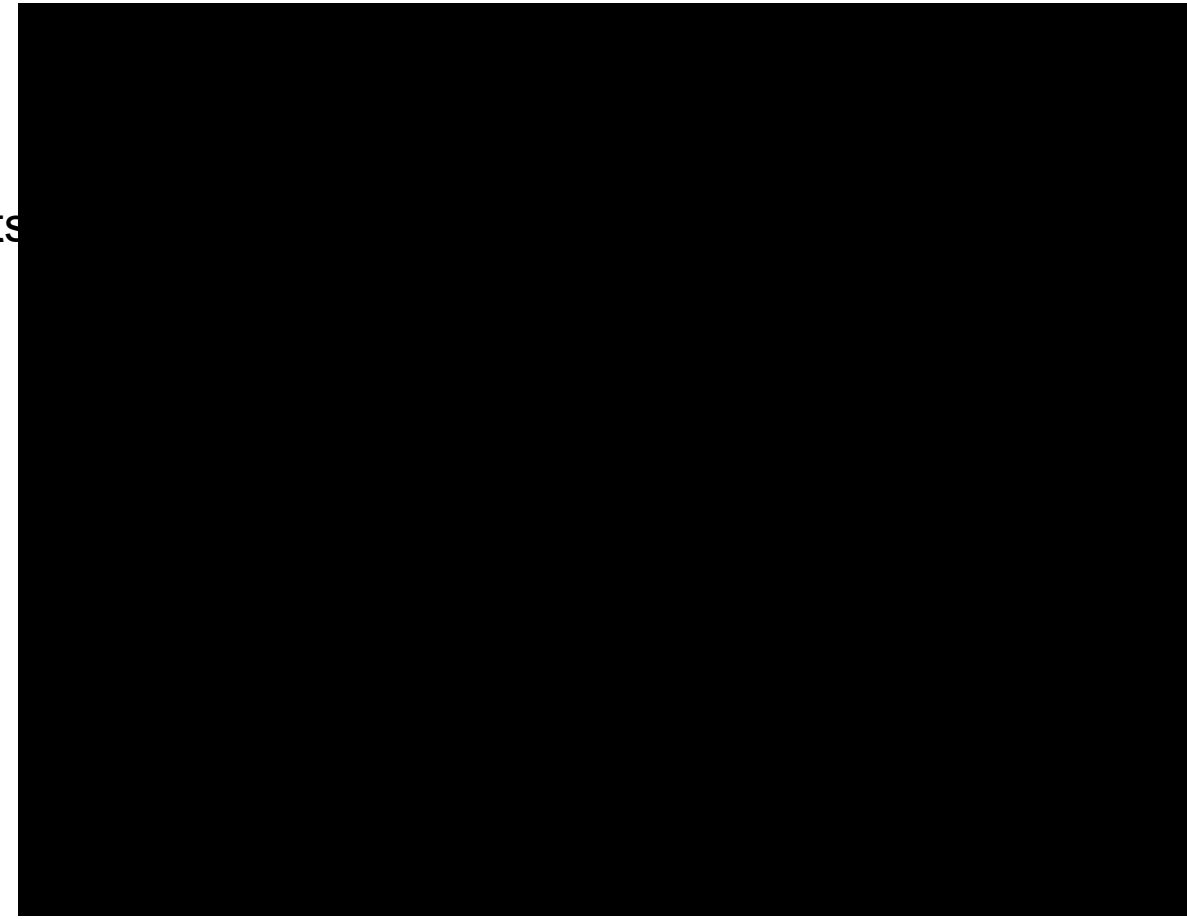
Bearings

How does train bearing works?


CROSS BEAM
ANTI-ROLL BAR

- 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.



UTRGV Bearing Test Setup


WS 17
OR 61
5
KAPWING

Develop questions for Dr. T and engineering students.

Visit with an engineer and do the following:

a. Discuss the work this engineer does and the tools the engineer uses.

b. Discuss with the engineer a current project and the engineer's particular role in it.

c. Find out how the engineer's work is done and how results are achieved.

d. Ask to see the reports that the engineer writes concerning the project.

e. Learn what that person does and how this person became interested in railroading. Find out what type of schooling and training are required for this position.

