Saskatchewan Mining Association: GeoRobotics

Mine Navigation Activity 1: Timing

Grade Level	**Target Grade 7-12**	**Difficulty**	Beginner
Subject	Practical and Applied Arts, Science, & Mathematics		
Description	The purpose of the "GeoRobotics" project is to help learners explore real applications of robotics and innovation in the mining industry with respect to making the workplace safer, environmental protection, and career opportunities. This activity will introduce learners to using functions to navigate a robotic car through a known mine pathway. Learners will develop a concept of timing, troubleshooting, and precision.		
Outcome(s)	**PAA** - **Electronics Modules:** ELEC01A, ELEC7A, ELEC8; **Robotics Modules**: ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A, ROBA48; **Energy and Mines**: ENMI1, ENMI8, ENMI24A, ENMI25, ENMI 31, ENMI44 **Science:** CE9.1, CE9.2, CE9.3, CE9.4, WS8.1, WS8.3, IE7.4, EC7.2 **Math:** P7.3, SS7.1, SS7.3, SS7.4, P8.1, N8.3, SS9.1, SS9.2 **ELA:** AR9.1, AR9.2, AR8.1, AR8.2 **Social Studies**: DR9.3, RW9.1, RW8.1, RW8.3, IN7.1, IN7.3, DR7.2, RW7.3		
SaskCode Required Prior Learning	GeoRobotics – Arduino Basics 101		
Time Frame	1 hour, depending on experience and possible extension activities		
Materials	**SaskCode Robotic Car Kit** (frame/wheels, Arduino Uno with motor driver, male/female jumper wires, and nine-volt batteries). A **computer** for each group, student **handouts/journals**, **cardboard or electrical tape,** and **sticky tack.**		
Additional Resources	https://www.saskcode.ca/ - SaskCode website http://saskmining.ca/ - Saskatchewan Mining Association website		

Assessment	Circulate the room observing and assisting. Encourage learners to record their learning in their "Design Journal." Setup clear expectations surrounding their "Design Journals." You may want to create a rubric, checklist or specific questions that learners should be answering within the journals. Also, at the end of each class have learners share their learning, errors and successes while reinforcing the importance of persistence and patience in programming.
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Mine Navigation Activity 1: Timing

Getting Started

1. Complete the **Basic Training** in order to learn how to use Arduinos and necessary components

Activity - Name, notes	**Time**
Arduino Basics 101 ○ Introduces Arduino programs, components, and robotic cars.	1 hour

2. **Engage:** Review the "Voice for Thought" materials and "Career Cards" with learners according to your own teaching preference. The laminated Career Cards will be used within the groups to discuss their strengths in order to divide up roles. Let students know that they are not stuck within the roles they pick. Students should be helping each other out.

3. **Explore**: Introduce the activity to groups. Groups learn about coding functions and navigate a mine pathway using time delays on a robotic car.

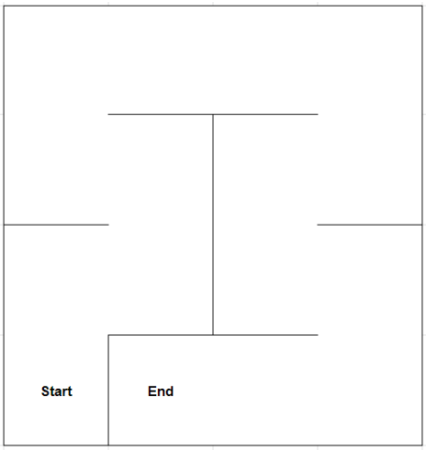
4. **Possible Extensions**: reverse the mine pathway, use a 3D printer for robotic car stand or try the Team Mega Mining Challenge.

SMA Saskatchewan Mining Association

Teacher Considerations

Paired Programming: Divide learners into groups of 2 – 4, depending on comfort level. Paired programming is highly recommended when working with coding and robotics so students can piggyback off each other's ideas and strengths. Have students collaborate ideas to encourage teamwork, build resilience and enhance problem solving.

Design Journal: Have each group communicate what they worked on, the problems that they encounter and how they solve these problems in a journal. This activity has a significant design portion, which will involve designing and testing various components both physically and electronically. It is a good idea to review the design process, and promote brainstorming many different ideas!



Mine Pathway: Design and setup a mine maze using carboard or electrical tape. It is recommended to use a clear and consistent pathway for this activity, so being able to setup the pathway and leave it until the completion of the activity is crucial. Pathways could be any setup as you see fit.

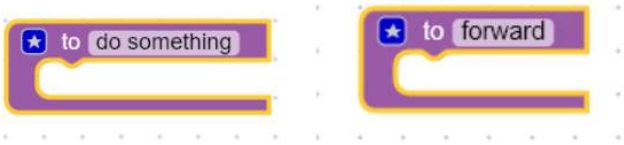
Mine Navigation Timing - Student Info

Timing Activity:

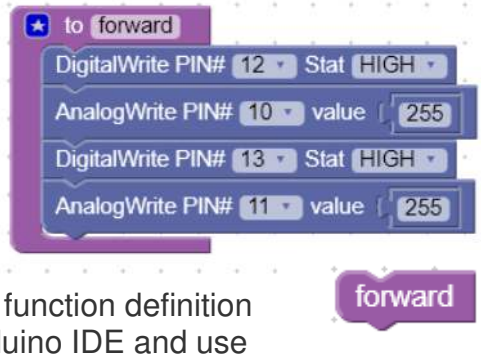
Using functions and time delays, navigate the robotic car through the mine pathway without hitting or touching walls. Document your ideas, challenges, questions, sketches and learning in your design journal. Read below for some hints on getting started.

Debugging:

In the Function menu, grab the following block and change the text to forward:



Define what this function is supposed to do. Insert the blocks that describe the forward motion. The robotic car is controlled by two motors each with a direction and speed. **255 is the maximum speed**. It is better to use a speed of around 150-200.



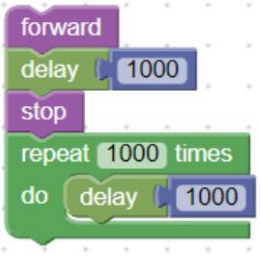
The forward block will appear in your function's menu. Drag it out so that you have this block and the function definition in your program. Copy the BlockyDuino code into Arduino IDE and use the USB to send it to the Uno. Test the "forward" function.

If the wheels are spinning in the opposite directions, experiment with changing the wheel that is spinning backward from High to Low. The High and Low changes the spinning direction of the motor.

```
12 -> Motor A dir
10 -> Motor A speed
13 -> Motor B dir
11 -> Motor B speed
```

Let's Program:

Before trying the Mine Pathway, start with some basics. Create the remaining functions and perform some baseline movements, such as "Turn Right 90 degrees" or "Go Forward 30 centimeters". Using the blocks for precise movements requires time delays. The tricky part about precision movement is getting the delay right!



This example has the robotic car moving forward for 1 second, and then stopping. The "repeat" block is used to give you time to measure out distances and degrees. Without the delay block, the program will loop back to the beginning.

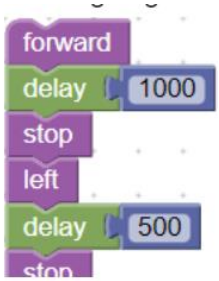
Fill in the Chart by Coding and Testing each Function and Delay

Movement	Function Block	Delay
Forward	DigitalWrite PIN# 12 Stat _____ AnalogWrite PIN# 10 value _____ DigitalWrite PIN# 13 Stat _____ AnalogWrite PIN# 11 value _____	30 cm forward = _____ 15 cm forward = _____
Backward	DigitalWrite PIN# 12 Stat _____ AnalogWrite PIN# 10 value _____ DigitalWrite PIN# 13 Stat _____ AnalogWrite PIN# 11 value _____	30 cm backward =_____ 15 cm backward =_____
Stop	DigitalWrite PIN# 12 Stat _____ AnalogWrite PIN# 10 value _____ DigitalWrite PIN# 13 Stat _____ AnalogWrite PIN# 11 value _____	
Turn Left	DigitalWrite PIN# 12 Stat _____ AnalogWrite PIN# 10 value _____ DigitalWrite PIN# 13 Stat _____ AnalogWrite PIN# 11 value _____	90 degrees left =_____ 180 degrees left =_____
Turn Right	DigitalWrite PIN# 12 Stat _____ AnalogWrite PIN# 10 value _____ DigitalWrite PIN# 13 Stat _____ AnalogWrite PIN# 11 value _____	90 degrees right =_____ 45 degrees right =_____

Let's Navigate!

Using functions and time delays, navigate the robotic car through the mine pathway without hitting or touching walls.

1. Measure and sketch the mine pathway
2. Create a flowchart or list of the movements and measurements needed to navigate each part of the mine pathway
3. Code the movements in order
   Hint – after each movement and delay, tell the motors to stop
4. Transfer code onto the uno of the robotic car
5. Test your robotic car in the mine pathway



If it doesn't work perfectly the first time, that is ok! Just keep trying and changing the delays until you have it working!

Early finisher?

Navigate the mine pathway in reverse. What changes when going in reverse?

OR

Have your teacher (or with permission yourself) create another mine pathway to navigate and challenge other early finishers.

