Marble Hopper Challenge

Grade Level	**Target Grade 7-12**	**Difficulty**	Intermediate
Subject	Practical and Applied Arts, Science, Math, ELA & Social		
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. In this challenge learners will design and construct a "hopper" to hold marbles, which will have a mechanism to automatically drop marbles when something is detected at the desired distance. This challenge involves designing and constructing the machine, as well as developing and programming the circuit.		
Outcome(s)	**PAA** - **Electronics Modules:** ELEC01A, ELEC7A, ELEC8; **Robotics Modules**: ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A, ROBA37A, 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	Downloading Programs for Arduino Projects Activity – Servo Motors (Use "coding and angles" for the Servo, not Potentiometer) Activity - Distance Sensor (ultrasonic sensor)		
Time Frame	4-10 hours, depending on experience (Prior Learning, Design & Construction and Wiring & Programming)		
Materials	**SaskCode Arduino Classroom Kit of 15**: specifically - 1 Servos, 1 Arduino Uno, 1 Breadboard,1 Ultrasonic Sensor, Jumper wires, 9 V battery connector and battery OR 4-6x AA batteries (and battery pack) A **computer** for each group, student **handouts/journals**, **marbles** and **construction materials** (cardboard, glue gun, tape, etc.). Can create construction materials using a 3D printer, if available.		
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

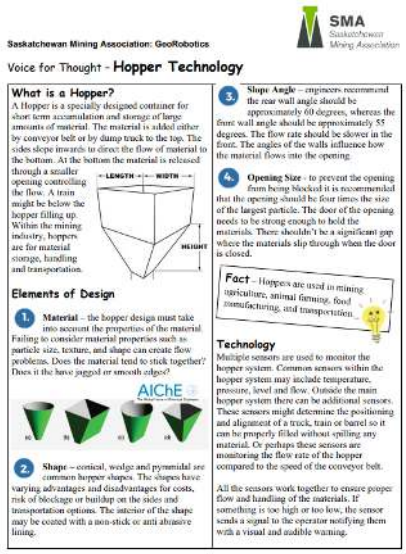
Marble Hopper Challenge

Getting Started

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

Activity - Name, notes	**Time**
Downloading Programs for Arduino ○ Review for information on downloading code, safety, breadboards, etc.	30 minutes
Activity – Servo Motors ○ Do not need a potentiometer. Use 'coding and angles'	1 hour
Activity - Distance Sensor (ultrasonic sensor)	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.


Saskatchewan Mining Association: GeoRobotics

Voice for Thought - **Hopper Technology**

What is a Hopper?

A Hopper is a specially designed container for short term accumulation and storage of large amounts of material. The material is added either by conveyor belt or by dump truck to the top. The sides slope inwards to direct the flow of material to the bottom. At the bottom the material is released through a smaller opening controlling the flow. A train might be below the hopper filling up. Within the mining industry, hoppers are for material storage, handling and transportation.

Elements of Design

1. **Material** – the hopper design must take into account the properties of the material. Failing to consider material properties such as particle size, texture, and shape can create flow problems. Does the material tend to stick together? Does it the have jagged or smooth edges?

2. **Shape** – conical, wedge and pyramidal are common hopper shapes. The shapes have varying advantages and disadvantages for costs, risk of blockage or buildup on the sides and transportation options. The interior of the shape may be coated with a non-stick or anti abrasive lining.

3. **Slope Angle** – engineers recommend the rear wall angle should be approximately 60 degrees, whereas the front wall angle should be approximately 55 degrees. The flow rate should be slower in the front. The angles of the walls influence how the material flows into the opening.

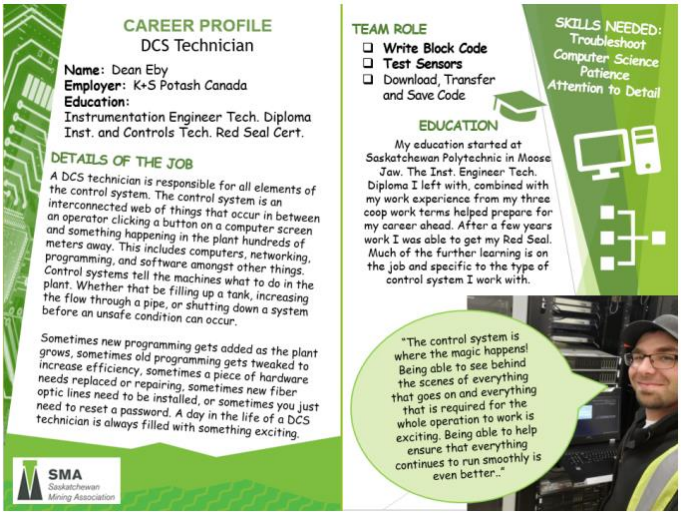
4. **Opening Size** - to prevent the opening from being blocked it is recommended that the opening should be four times the size of the largest particle. The door of the opening needs to be strong enough to hold the materials. There shouldn't be a significant gap where the materials slip through when the door is closed.