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.

DO NOT DISASSEMBLE ROBOT.

Plug your bot 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

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DAY4/5

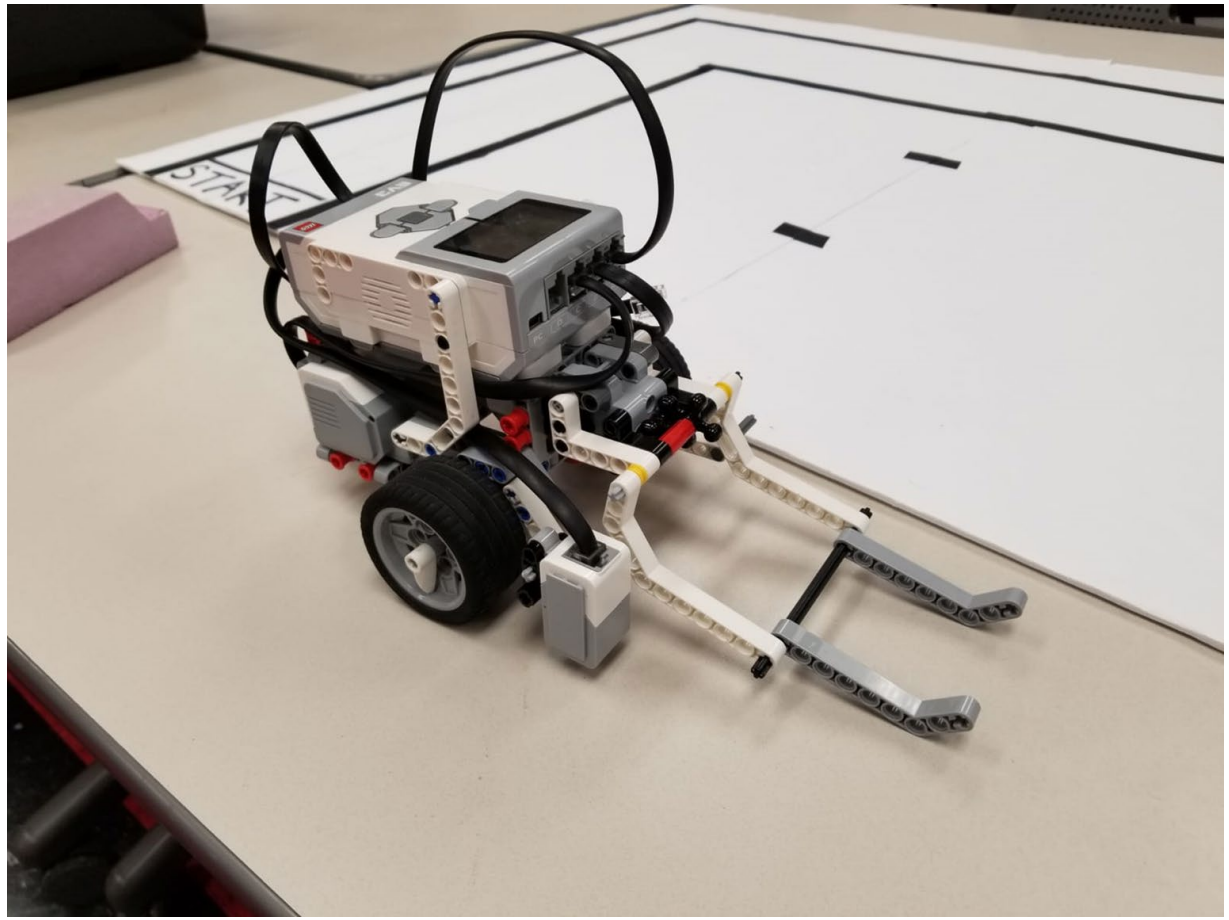
Railway Safety Forklift Design Challenge

RECAP:

1. How are wheel-axle assemblies replaced?
2. Why is it important to do maintenance on trains?
3. How are we applying trial and error to our challenge?
4. What is the challenge/goal for today?