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Saskatchewan Mining Association: GeoRobotics

Mine Navigation Activity 2: Avoidance

Grade Level	**Target Grade 7-12**	**Difficulty**	Beginner
Subject	Practical and Applied Arts, Science, & Mathematics		
Description	The purpose of the "GeoRobotics" project is to help learners explore real applications of robotics and innovation in the mining industry with respect to making the workplace safer, environmental protection, and career opportunities. This activity introduces learners to obstacle avoidance and navigation through a mine pathway using an ultrasonic sensor on a robotic car. The ultrasonic sensor allows the robot car to avoid obstacles.		
Outcome(s)	**PAA** - **Electronics Modules:** ELEC01A, ELEC7A, ELEC8; **Robotics Modules**: ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A, ROBA37A, ROBA48; **Energy and Mines**: ENMI1, ENMI8, ENMI24A, ENMI25, ENMI 31, ENMI44 **Science:** CE9.1, CE9.2, CE9.3, CE9.4, WS8.1, WS8.3, IE7.4, EC7.2 **Math:** P7.3, SS7.1, SS7.3, SS7.4, P8.1, N8.3, SS9.1, SS9.2 **ELA:** AR9.1, AR9.2, AR8.1, AR8.2 **Social Studies**: DR9.3, RW9.1, RW8.1, RW8.3, IN7.1, IN7.3, DR7.2, RW7.3		
SaskCode Required Prior Learning	GeoRobotics – Arduino Basics 101 GeoRobotics – Mine Navigation Activity 1: Timing		
Time Frame	1-4 hours, depending on experience and possible extension activities		
Materials	**SaskCode Robotic Car Kit** (frame/wheels, Arduino Uno with motor driver, ultrasonic sensor, male/female jumper wires, and nine-volt batteries). A **computer** for each group, student **handouts/journals**, **cardboard, obstacles to avoid** and **sticky tack. This path must be made with walls at least 5.5 inches in height. Cardboard and tape work great, as do 2x6s!**		
Additional Resources	https://www.saskcode.ca/ - SaskCode website http://saskmining.ca/ - Saskatchewan Mining Association website		

Assessment	Circulate the room observing and assisting. Encourage learners to record their learning in their "Design Journal." Setup clear expectations surrounding their "Design Journals." You may want to create a rubric, checklist or specific questions that learners should be answering within the journals. Also, at the end of each class have learners share their learning, errors and successes while reinforcing the importance of persistence and patience in programming.
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Mine Navigation Activity 2: Avoidance

Getting Started

1. Complete the **Basic Training** in order to learn how to use Arduinos and necessary components.

Activity - Name, notes	**Time**
GeoRobotics – Arduino Basics 101 ○ Introduces Arduino programs, components, and robotic cars.	1 hour
Mine Navigation Activity 1: Timing ○ Introduces concept of creating functions to represent a series of commands. Challenge learners to navigate through a mine pathway using functions and time delays.	1 hour

2. **Engage:** Review the "Voice for Thought" materials and "Career Cards" with learners according to your own teaching preference. The laminated Career Cards will be used within the groups to discuss their strengths in order to divide up roles. Let students know that they are not stuck within the roles they pick. Students should be helping each other out.

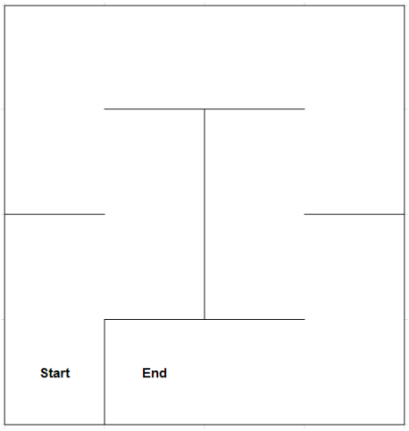
3. **Explore**: Introduce the activity to groups. Groups avoid obstacles and navigate a mine pathway using an ultrasonic sensor on a robotic car in this two-part activity.

4. **Possible Extensions**: using a 3D printer or try the Team Mining Challenge.

5. **Early finisher?**
   Navigate the mine pathway in reverse. What changes when going in reverse?
   OR
   Have your teacher (or with permission yourself) create another mine pathway to navigate and challenge other early finishers. Try using different turn angles!

Teacher Considerations

Paired Programming: Divide learners into groups of 2 – 4, depending on comfort level. Paired programming is highly recommended when working with coding and robotics so students can piggyback off each other's ideas and strengths. Have students collaborate ideas to encourage teamwork, build resilience and enhance problem solving.



Design Journal: Have each group communicate what they worked on, the problems that they encounter and how they solve these problems in a journal. This activity has a significant design portion, which will involve designing and testing various components both physically and electronically. It is a good idea to review the design process, and promote brainstorming many different ideas!

Mine Pathway: Design and setup a maze that must have walls at least 5.5 inches in height. Cardboard and tape work great, as do 2x6s! It is recommended to use a clear and consistent pathway for this activity, so being able to setup the pathway and leave it until the completion of the activity is crucial. Pathways could be any setup as you see fit.

Mine Navigation Avoidance - Student Info

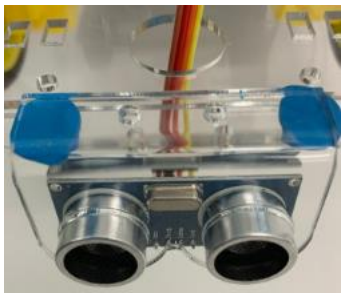
Ultrasonic Activities:

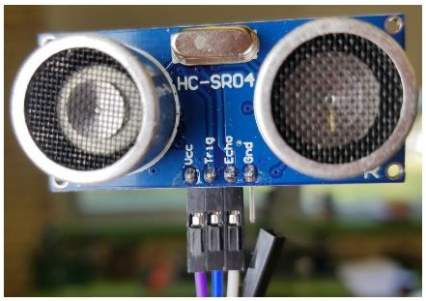
The goal of these activities is avoiding obstacles and navigating along a mine pathway using an ultrasonic sensor on a robotic car. Use your design journals to document your ideas, challenges, questions, sketches, and learning. Read below for some hints on getting started.

New Components:

Ultrasonic Sensor: Distance sensors work by sending pulses of light or sound out from a transmitter, then timing how long it takes for the signals to bounce off an object and return to a receiver (just like sonar). This sensor provides 2 cm - 400 cm measurement, and the ranging accuracy is 3mm. There are only four pins that you need to worry about on the HC-SR04: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground).

Let's Build: Connect and attach the ultrasonic sensor on the Arduino Uno Car





UltraSonic	Uno
VCC	Vin
Trig	Pin 7
Echo	Pin 8
Gnd	Gnd

1. Secure the ultrasonic sensor to the robotic car using a sensor mount, 3D printed design or cardboard cutout. A little sticky tack or tape will help it stay.

2. Attach the Ultrasonic sensor on the uno motor shield according to the table.

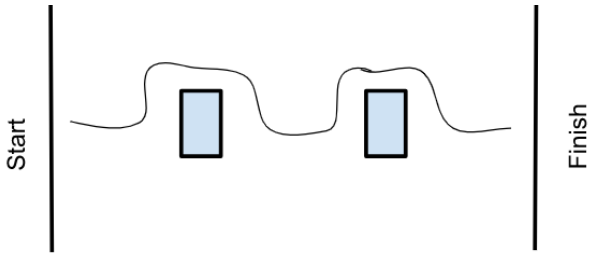
Debugging: Test the sensor to ensure it is working. Use the ultrasonic sensor to read distance in centimeters. Set up a "Serial" monitor reading system. Use an object to test the ultrasonic sensor at different distances. Turn on your serial print monitor and observe the readouts on Arduino IDE. Make sure to move the object to ensure the distance is changing!

Helpful coding hints- Refresh page, if it spits blocks out. Add and rename one "item" variable at a time.

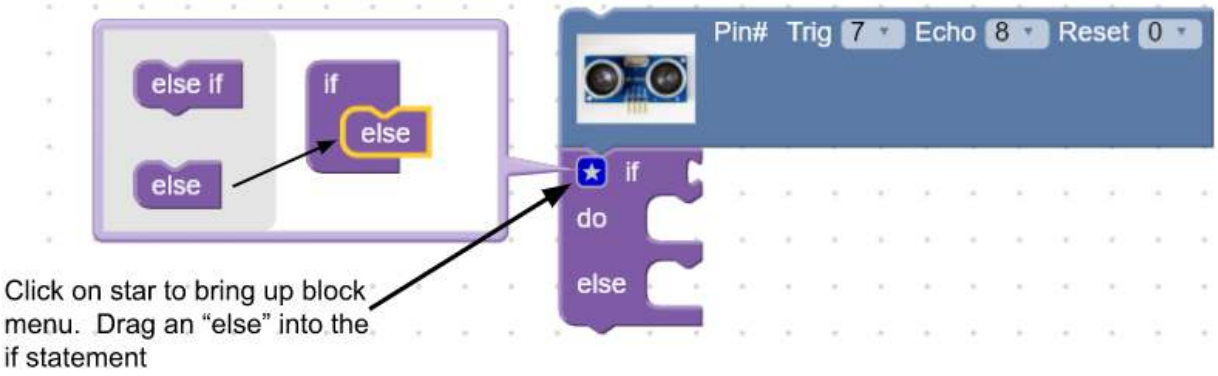
Add the ultrasonic library in BlockyDuino by clicking on gear in the corner of the top right. This pop opens a "Option Blocks" window. Click on the box next to "Ultrasonic" so it is check marked and click "OK"

Let's Program Part 1: Obstacle Avoidance

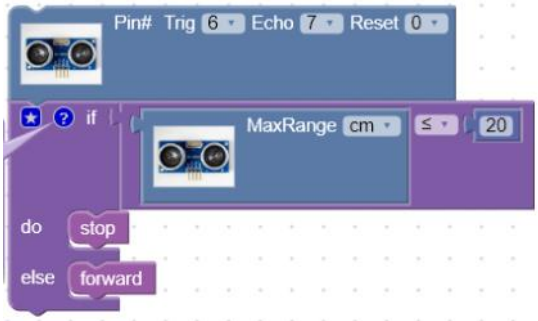
Activity - Make a straight path on the floor with a few obstacles for the robotic car to navigate around using an ultrasonic sensor.



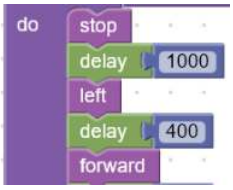
Use the same robotic car and movement functions from the previous "Timing" lesson. Add the movement functions to the BlockyDuino editor. Then, add your ultrasonic sensor block and logic statement block.