Fact – Hoppers are used in mining, agriculture, animal farming, food manufacturing, and transportation.

Technology

Multiple sensors are used to monitor the hopper system. Common sensors within the hopper system may include temperature, pressure, level and flow. Outside the main hopper system there can be additional sensors. These sensors might determine the positioning and alignment of a truck, train or barrel so it can be properly filled without spilling any material. Or perhaps these sensors are monitoring the flow rate of the hopper compared to the speed of the conveyor belt.

All the sensors work together to ensure proper flow and handling of the materials. If something is too high or too low, the sensor sends a signal to the operator notifying them with a visual and audible warning.


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.

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.."

3. **Explore**: Introduce the design challenge to groups. Groups will design, construct and code a hopper to hold and then to drop marbles when something is detected at the desired distance.

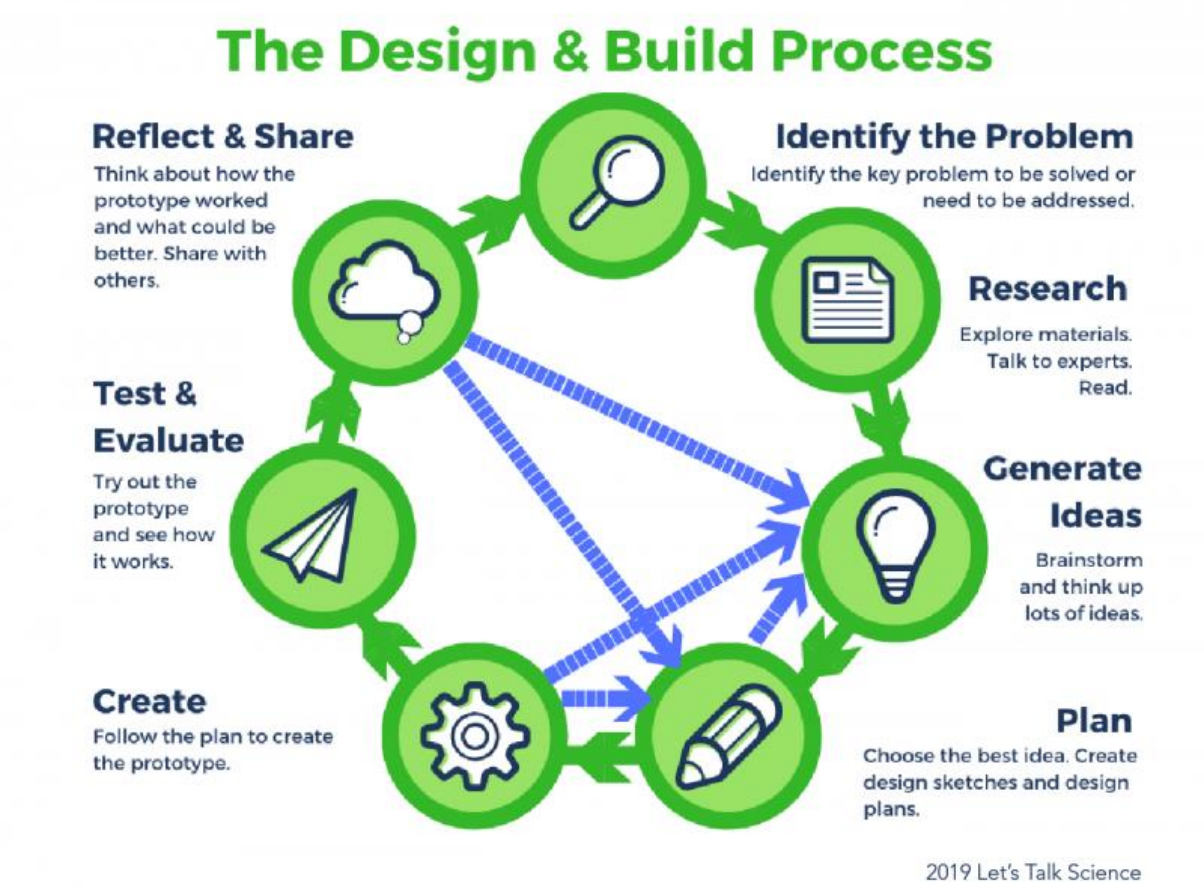
4. Possible Extensions: use a 3D printer or try the Class Team Mega Mining Challenge.