Railway Safety Forklift Design Challenge

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



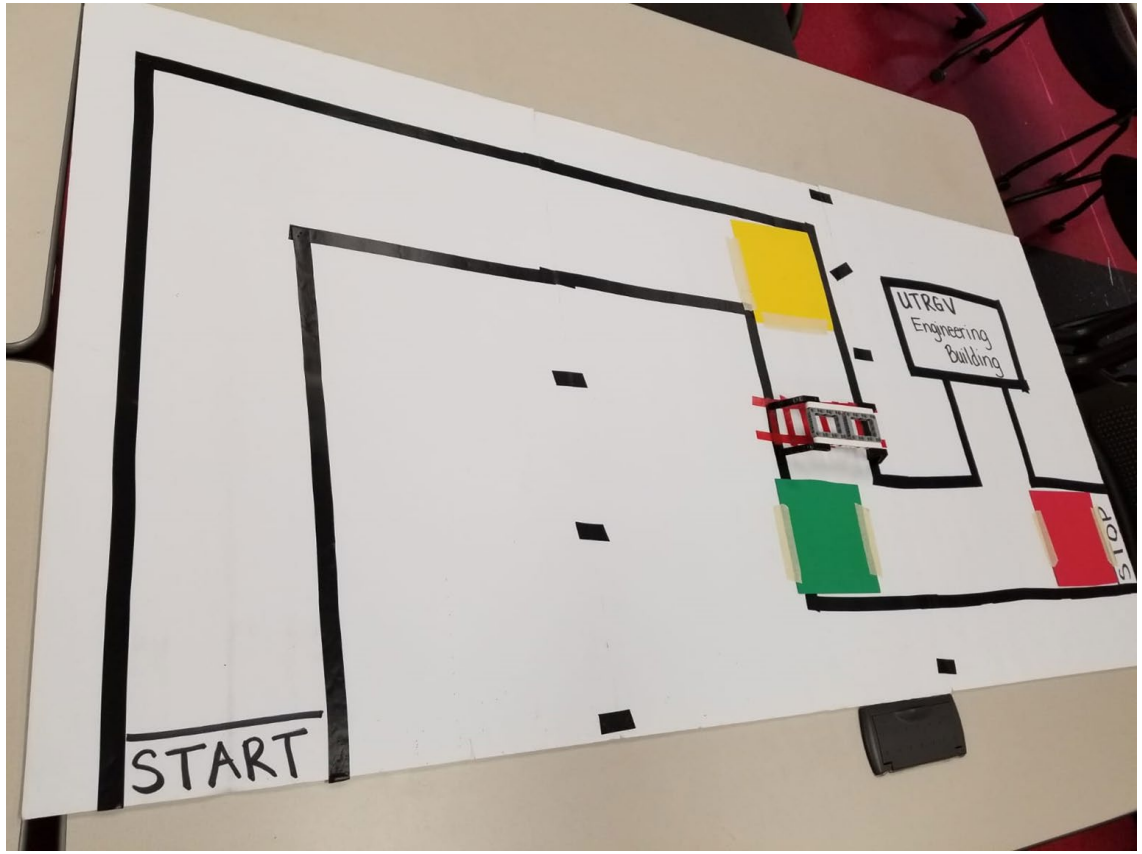
Objective:

1. Apply principles of engineering and programming to design their own transportation safety LEGO® MINDSTORM® EV3 robot and follow a predesigned path using motors and color sensor.