Using the following code, if an object is detected at or less than 20cm the car will stop. Else, it will go forward.



Change the code using movement functions (stop, left, right, forward) and time delays between each movement, so your robotic car goes around the obstacles and keeps driving to reach the finish line.



Remember!
When using the ultrasonic sensor, delete a section of code in the Arduino IDE.

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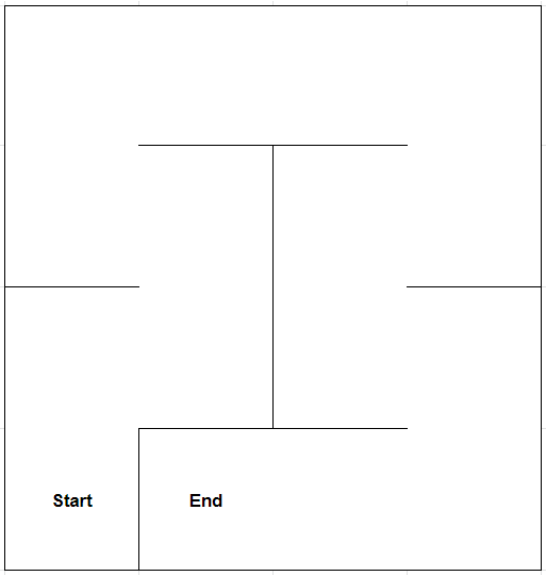
Let's Program Part 2: Mine Navigation



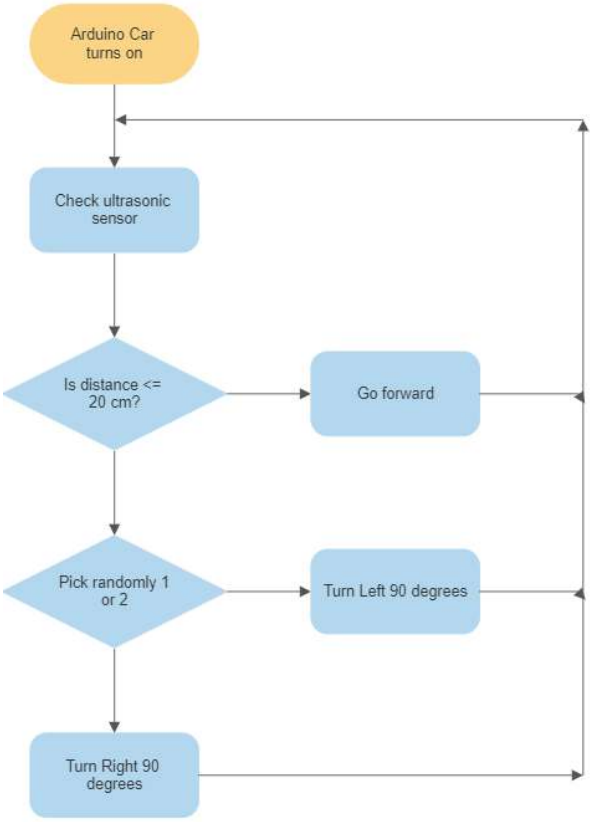
Activity - Navigate the robotic car through the mine pathway, without hitting the walls, using the ideas learned in obstacle avoidance.

Navigating Different Turns

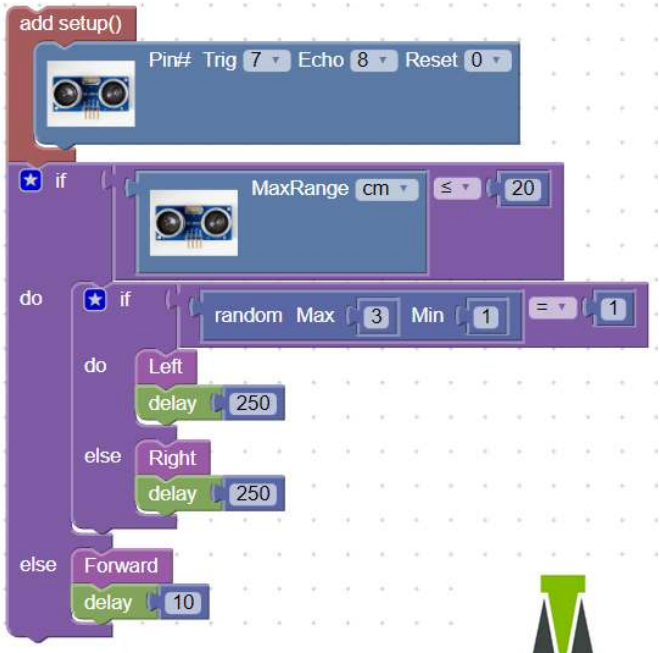
Did you get stuck in the mine? How can you program a robotic car to turn left or right, depending on the situation? What if you are navigating an unknown pathway or a pathway you cannot see? Brainstorm 3 different solutions to this problem and record them in the design journal.

One Possible Solution – **Turning Randomly**

Flowchart



Note: When using the "random" block, it will select a number between the min value and the max value, but not the max value. The highest value it will return in 1 less than the max value!



If it doesn't work perfectly the first time, that is ok! Just keep trying!

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Mine Navigation Activity 3: Lines

Grade Level	**Target Grade 7-12**	**Difficulty**	Beg. – Interm.
Subject	Practical and Applied Arts, Science, & Mathematics		
Description	The purpose of the "GeoRobotics" project is to help learners explore real applications of robotics and innovation in the mining industry with respect to making the workplace safer, environmental protection, and career opportunities. This activity introduces learners to navigating a mine pathway using a tracker sensor on a robotic car and problem solving with coding. The tracker sensor "looks" down and is able to differentiate between dark and light colours. This allows the robot car to follow lines, stay within lines, or stop if it detects a change in colours.		
Outcome(s)	**PAA** - **Electronics Modules:** ELEC01A, ELEC7A, ELEC8; **Robotics Modules**: ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A, ROBA35A, ROBA48; **Energy and Mines**: ENMI1, ENMI8, ENMI24A, ENMI25, ENMI 31, ENMI44 **Science:** CE9.1, CE9.2, CE9.3, CE9.4, WS8.1, WS8.3, IE7.4, EC7.2 **Math:** P7.3, SS7.1, SS7.3, SS7.4, P8.1, N8.3, SS9.1, SS9.2 **ELA:** AR9.1, AR9.2, AR8.1, AR8.2 **Social Studies**: DR9.3, RW9.1, RW8.1, RW8.3, IN7.1, IN7.3, DR7.2, RW7.3		
SaskCode Required Prior Learning	GeoRobotics – Arduino Basics 101 GeoRobotics – Mine Navigation Activity 1: Timing GeoRobotics – Mine Navigation Activity 2: Avoidance		
Time Frame	3 to 8 hours, depending on experience and extension activities		
Materials	**SaskCode Robotic Car Kit** (frame/wheels, Arduino Uno with motor driver tracker sensor, 5 male/female jumper wires, and nine-volt batteries). • Small Phillips screwdriver for adjusting sensitivity of sensor A **computer** for each group, student **handouts/journals**, **black electrical tape, cardboard,** and **sticky tack.**		
Additional Resources	https://www.saskcode.ca/ - SaskCode website http://saskmining.ca/ - Saskatchewan Mining Association website		

Assessment	Circulate the room observing and assisting. Encourage learners to record their learning in their "Design Journal." Setup clear expectations surrounding their "Design Journals." You may want to create a rubric, checklist or specific questions that learners should be answering within the journals. Also, at the end of each class have learners share their learning, errors and successes while reinforcing the importance of persistence and patience in programming.
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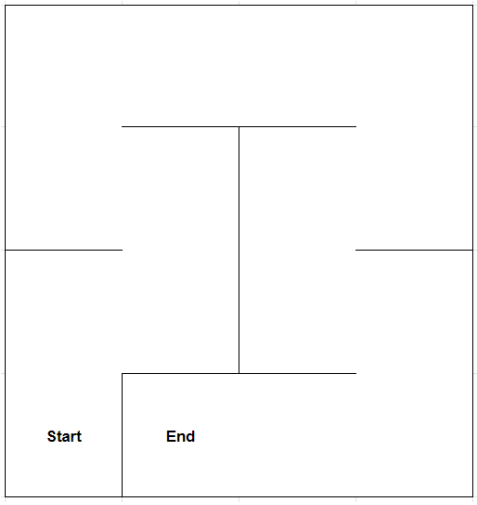
Mine Nav. Activity 3: Lines

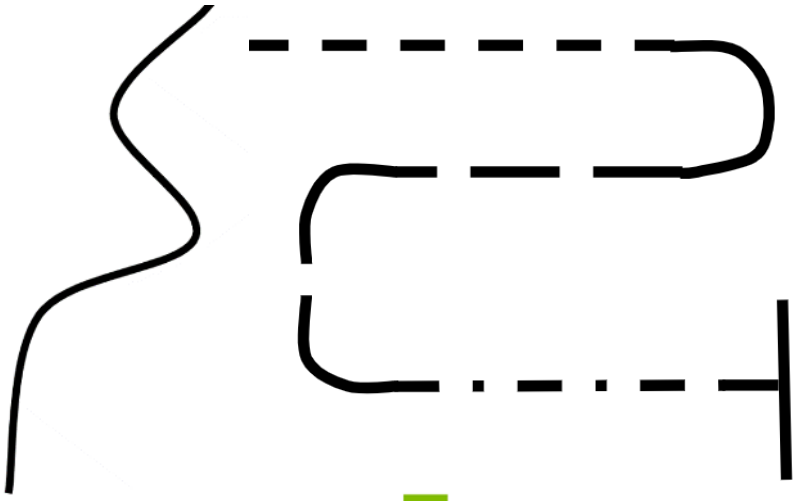
Getting Started

1. Complete the **Basic Training** in order to learn how to use Arduinos and necessary components

Activity - Name, notes	**Time**
GeoRobotics – Arduino Basics 101 ○ Introduces Arduino programs, components, and robotic cars.	1 hour
Mine Navigation Activity 1: Timing ○ Introduces concept of creating functions to represent a series of commands. Challenge learners to navigate through a mine pathway using functions and time delays.	1 hour
Mine Navigation Activity 2: Avoidance ○ Challenge learners to navigate around obstacles and through a mine pathway using an ultrasonic sensor.	2 hours

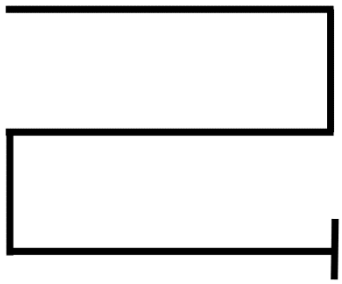
2. **Engage:** Review the "Voice for Thought" materials and "Career Cards" with learners according to your own teaching preference. The laminated Career Cards will be used within the groups to discuss their strengths in order to divide up roles. Let students know that they are not stuck within the roles they pick. Students should be helping each other out.
3. **Explore**: Introduce the activity to groups. Groups navigate a mine pathway using a tracker sensor on a robotic car and problem solve by changing their codes.
4. **Possible Extensions**: Navigating Curved Lines, Navigating Dotted Lines, Bounce in Borders, using a 3D printer or try the Team Mega Mining Challenge.