SMA Saskatchewan Mining Association

Teacher Considerations

Paired Programming: Divide learners into groups of 2 - 4 (**Paired Programming**) 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!



The stages of the Design & Build Process (©2019 Let's Talk Science).
https://letstalkscience.ca/educational-resources/backgrounders/design-build-process

1. Identifying what we need to do.
2. Research how we can do this.
3. Develop a list of ideas.
4. Create a plan.
5. Create the part/section.
6. Test the part/section.
7. Reflect on the effectiveness of the part/section.

SMA Saskatchewan Mining Association

Marble Hopper Challenge - Student Information

Design Challenge:

The goal of this challenge is to design, construct, and program a device to hold marbles and then drop marbles when something is detected at the desired distance. You will be designing the overall structure, various components within the structure, the electronic structure, and the program to achieve this task! Use your design journals to document your ideas, challenges, questions, sketches, and learning. This activity will make use of servos, ultrasonic sensors, and physical construction components. Read below for some hints on getting started.

Part 1: Draw & Build a Design
Identify Phase - What is the problem?
We want to drop marbles out of a hopper using a servo door and into a container, but only when the container is positioned properly. What do we need to build?

1. A starting “hopper” to hold all the marbles.
2. A door that can be opened to release all the marbles.
3. A pathway to ensure the marbles are directed into the container properly.
4. A sensor to detect the container location

It is now time for you to do some work and research, develop ideas, create a plan and construct your design! In your pairs, research and develop some ideas (take about 30 minutes to do this). Once you have done some research, select an idea and sketch it out.

When doing the research, keep the following things in mind:

- What components do you have in your kits?
- What supplies do you have to build with?
- What components will control each part and where will they be located?
- How will you connect the constructed parts to your electrical components?
- What will you use to power your system?

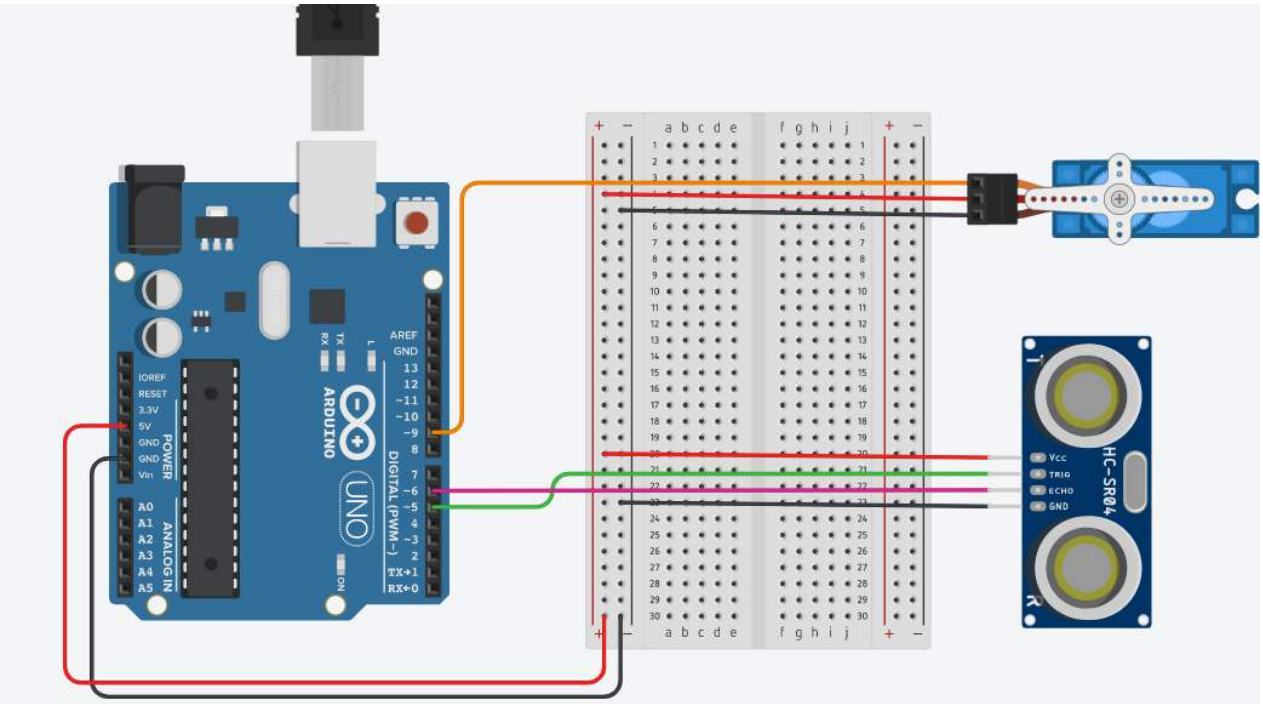
Once you have sketched out your design plan, meet with either your teacher or another group to discuss designs and to share any constructive feedback. If needed, modify your designs. Once this is complete, it is time to build & test your design!