Materials

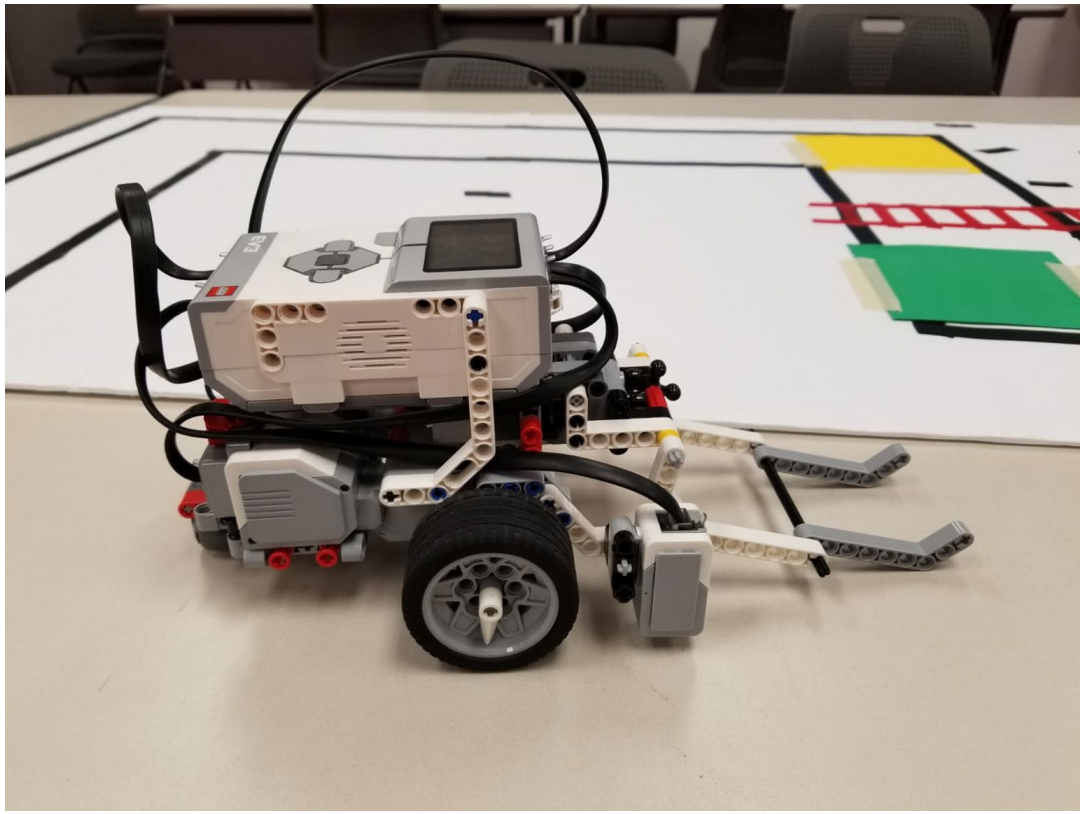
Materials: (per group)

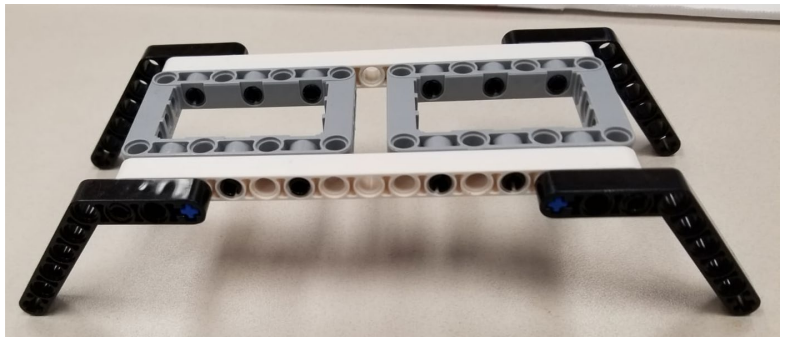
- One LEGO® MINDSTORM® EV3 robotics kit
- LEGO® MINDSTORM® EV3 manual
- Laptop or Ipad
- LEGO® MINDSTORM® software installed on the laptop or Ipad
- Meter stick
- Electrical tape to delineate the challenge course
- My Robot – Grading Rubric



Lesson Flow:

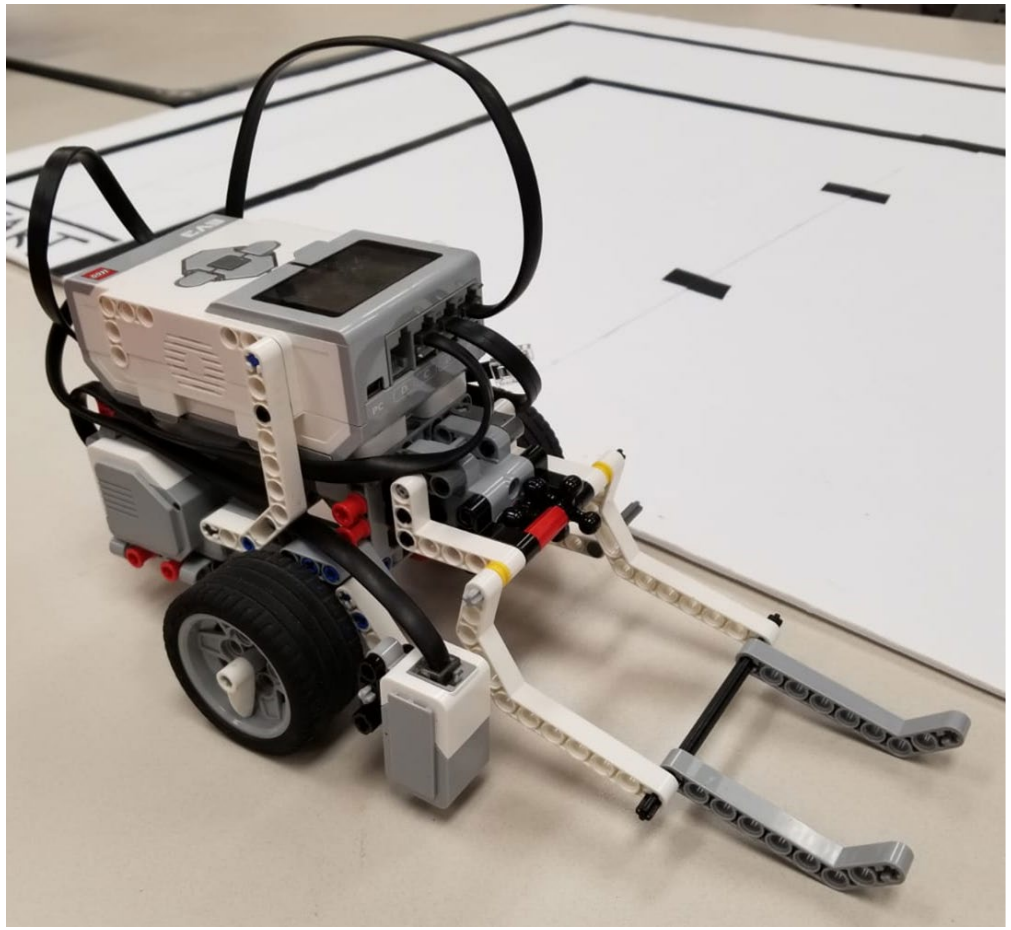
1. The final challenge will be to build a robot and program it to have at least two mechanisms in place. This is designed to be an open-ended challenge.
2. Explain the rules for the final competition and the selection criteria to be used during the Final
3. Challenge for selecting the winning team.
4.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





Directions:

1. Begin Challenge Design: How will your robot be used in railway safety? Example, how will it safely pick up the railway track? Be able to detect speed limits or railway signs?
2. Teams design their Railway Safety Forklift
3. Teams must check if all sensors and motors used are functional. They may use programming ONLY to check if each sensor and motor are working correctly and use the correct forms on measurements on each action block.



FINAL CHALLENGE

Lesson Overview: Teams will present their solutions to railway transportation issues to the class.