Paired Programming: Divide learners into groups of 2 – 4, depending on comfort level. Paired programming is highly recommended when working with coding and robotics so that students can piggyback off each other's ideas and strengths. Have students collaborate ideas to encourage teamwork, build resilience and enhance problem solving.

Design Journal: Have each group communicate what they worked on, the problems that they encounter and how they solve these problems in a journal. This activity has a significant design portion, which will involve designing and testing various components both physically and electronically. It is a good idea to review the design process, and promote brainstorming many different ideas!



Mine Pathway: Design and setup a black electrical tape pathway for the robot car to track. Use a clear and consistent pathway that can be left until the completion of the activity. Begin with a simple pathway using straight lines and right angles. Make a "T" at the end of the path.

Mine Navigation: Lines - Student Info

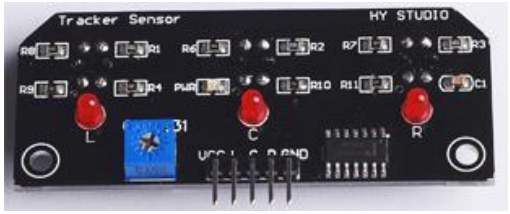
Line Activity:

The goal of this activity is to navigate along a mine pathway using a tracking sensor on a robotic car. The tracker sensor "looks" down and is able to differentiate between dark and light colours. This allows the robot car to follow lines, stay within lines, or stop if it detects a change in colours. The mine pathway will be made of electrical tape lines. Use your design journals to document your ideas, challenges, questions, sketches, and learning. Read below for some hints on getting started.

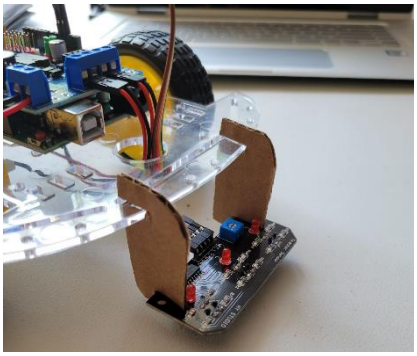
New Components:

Tracker Sensor: This sensor has three transmitters that send out light. It also has three receivers that measure the light that is reflected off the surface. White objects will reflect most of the light, and black objects will absorb light. The robot car can make decisions based upon the colour of the surface it travels. For example, it can be programmed to follow a black line, or be programmed to bounce within borders.

There are four pins that you wire to the robot car's motor shield: VCC (Power), L (left sensor), C (center sensor), R (right sensor) and GND (Ground).

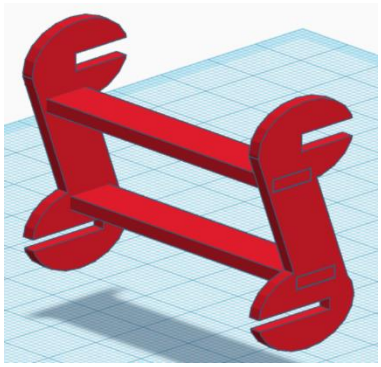


Let's Build: Connect and attach the tracker sensor on the Arduino Car



1. Attach the female end of the jumper wires to the pins of the tracker sensor. It is good practice to use red for VCC and black for GND.

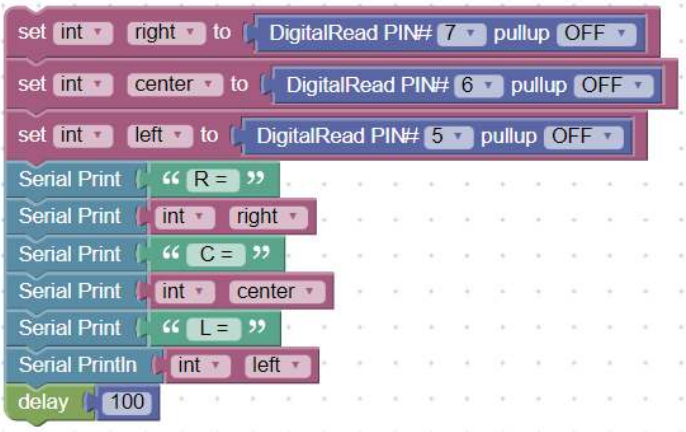
2. Attach the tracker sensor with sticky tack, so the red LED bulbs are facing up. This sensor needs to be ~1cm from the drive surface, or it will not be able to read the lines with any accuracy. This is where some construction might be needed, depending on the model of the Arduino Car.



3. Attach the five jumpers on the motor shield as follows:

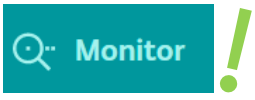
Tracker Sensor	Motor Shield
VCC	Vin
L (left)	Pin 5
C (center)	Pin 6
R (right)	Pin 7
GND	Gnd

Debugging: Test the sensor to ensure it is working. The sensor has three receivers to collect data returning a value of 1 or 0, depending on if it detects a line or not. Code a Serial Monitor system with three variables as shown. **Helpful coding hints**- Refresh page, if spits blocks out. Add and rename one "item" variable at a time.



Get a piece of white paper and make a black line on it using a marker or pencil. Load the code onto your Arduino IDE. Turn on your serial print monitor. After your code is loaded, put each sensor over the black line and observe the readouts.
The read out could be…

```
R = 0 C = 0 L = 0
R = 0 C = 0 L = 0
R = 0 C = 0 L = 0
R = 0 C = 0 L = 0
R = 0 C = 0 L = 0
R = 0 C = 0 L = 0
R = 0 C = 0 L = 0
```



1 – line is detected under the sensor
0 - no line is detected under the sensor

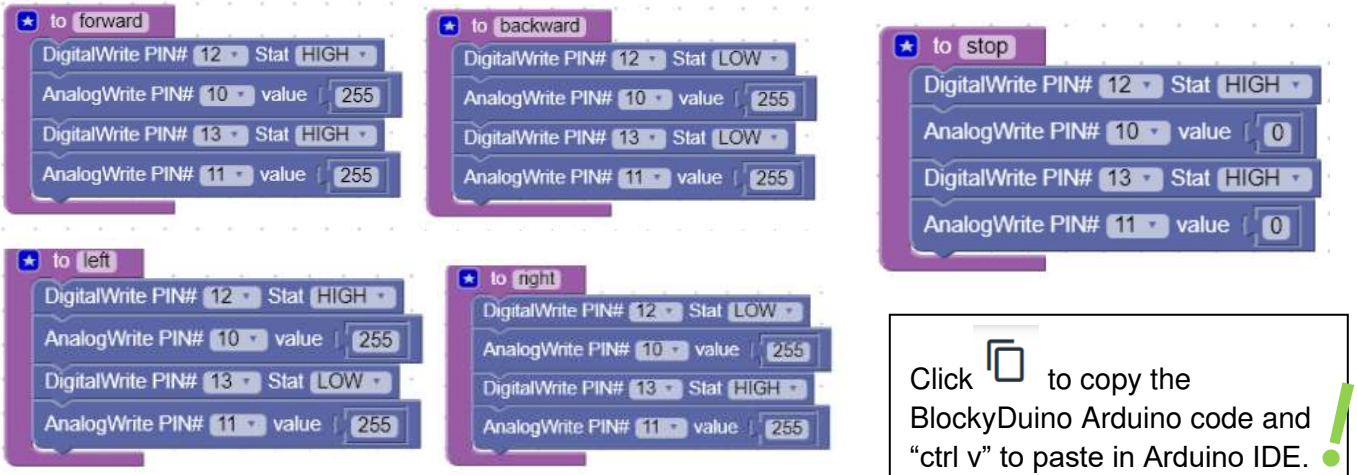
This is entirely dependent on the surface and the lines!

Adjust the sensitivity of the line tracker, if necessary. By turning the screw to the right, you will increase the sensitivity.