Worth noting: When we are running a larger system like this, battery power is very important. This might require changing our batteries more frequently, or switching to a different battery system. One thing to look out for is erratic or “laggy” performance, especially with the servos. This usually indicates there is not enough current or voltage being produced!

SMA Saskatchewan Mining Association

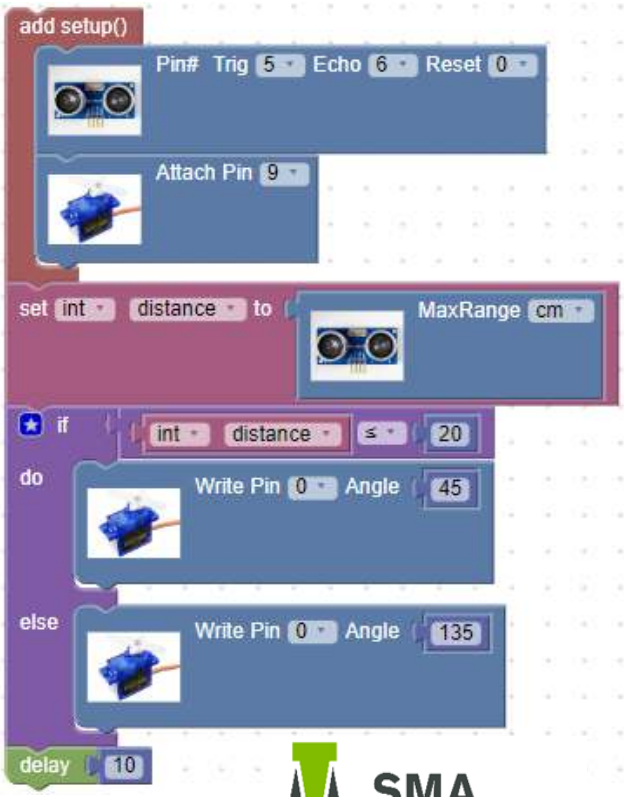
Part 2: Wire & Program

Once constructed, it is now time to program your design. Since this could be different for everyone, it is important to take some time to sketch out exactly what you want to happen. Create a flowchart for how you want your program and machine to function. For this activity, we should only be using servos and buttons. Use the example schematic below as a guide.



For this refresher, I will show what the program looks like to have the sensor control the servo. For this particular example, I will have the servo turn to 45 degrees when the sensor detects an object within 20 cm and 135 degrees when it does not. It looks like this →

Hint: include a time delay, to ensure the container is in the proper location and not randomly moving!



Part 3: Test

Try out your marble hopper!

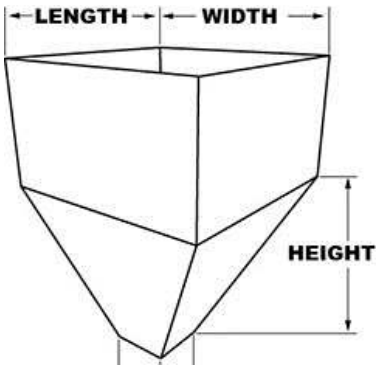
Does it release marbles properly into the container? Are improvements needed? If so, what can be improved?