Objective:

1. Apply principles of engineering and programming to design their own transportation safety LEGO® MINDSTORM® EV3 robot.

Rubric

1 hour

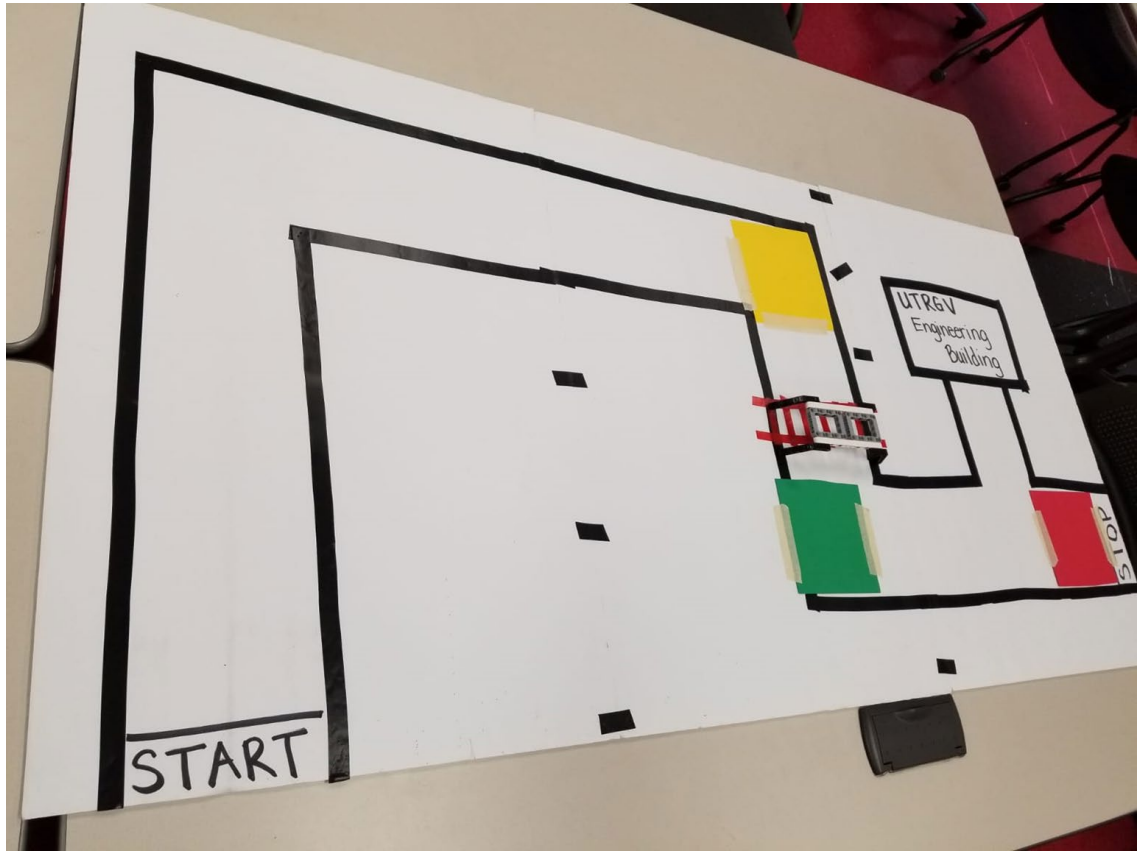
Team # _____

My Robot- Grading Rubric

Criteria	Maximum Amount of Points Per Criterion					Total Score (40 points possible)
	10	8	6	4	2	
Accuracy in navigating through the course.	0 infractions	1 infraction	2 infractions	3 infractions	4+ infractions	
Task completion	Fully Complete	1 step away	2 steps away	3 steps away	4+ steps away	
Efficiency of the program	Fully complete and working	Fully complete but not working	1 block left	2 blocks left	3+ blocks left	
Teamwork	All members helping and engaged during 5 random checks	All members helping and engaged during 4 random checks	All members helping and engaged during 3 random checks	All members helping and engaged during 2 random checks	All members helping and engaged during 1 random check	
						Grand Total:

Lesson Flow:

1. Each team will design their own robot to be able to move. The robot must include a forklift and color sensor.
2. Review programs for color sensor and forklift.
3. Review My Robot Grading Rubric



Scenario:

"A large semi-truck broke a section of railway track on University Drive. Dr. Tarawneh needs to send a Railway Safety Forklift to lift and carry the railway track back to the engineering building. The response time must be quick, however all speed limits must be obeyed to ensure transportation safety."