Adjust sensor sensitivity with a phillips screwdriver

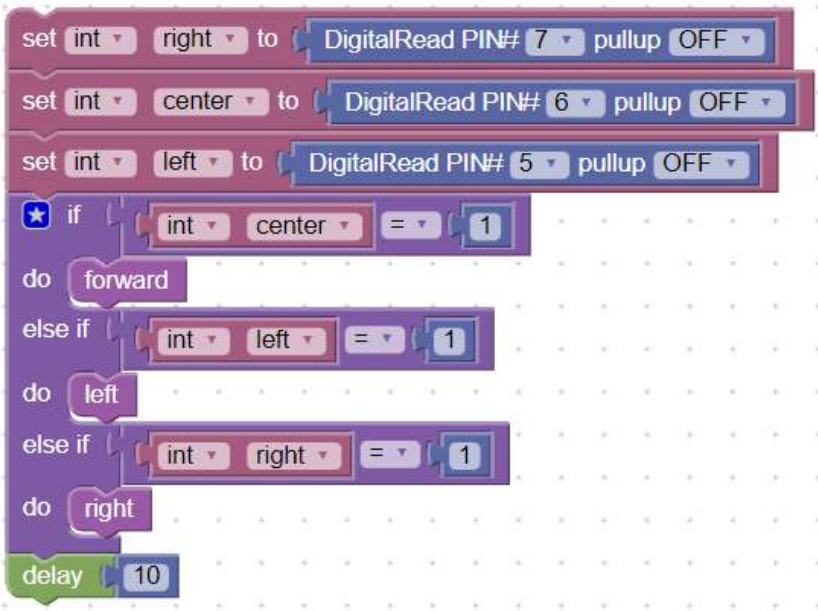
Let's Program: https://code.makewitharduino.com/#

Movement Functions Review, May Look Like This…



Click to copy the BlockyDuino Arduino code and "ctrl v" to paste in Arduino IDE.

The goal is to move forward when the centre sensor detects a line, turn left when the left sensor detects the line, and turn right when the right sensor detects the line. Start with this program, and attempt to navigate the mine pathway!



Reflection Time!
Are you able to navigate the pathway with this code?

Fix the problems…
Problem #1
Will it turn 90 degrees?

Problem #2
What happens at the end of the line? How can we make the car stop at the "T"?

Problem #3
What happens when it loses the line?

Fixed the problems early and documented everything in your design journal? Ask your teacher for extension activities.

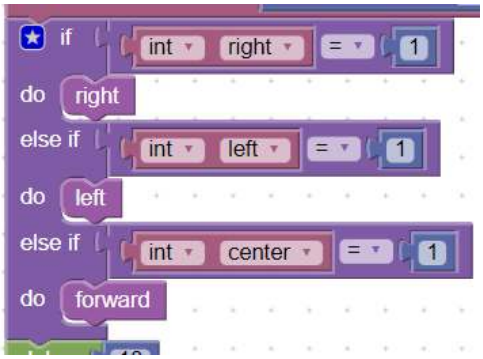
Mine Navigation Lines Answer Key

Purpose:

The goal of this activity is to navigate a mine pathway using a tracker sensor on a robotic car and coding using functions. The tracker sensor "looks" down and is able to differentiate between dark and light colours. This allows the robot car to follow lines, or stop if it detects a change in colours.

The basic program for following a line is given in the student info. Learners are faced with three problems.

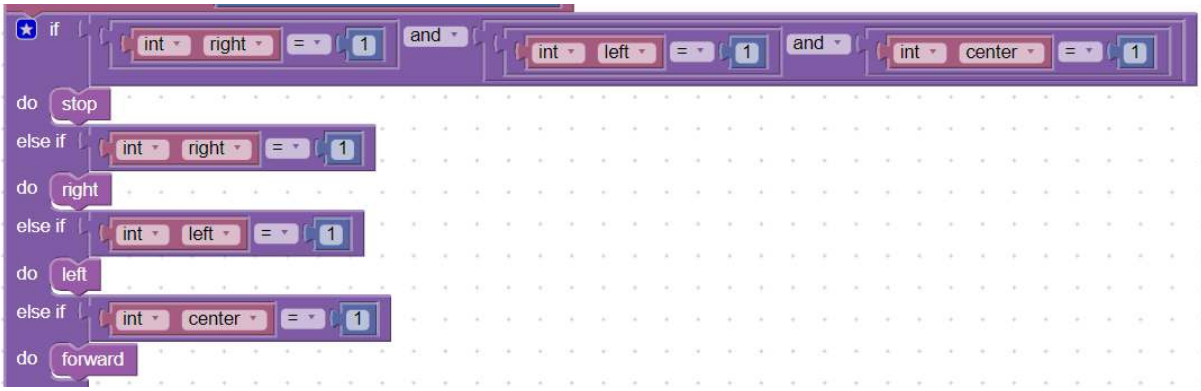
Problem 1: When the robot car tracks the line to a 90-degree angle it seems to keep going straight. Watch the LEDs on top of the sensor. It is detecting the line on the side sensor and the centre line. **The order of the program is important**! The "if" statement is arranged so that it is checking the centre sensor first, which will tell the car to move forward if it sees anything. It does not check the others!



If the first comparison is true, it will do that action. If the first is false, then it moves to the second. If the second is true, it does that action. If both the first and second are false, it moves to the third.

To fix the problem, alter the order of comparisons. Put the center comparison at the end.

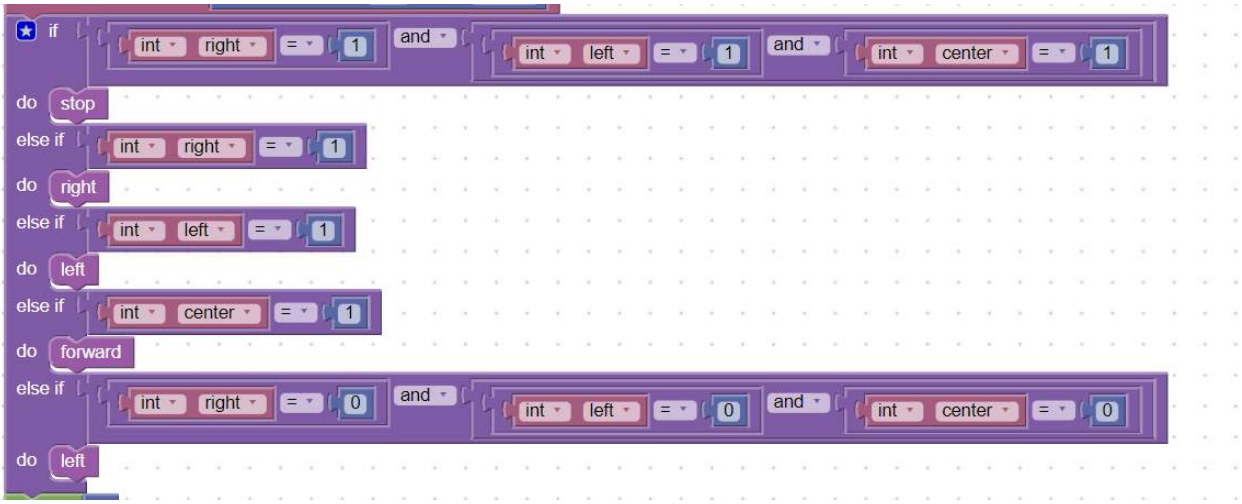
Problem 2: The robot car does not stop at the end "T".
The robot car is not programmed to stop at the "T" when it detects a line under all three. Use the logic operator "AND" in a comparison to check to see if all the sensors read the line at the same time. Keep in mind the order of the comparisons in the "if" statement (as discussed above), and put this comparison set first!



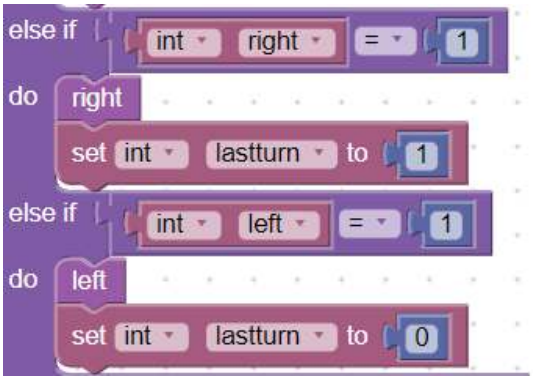
Problem 3: What if we lose the line? There are many options for solving this. Some might have the robot car stop with the reasoning that it would be unsafe for the robot to navigate on its own in a mine. In this case a human operator would place (“drive”) the car back on the path. Others might try to find the line.

Learners can add in another comparison at the very end of the “if” statement, causing the robot car stop if it detects no line (all values are 0).

Or they might have the robot car turn around.

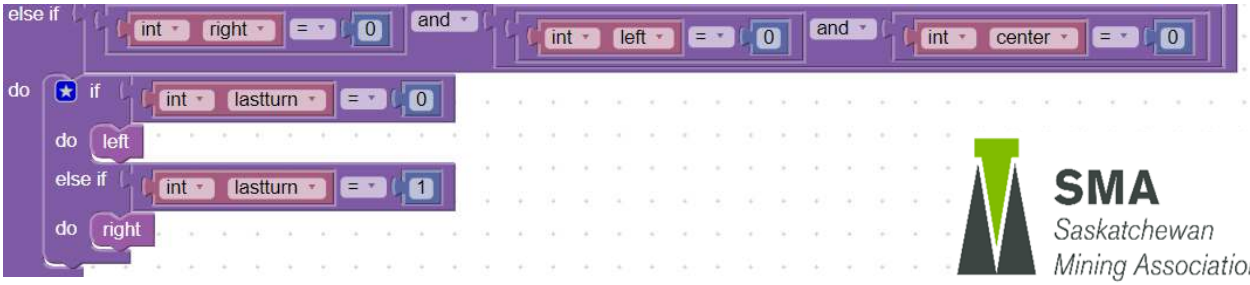


Having the robot car turn when not detecting any lines, will likely cause the robot car to continuously turn in circles. To fix the continuous turning issue, program the robot to only turn a certain way depending on the last sensor it detected. Define the variables.



For this example, a right sensor reading will turn the car right and set the lastturn value to 1, while a left sensor reading will turn the car left and set the lastturn value to 0.

Then, go into the “0-0-0” section of the “if” statement and decide which way to have the car turn based on the lastturn.