SMA Saskatchewan Mining Association

Voice for Thought – Hopper Technology

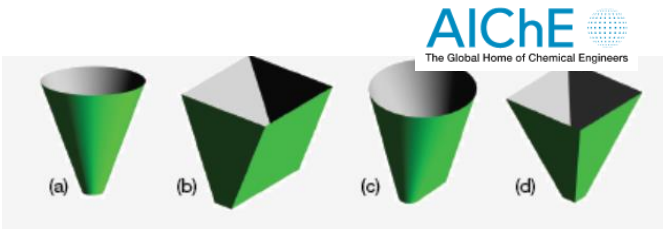
What is a Hopper?

A Hopper is a specially designed container for short term accumulation and storage of large amounts of material. The material is added either by conveyor belt or by dump truck to the top. The sides slope inwards to direct the flow of material to the bottom. At the bottom the material is released through a smaller opening controlling the flow. A train might be below the hopper filling up. Within the mining industry, hoppers are for material storage, handling and transportation.



Elements of Design

1. **Material** – the hopper design must take into account the properties of the material. Failing to consider material properties such as particle size, texture, and shape can create flow problems. Does the material tend to stick together? Does it the have jagged or smooth edges?



2. **Shape –** conical, wedge and pyramidal are common hopper shapes. The shapes have varying advantages and disadvantages for costs, risk of blockage or buildup on the sides and transportation options. The interior of the shape may be coated with a non-stick or anti abrasive lining.

3. **Slope Angle** – engineers recommend the rear wall angle should be approximately 60 degrees, whereas the front wall angle should be approximately 55 degrees. The flow rate should be slower in the front. The angles of the walls influence how the material flows into the opening.

4. **Opening Size** - to prevent the opening from being blocked it is recommended that the opening should be four times the size of the largest particle. The door of the opening needs to be strong enough to hold the materials. There shouldn't be a significant gap where the materials slip through when the door is closed.

Fact – Hoppers are used in mining agriculture, animal farming, food manufacturing, and transportation.

Technology

Multiple sensors are used to monitor the hopper system. Common sensors within the hopper system may include temperature, pressure, level and flow. Outside the main hopper system there can be additional sensors. These sensors might determine the positioning and alignment of a truck, train or barrel so it can be properly filled without spilling any material. Or perhaps these sensors are monitoring the flow rate of the hopper compared to the speed of the conveyor belt.

All the sensors work together to ensure proper flow and handling of the materials. If something is too high or too low, the sensor sends a signal to the operator notifying them with a visual and audible warning.

Saskatchewan Uranium Milling

Orano Canada's McClean Lake operation is one of the most technologically advanced uranium mills in the world because it processes uranium without any dilution. Once uranium rich rocks are mined, they need to be crushed and separated so only the uranium remains. Through a 15-step process involving a series of chemical treatments within different hopper systems, a final product called yellowcake is produced. The yellowcake is then packaged into barrels using a conveyor belt system combined with a hopper system. Note, not shown in the diagram is the conveyor belt feeding in the dried powdered yellowcake from above the bin.