Directions

1. Teams program their robot to safely follow the path. The Railway Safety Forklift must obey all speed limits. The Railway Safety Forklift must lift a railway track and transport it to UTRGV Engineering Building. The Railway Safety Forklift must leave track in building and exit.
2. Teams must check if all sensors and motors used are functional. They may use manual program ONLY to check if each sensor and motor are working correctly and use the correct forms on measurements on each action block.
3. Remind students to program block by block and check robot on track before moving to the next block.
4. Set an end time to the challenge. Each team can attempt the challenge as many times to improve their rank until the time limit set.

Calculating Winners

Explain rules to students. Teams will be scores according to:

a. Accuracy in navigating through the course.
b. Task completion
c. Efficiency of the program
d. Teamwork

FINAL Cleanup and Closing Discussion

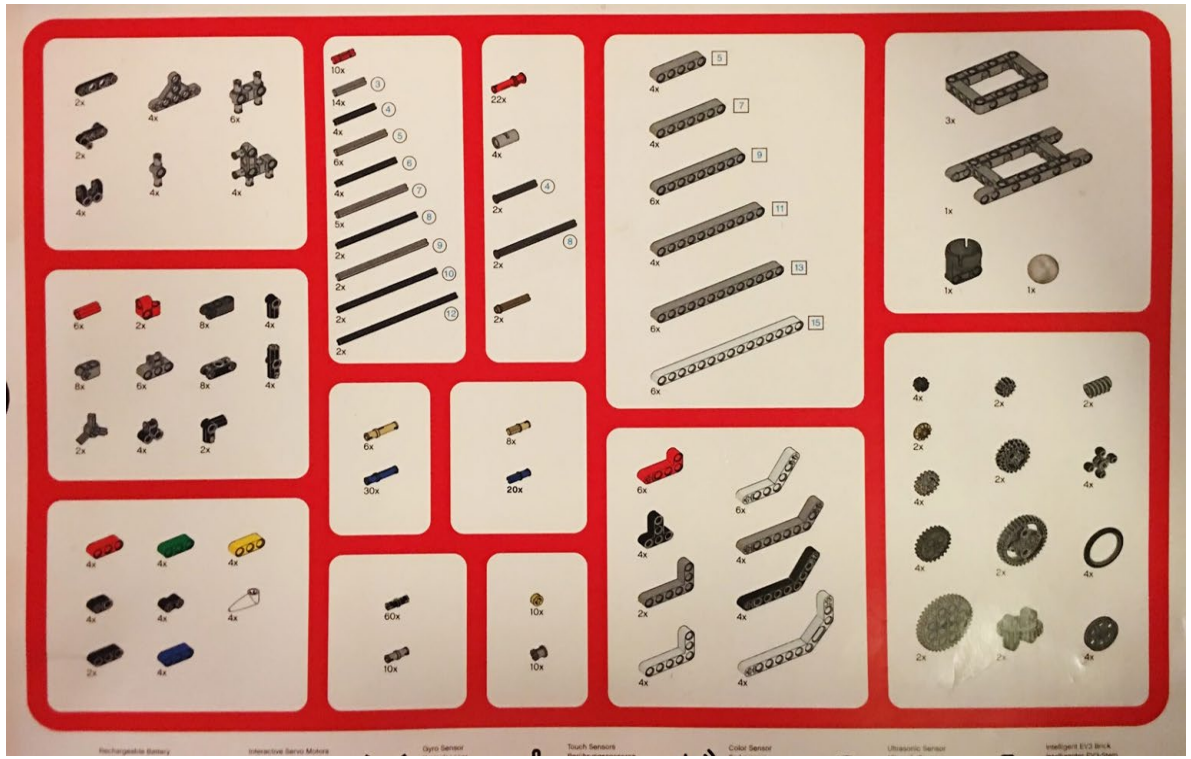
Lesson Overview: Have students reflect on the real challenges transportation engineers face on a daily basis.