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Saskatchewan Mining Association: GeoRobotics

Mine Navigation Activity 4: Haul Truck

Grade Level	**Target Grade 7-12**	**Difficulty**	Intermediate
Subject	Practical and Applied Arts, Science, & Mathematics		
Description	The purpose of the "GeoRobotics" project is to help learners explore real applications of robotics and innovation in the mining industry with respect to making the workplace safer, environmental protection, and career opportunities. This activity will have learners using their previously developed functions and tracker sensor from "Activity 3: Lines" for transporting and unloading materials by turning their robotic Arduino car into a haul truck.		
Outcome(s)	**PAA** - **Electronics Modules:** ELEC01A, ELEC7A, ELEC8; **Robotics Modules**: ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A ROBA35A, ROBA48, ROBA49; **Energy and Mines**: ENMI1, ENMI8, ENMI24A, ENMI25, ENMI 31, ENMI44 **Science:** CE9.1, CE9.2, CE9.3, CE9.4, WS8.1, WS8.3, IE7.4, EC7.2 **Math:** P7.3, SS7.1, SS7.3, SS7.4, P8.1, N8.3, SS9.1, SS9.2 **ELA:** AR9.1, AR9.2, AR8.1, AR8.2 **Social Studies**: DR9.3, RW9.1, RW8.1, RW8.3, IN7.1, IN7.3, DR7.2, RW7.3		
SaskCode Required Prior Learning	GeoRobotics – Arduino Basics 101 GeoRobotics – Mine Navigation Activity 1: Timing GeoRobotics – Mine Navigation Activity 3: Lines		
Time Frame	Several hours		
Materials	**SaskCode Robotic Car Kit** (frame/wheels, Arduino Uno with motor driver, **tracker sensor**, 5 male/female jumper wires, **servo motor** and nine-volt batteries). • Small Phillips screwdriver for adjusting sensitivity of sensor A computer for each group, student handouts/journals, cardboard or electrical tape, sticky tack, construction materials and **mining material** to deliver (marbles, paper balls, wood blocks, etc.).		

Additional Resources	https://www.saskcode.ca/ - SaskCode website http://saskmining.ca/ - Saskatchewan Mining Association website
Assessment	Circulate the room observing and assisting. Encourage learners to record their learning in their "Design Journal." Setup clear expectations surrounding their "Design Journals." You may want to create a rubric, checklist or specific questions that learners should be answering within the journals. Also, at the end of each class have learners share their learning, errors and successes while reinforcing the importance of persistence and patience in programming.
Thank you to our SMA Education Outreach Superhero Sponsors!	BHP, Mosaic, Graham, NexGen Energy Ltd., K+S youth+us, Nutrien

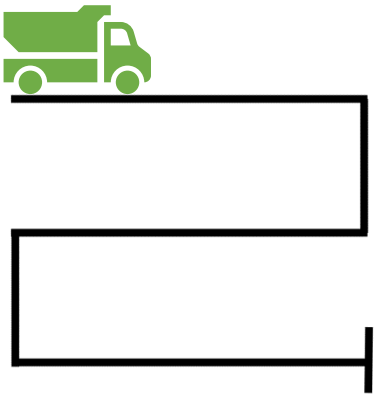
Mine Navigation Activity 4: Haul Truck

Getting Started

1. Complete the **Basic Training** in order to learn how to use Arduinos and necessary components

Activity - Name, notes	**Time**
GeoRobotics – Arduino Basics 101 ○ Introduces Arduino programs, components, and robotic cars.	1 hour
Mine Navigation Activity 1: Timing ○ Introduces concept of creating functions to represent a series of commands. Challenge learners to navigate through a mine pathway using functions and time delays.	1 hour
Mine Navigation Activity 3: Lines ○ Challenge learners to navigate a mine pathway using a tracker sensor on a robotic car and problem solve by changing their code.	2 hours

Mine Navigation: Haul Truck

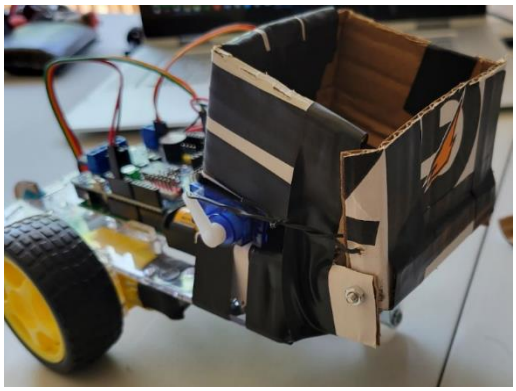


Goal: Turn your robotic car into a haul truck and navigate a mining pathway using a tracking sensor to deliver a payload to a specified delivery area. The mine pathway and delivery area will be made of electrical tape lines. Use your design journals to document your ideas, challenges, questions, sketches, and learning. Read below for some hints on getting started.

Sample Path: If not already created by your teacher, use electrical tape to design a mine pathway for your robotic car to follow. The delivery area or box should be placed around the "T" intersection.

Let's Build:

1. Use the tracker sensor and instructions from "Activity 3: Lines." Attach the tracker sensor to the Arduino robotic car and debug the sensor.
2. Design a "**bucket**" on the back of the robotic car out of cardboard or using a 3D printer. The bucket needs to have a door that closes to hold the material for transport and opens to unload the material at the delivery area. The door can be connected to a **servo motor**.



Example for a Bucket Design

This is constructed of cardboard, tape, 2 nuts and bolts, and 1 twist tie. The bottom is slanted toward the door. The door is connected to the servo motor using a twist tie.

New Components:

Servo Motor: rotate to a specific angle and stay there. Common servos rotate over a range of about 0° to 180°. Attach the servo wires to the motor shield using the table below. Included with your servo motor you will find a variety of motor mounts that connect to the shaft of your servo.

Servo Motor	Motor Shield
Brown	G (Ground)
Red is Positive	+ 5
Orange is data	9

Note: To avoid damaging the motor a range of 20-170 works best.

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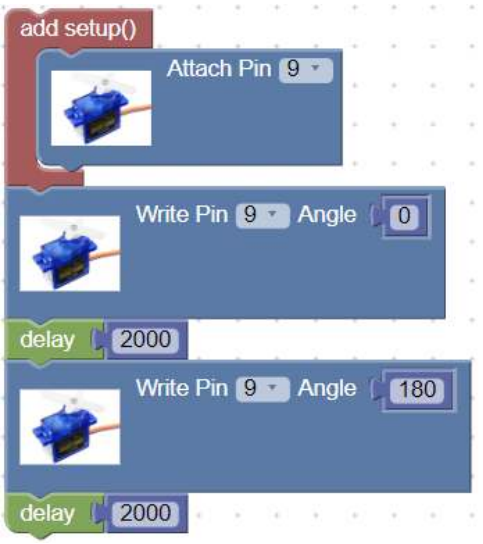
Servo Debugging: Determine the “0 degree” point, the “180 degree” point and the direction of rotation.

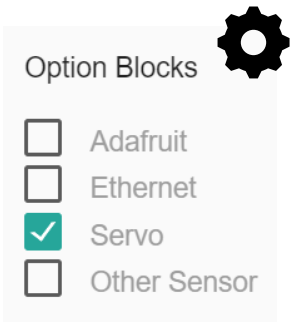


Load this onto the Arduino car, and observe how the servo rotates. Make note of a few things:

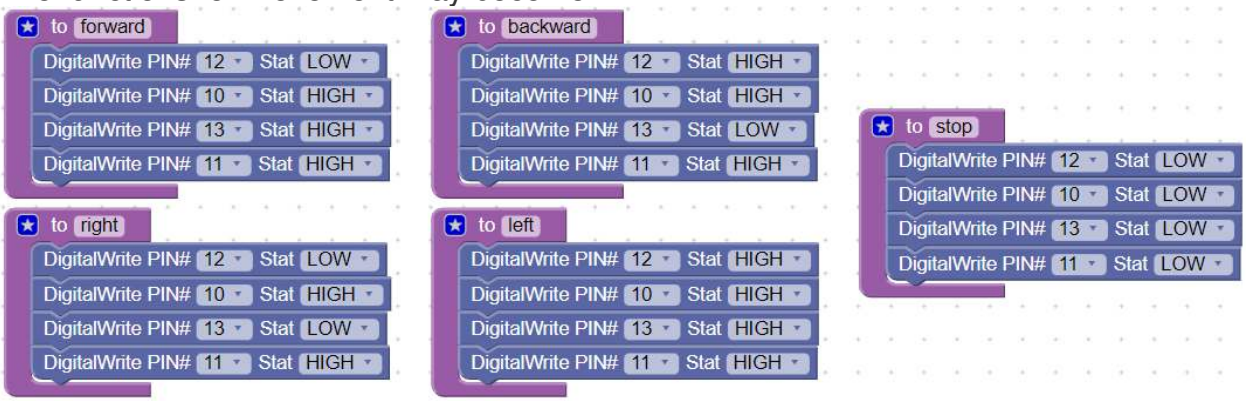
1. Where is the “0 degree” point?
2. Where is the “180 degree” point?
3. What is the direction of rotation?
4. Which end (the 0 degrees or the 180 degrees) will have the door held closed?

Connect your servo motor to the door of the bucket you designed, keeping in mind the degree points. Keep tweaking the code until the angles work nicely to open and close the door of the haul truck. Record your open-door angle and closed-door angle in your design journal.

Let’s Program: Click the gear in the top right corner of Blocky Duino and make sure the servo sensor is checked. Press “OK.” The servo will affect the ability of the Arduino to use the “analogWrite” function on pin 9 and pin 10. These pins control the speed of the robotic car motors. Switch all the movement functions to “digitalWrite” setting to “LOW” and to “HIGH.” For speed, LOW will cause the robotic car to not move and HIGH will have the motors go a max speed.



The functions for movement may become:



Use the main code from “Activity 3: Lines” as a starting point. Adjust the code to add some servo blocks to close the door before navigating and open the door when at the “T” intersection. At the “T” intersection, the robot car should stop, turn around, unload the material that is in its bucket for a specific amount of time and then close the door. The easiest way is to create a function for the “T” intersection.

Example for a “dropoff” Function

In this function, we first should stop the car for a brief moment.