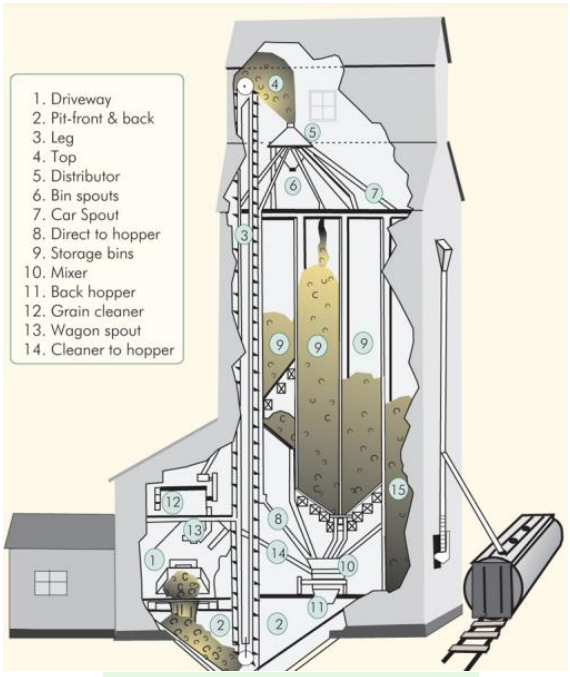
Saskatchewan Coal Train Loading

At Westmoreland Mining, Poplar River, large haul trucks transport many tonnes of coal from the strip mine to the railyard. The haul trucks have their own hopper like system with angled sides and a bottom hatch door. Once the haul truck is over a grate in the road, it opens the hatch to drop the coal in a matter of seconds. An underground conveyor belt combined with an above ground inclined conveyor belt carries the coal to the hopper system. The hopper system can hold enough coal to fill a 22-railcar train.

As the train slowly goes underneath the hopper, the individual boxcars fill up using sensors to judge the capacity and the positioning of each boxcar. The train loads and unloads 4 to 6 times in a day, transporting from the hopper to the power station. 38% of Saskatchewan's power comes from coal.

Did You Know?

Hopper systems are a prairie icon. Grain elevators were invented by farmers trying to move grain faster into rail boxcars. Farmers had to shovel grain into sacks, where they were emptied one by one into the waiting boxcar. Hoppers were the answer to the agriculture industry storing and shipping problem in the 1880's. The Encyclopedia of Saskatchewan accounts 6000 grain elevators in Saskatchewan by the 1930's.



Canadian Plains Research Center

Voice for Thought

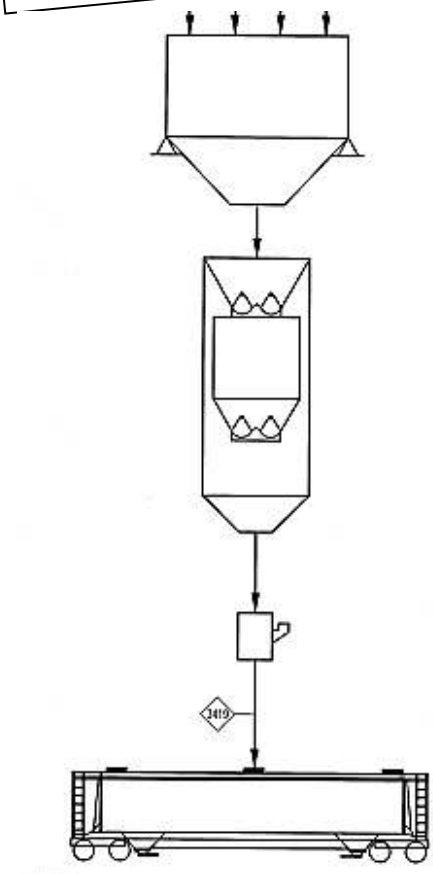
KSPC Questionnaire

How does KSPC use Hopper Loading to Move or Process Ore?

"Reclaim Belts transfer potash from our Product Warehouses up to the loadout building. Sizing and treatment equipment are utilized to ensure the product is meeting the specifications for the customer. From there it is transferred to a surge bin that will hold the product until the system is ready to load. Once railcars are in the proper position, the upper garners (gates) on the weigh system will open to weigh the specified amount of material that will be distributed within the railcar. Once set point is reached, the upper garners will close and the lower garners will open to transfer into the railcar. These steps are repeated until the target weight for the railcar is achieved."

Is this Process Automated?

"Our loadout production area is run under the loadout management system where majority of the process is automated. The process runs at controlled reclaim rates that efficiently size, treat, and weigh product into railcars. A variety of instruments are used throughout the process. For example, load cells accurately weigh the required amount of product to distribute the weight across the railcar. Bin radar level indication and high-level safety switches monitor level and ensure capacities are not exceeded. The railcar movement is automated with an indexer that hooks up to the knuckle of the railcars and slowly moves the unit across the loading spots."



Important Aspects in Hopper Processing?

"Hopper design and geometry is very important to allow to proper operation of a system and provide buffer capacity during process upset conditions. If designed incorrectly, such as materials of construction or geometry, product can hang up in the bin or unable to flow causing plugging.

KSPC is always continuously analyzing data and seeking improvements throughout the process. These opportunities to allow us to run safer, higher efficiency and improved system performance. In loadout, we continue to tweak and make improvements to the current set up to allow for improved efficiency at higher loading rates."