Objectives:

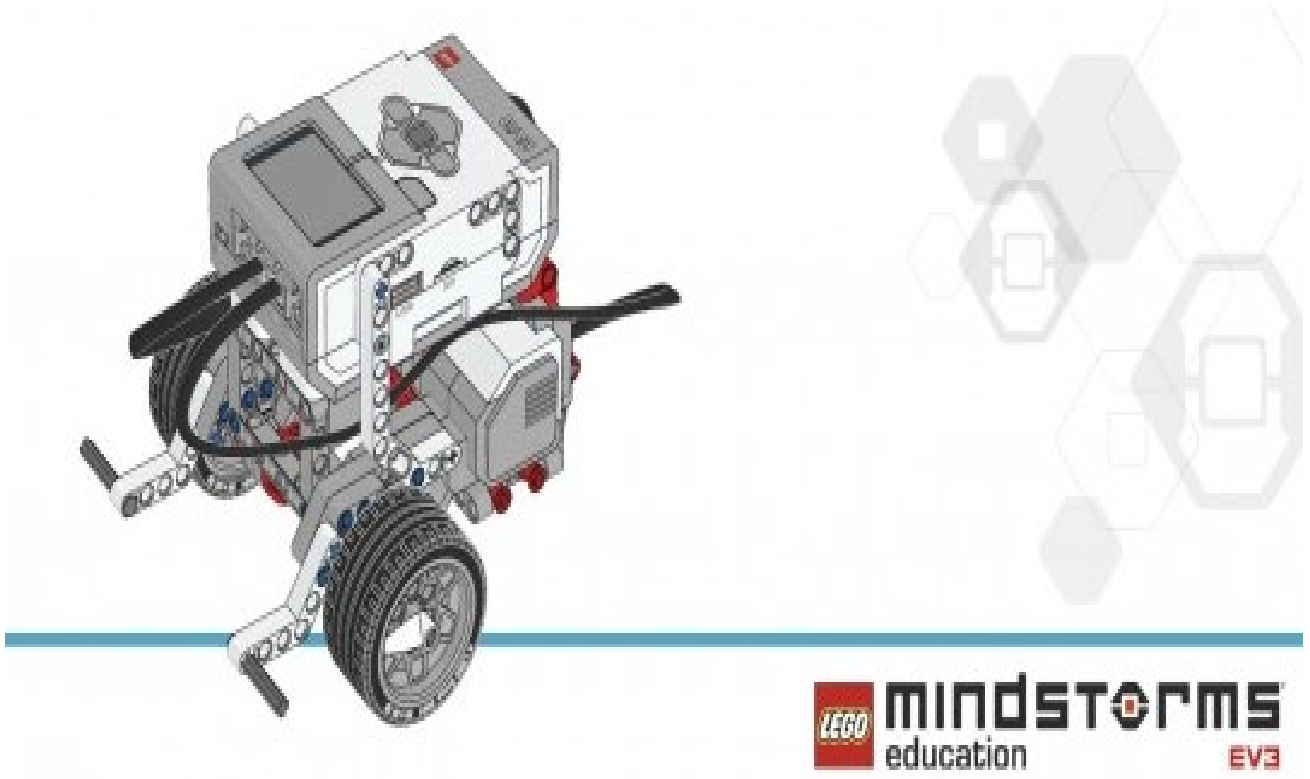
1. Count and clean all material used.
2. Reflect on student understanding of transportation engineering real-life challenges.

Lesson Flow:

1. Have a discussion about expectations of engineering to make sure they have enough supplies on hand when they report to a job site.
2. Provide a copy of the inventory picture as their engineer inventory of equipment.
3. Make sure students count and put all materials back in the box and Lego parts are not misplaced, left behind, or missing. Take count of missing parts per bin to fill in extras.
1. Announce the winning team, and let them know that they will be advancing to an overall competition (if there is an overall competition). Otherwise, announce the 1st, 2nd, and 3rd place winners.



DAY 5



UTRGV COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

Exit Ticket

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


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 5 References

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