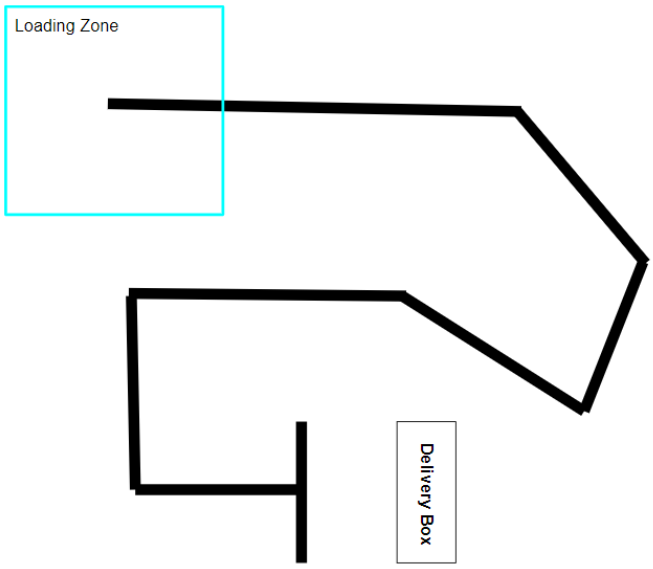
We will then turn the car until we are lined up (in this example that is a right turn for 750 milliseconds). This will need to be tweaked as needed!

We then stop the motors, and open the door by setting the servo to the “open door” angle. We leave the door open for 2 seconds, and then close the door by setting the servo to the “closed door” angle. We then allow a delay for the door to close, and get back to the main program!

How can you get your car to travel the full pathway? Are you able to successfully deliver the mine payload? Keep trying and tweaking until you are able to!

Extension Activities

- Deliver 3 loads of mining payload to the delivery area. For this, manually load the payload at one end of the mine pathway, and deliver it into the delivery zone!
- Once you have mastered the “Mine Pathway”, try to develop your own and challenge your classmates to navigate yours! Try using different turn angles!
- Team Maga Mining Challenge!



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Saskatchewan Mining Association: GeoRobotics

Team Mega Mining Challenge!

Grade Level	**Target Grade 7-12**	**Difficulty**	Intermediate
Subject	Practical and Applied Arts, Science, & Mathematics		
Description	The purpose of the "GeoRobotics" project is to help learners explore real applications of robotics and innovation in the mining industry with respect to making the workplace safer, environmental protection, and career opportunities. Using the Marble Sorter Challenge, the Marble Hopper Challenge and the Mine Navigation Activities, learners will work together as a team of 6 to sort, load and transport materials around a mining site to the desired location! This is a great way to combine different activities and challenges into a larger team mega challenge.		
Outcome(s)	**PAA** - **Electronics Modules:** ELEC01A, ELEC7A, ELEC8; **Robotics Modules**: ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A ROBA35A, ROBA37A, ROBA48, ROBA49; **Energy and Mines**: ENMI1, ENMI8, ENMI24A, ENMI25, ENMI 31, ENMI44 **Science:** CE9.1, CE9.2, CE9.3, CE9.4, WS8.1, WS8.3, IE7.4, EC7.2 **Math:** P7.3, SS7.1, SS7.3, SS7.4, P8.1, N8.3, SS9.1, SS9.2 **ELA:** AR9.1, AR9.2, AR8.1, AR8.2, CC9.4, CC8.6, CC7.6 **Social Studies**: DR9.3, RW9.1, RW8.1, RW8.3, IN7.1, IN7.3, DR7.2, RW7.3		
SaskCode Required Prior Learning	GeoRobotics – Marble Sorter Challenge GeoRobotics – Marble Hopper Challenge GeoRobotics – Mine Navigation Activities 1 – 4		
Time Frame	Individually from Scratch: 15 – 20 hours Working in Teams: approx. 5 hours		
Materials	**SaskCode Robotic Car Kit** **SaskCode Arduino Class Kit** A computer for each group, student handouts/journals, cardboard or electrical tape, sticky tack, construction materials and mining material to deliver (marbles, paper balls, wood blocks, etc.).		

Additional Resources	https://www.saskcode.ca/ - SaskCode website http://saskmining.ca/ - Saskatchewan Mining Association website
Assessment	Circulate the room observing and assisting. Encourage learners to record their learning in their "Design Journal." Setup clear expectations surrounding their "Design Journals." You may want to create a rubric, checklist or specific questions that learners should be answering within the journals. Also, at the end of each class have learners share their learning, errors and successes while reinforcing the importance of persistence and patience in programming.
Thank you to our SMA Education Outreach Superhero Sponsors!	BHP, Mosaic, Graham, NexGen Energy Ltd., K+S youth+us, Nutrien

Team Mega Mining Challenge!

Getting Started

1. Before beginning the mega challenge, prepare the **mining material** so it is easy to distinguish between the target resource to be mined ("ore") from the unwanted materials ("waste"), for example by using different coloured marbles.

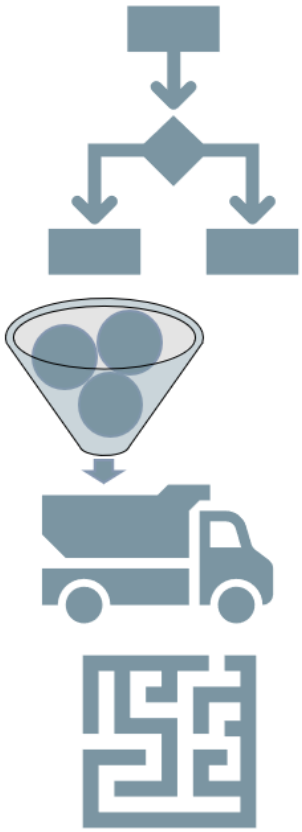
2. Prepare the loading area, mine pathway, and delivery area using electrical tape. Depending on space and preference, you can prepare a **mining area** for each team with just the loading & delivery. Then, let learners design the mine maze pathway themselves with a set of rules to follow.

3. Divide learners into **teams** of six. Within the team, learners will be paired together to work on either the Marble Sorter Challenge, the Marble Hopper Challenge or the Mine Navigation Activities. This will allow each team to have one pair doing each activity and fulfilling each role.

Team Mega Mining Challenge!

Mission:

This mission requires 3 components, all working together to be successful. You will sort mining payload (marbles) using a "Mine Sorter," which will separate the marbles into the target ore and the waste material. The ore will then go into a "Mine Hopper." Once the haul truck (robotic car) arrives, it will align with the Hopper to automatically deposit the target ore into the haul truck's bucket.



When the haul truck has the payload, it will travel along the mine pathway and deliver the payload into the desired area.

The Rules

- In your team of 6, divide into 3 pairs. One pair should work on each of the 3 components.
- Three components will be needed:
  - Marble Sorter
  - Marble Hopper
  - Mine Navigation
- Students should work together and encourage each other!

Consider

- How will you organize all the components?
- How will you link them together?
- How can you ensure all things function together?
- Are any modifications needed?

Team Components	**Team Name:**	
Marble Sorter Challenge	**Marble Hopper Challenge**	**Mine Navigation Activities**

Voice for Thought – **Autonomous Mining Technology**

What do you picture when you think of mining? A common mining stereotype is someone working with a shovel or pickaxe. However, visit a mine today and you will likely see people working with laptops and even operating equipment autonomously or with remote controls rather than doing physical labor.

Mining in the digital age reduces greenhouse gas emissions by optimizing efficiency, improves worker safety and requires workers with high-tech skills. During this "technology transition" current workers are either being shifted into another role or retrained. For example, an equipment operator who drives a haul truck is being trained to operate the haul truck remotely in a comfortable safe control room. No longer does the worker have to be in a dusty, loud and hot environment. Also, using technology in the mining industry makes it more inclusive to a diverse workforce including women, older workers and variously abled workers.

Railcar Loading at K+S Potash Canada

Instead of having a driver to operate the railcar, the "indexer" moves the railcars. The "indexer" is a big arm that hooks up to the knuckle of the railcars and pulls them through as the railcar are being filled with product. It has its own track that it travels on. Once, it is at the end of the track the arm lifts up and it moves to the opposite end and reconnects to the knuckle of the railcar continuing to pull them through.

Fact – BHP's Jansen project in Saskatchewan has the potential to be one of the largest potash mines in the world, providing nutrient-rich soils.

Haulage Technology at BHP

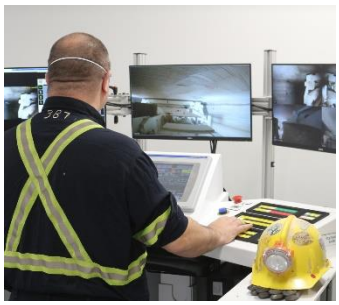
Autonomous Mining Trucks are "self-driving" mining vehicles that can sense the surroundings and navigate a mine pathway using lasers, radar, cameras, and sensing technology.

Unexpected obstacles are sensed immediately and the autonomous vehicle stops waiting for direction from an operator or even a driver will climb back into the seat.

BHP uses a colour coded system to identify different vehicles. Heavy vehicles have green flashing lights, light vehicles have orange lights and autonomous vehicles have blue flashing lights.

By September 2023, an entire fleet of over 40 haul trucks in Australia's BHP mine will be autonomous, along with about 180 other types of vehicles used at South Flank.

Tele-Remote Mining at Nutrien



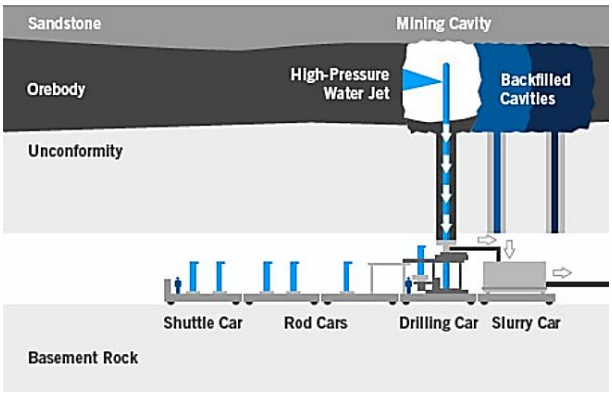
Lanigan's underground potash mine used tele-remote technology and AI to mine an entire wing of potash without any people in the area. Operators control the mining equipment from a remote location, instead of in the active mining area. This increases operator safety by eliminating the risk of getting hit by rockfall or tripping over rocks/cords. Also, it reduces noise exposure and increases air quality for the worker.

The efficiency of the mine increased because the equipment can operate during breaks and shift changes. AI can operate the equipment for short times in-between breaks and shift changes.

Also, Nutrien's Cory potash mine used tele-remote mining to cut into rock that would be unsafe for workers to enter without stopping every 8 meters to bolt and cage the walls. Instead, the workers operated the equipment from the surface without having to enter into the hazardous area. This increased production and most importantly increased the safety of the workers.

Cameco's Cigar Lake Mine

A remotely operated jet boring machine is used to mine uranium at Cigar Lake. The machine cuts through the uranium, that is sandwiched between sandstone and bedrock, with powerful water jets. The mixture or slurry is brought to the surface to be processed.



Jet Boring Amination

With the support of Sask Polytech, Cameco is investigating incorporating big data, AI and machine learning into their jet boring system to mine with more accuracy. This would reduce the amount of waste material being brought to the surface and reduce environment impact.

The challenge with AI in mining is that you do not have a repetitive task or predictable situation. Cameco is sending mining data to Sask Polytech to use to create a graph database. The graph database uses AI to analyze the data and predict the amounts of uranium present.

Did You Know?

Jet Boring involves freezing the surrounding rock for over a year using pipes that circulate minus 40-degree Celsius brine. Only once the ground becomes stable enough, are tunnels created and the equipment is positioned to begin mining the uranium.

CAREER PROFILE

Mechanical Engineer

Name: Rob Martell
Employer: BHP
Education: BSc. Mechanical Engineering

DETAILS OF THE JOB

Mechanical engineering is about designing equipment that will make a process work the way we want it to. You have to find a balance between relying on what you know works, and at the same time looking into innovative solutions to solve problems in a new way.

Rob is ensuring that the engineering done for the Jansen surface mill results in the safest, highest producing, most efficient and technologically advanced mill possible. New and innovative technologies being introduced at Jansen include drones, robotics, remote automation and virtual reality.

In a given day, Rob will review data and documents; meet with stakeholders; and review engineering design and data in 3D. He also travels to engineering offices within Canada and internationally to meet with equipment suppliers and inspect equipment.

HELPFUL HIGH SCHOOL COURSES

Chemistry 30 Calculus 30 Physics 30

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TEAM ROLE

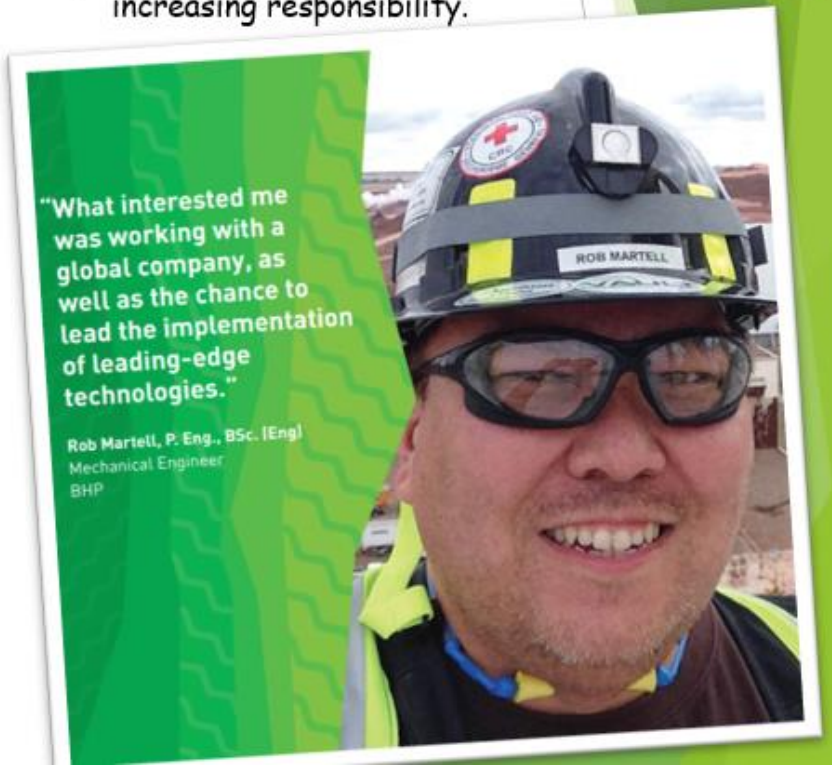
- ❑ **Voice for Thought**
- ❑ **Design & Build Model**
- ❑ Problem Solve

EDUCATION

Rob received a Bachelor of Science in Mechanical Engineering from the University of Saskatchewan. He started as a junior design engineer, then spent time as a maintenance engineer before moving on to project engineering roles with increasing responsibility.

SKILLS NEEDED:

Problem Solve
Technical
Collaborate
Communicate



CAREER PROFILE

DCS Technician

Name: Dean Eby
Employer: K+S Potash Canada
Education:
Instrumentation Engineer Tech. Diploma
Inst. and Controls Tech. Red Seal Cert.

DETAILS OF THE JOB

A DCS technician is responsible for all elements of the control system. The control system is an interconnected web of things that occur in between an operator clicking a button on a computer screen and something happening in the plant hundreds of meters away. This includes computers, networking, programming, and software amongst other things. Control systems tell the machines what to do in the plant. Whether that be filling up a tank, increasing the flow through a pipe, or shutting down a system before an unsafe condition can occur.

Sometimes new programming gets added as the plant grows, sometimes old programming gets tweaked to increase efficiency, sometimes a piece of hardware needs replaced or repairing, sometimes new fiber optic lines need to be installed, or sometimes you just need to reset a password. A day in the life of a DCS technician is always filled with something exciting.

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TEAM ROLE

- ❑ **Write Block Code**
- ❑ **Test Sensors**
- ❑ Download, Transfer and Save Code

SKILLS NEEDED:

Troubleshoot
Computer Science
Patience
Attention to Detail

EDUCATION

My education started at Saskatchewan Polytechnic in Moose Jaw. The Inst. Engineer Tech. Diploma I left with, combined with my work experience from my three coop work terms helped prepare for my career ahead. After a few years work I was able to get my Red Seal. Much of the further learning is on the job and specific to the type of control system I work with.

"The control system is where the magic happens! Being able to see behind the scenes of everything that goes on and everything that is required for the whole operation to work is exciting. Being able to help ensure that everything continues to run smoothly is even better.."

EDUCATION

Instrument school is offered through Trade Schools in Moose Jaw at Sask Polytechnic as well as in Calgary at SAIT & in Edmonton at NAIT. There are two paths into Industrial Instrumentation. **1.** Straight out of high school into a trades school in the Instrumentation Technologist programs. **2.** Apprenticeships out in industry, which combine practical on the job training supplemented with trades school training in the Instrumentation Mechanic programs.

HELPFUL HIGH SCHOOL COURSES

Practical and Applied Arts
Pre-Calculus 30
Physics 30
ELA 30

TEAM ROLE

Safety & Building of the components

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CAREER PROFILE

INSTRUMENTATION TECHNOLOGIST

Name: Derek Worme
Home Community: Young, SK
Employer: Nutrien Ltd.

SKILLS NEEDED:
Communication
Safety First
Observant
Good at Building & Repairing

DETAILS OF THE JOB

I begin my day with a safety discussion with my crew called a toolbox meeting where we discuss safety, work for the day & share any relevant information. Prior to starting each repair, I perform a Job Hazard Assessment (JHA) to identify any potential hazards that may pose a risk to my or other worker's health & safety. Throughout my day, I frequently take a structured pause to check for hazards, get re-focused & stop work when unsure. With the huge variety of instruments contained in a potash refinery, the maintenance I perform every day is not the same day in day out. I come to work daily looking forward to what challenge lies ahead with the plan of going home safe, every day.

" If you are good at computers & working with wrenches, this trade is for you."

EDUCATION

" I took the Geological Technician course at Northlands College as soon as I graduated high school. As few months after I finished the course, I started as a Radiation Technician." Taryn has not stopped learning and trying new things. She is quick to mention, "I've been a radiation technician, a mine technician, environmental technician and now I'm a Jet Bore System (JBS) operator. I like learning something new every day."

A variety of backgrounds, such as machinists, carpenters, mechanics, and drillers may complete JBS training onsite. The position comes in five levels, according to a combination of education, training and experience.

"There are always new challenges, new ground conditions, various issues to solve with the drill. I retain all the info so I can use it in the future when similar issues arise."

TEAM ROLE

- ❑ **Operate Robotic Car**
- ❑ **Navigate Pathways**
- ❑ Problem Solve

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CAREER PROFILE
Jet Bore Operator

Name: Taryn Roske
Employer: Cameco
Home Community: La Ronge

DETAILS OF THE JOB

"We set up the drill under the planned cavity location. Once the rig is in place, we drill up a pilot hole and ream it out to enlarge the cavity. When the reaming is complete, we install casing up the hole and grout it into place to prevent the hole from caving in. Finally once the grout has set, we run the jet rods up into the cavity and begin jetting the ground to extract the uranium ore by turning it into a slurry. Once we've completed a cavity, the surveyors come to make sure all is in order, and then we can backfill it with concrete and move on to the next one."

"I am proud of being the first female JBS Operator. I not only represent women, but also Indigenous women in non-traditional roles."

SKILLS NEEDED:
Precision
Operating Machine
Lifelong Learning
Problem Solving