Careers

Process Engineer, Computer Engineers, DCS Specialist, Instrument Technicians, & Network Analysts

Voice for Thought

Cameco Flowchart

Bin House Hopper

From McArthur River to Key Lake

Radiation Scan

Cameco

"As part of the mining process at Cameco's McArthur River mine waste rock is created, and this material needs to be removed from the mine and shipped to Cameco's Key Lake mill for processing. The material from underground is transported to surface in a skip and dumped into the **bin house hopper**. This is referred to as "skipping" the material. The skip capacity is 5 metric tons. On average with the correct material the skip will make 80 trips in an 11-hour shift which equates to roughly 375metric tons of material.

The rock truck backs under the hopper and the material is dumped into the rock truck. The truck holds approximately 3.5 skips of material. The rock truck transports the material from the bin house to a waste pad. It is stored on this pad until we can transport it to Cameco's Key Lake mill for processing.

A truck will be loaded with material from the waste pad using a 972 CAT Loader with a 4.5 yd3 bucket. From there it will go under a **radiation scanner**. The scanners are on the steel beam above the truck box. This scan will tell us the amount of radiation there is in the material. Once scanned, the truck box is covered and the end gate is sealed. Now the driver is off to Key Lake."

Definitions

Skip: A manufactured container that transport rock from underground to surface.
Stockpiles: A pile or storage location for bulk materials.
Scanner: An instrument designed to measure levels of radiation.
Low Grade: Waste material from the mining process that still holds a value for processing.
Hopper: a bin that holds rock with a tapered bottom to allow discharge through the bottom.

EDUCATION

During the first 11 years of his career, Rob's work involved mechanical and civil drafting and design. Through the company's training and mentoring opportunities, Rob transitioned into a lead designer role. Saskatchewan Polytechnic offers programs in CAD.

HELPFUL HIGH SCHOOL COURSES

Computer Sci 20/30 Pre-Calculus 30 Physics 30
Drafting and Computer Design 10/20/30

SMA Saskatchewan Mining Association

freepik flaticon

CAREER PROFILE
CAD DESIGNER

Name: Rob McKellep
Employer: Orano Canada Inc.
Education: CAD/CAM Engineering Diploma

DETAILS OF THE JOB

As a Lead CAD Designer, Rob provides technical support and reviews drawings and documentation prepared by other designers. Robs spends most if his time in the engineering department in Saskatoon, but travels to northern Saskatchewan mine sites to review existing and new construction designs.

" My favourite part of the job is making 3D models of new designs and providing virtual walk-throughs before the design is even constructed."

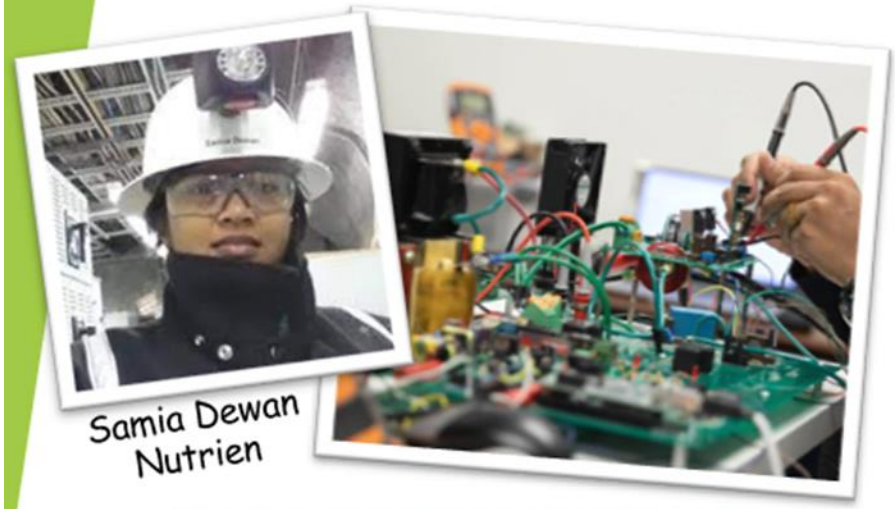
TEAM ROLE

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

SKILLS NEEDED:
Problem Solving
Attention to Details
CAD Software
Computer Science
Design

EDUCATION

After his graduation from high school, Chad knew he wanted to stay in Saskatchewan. "I knew I should look for a career in mining and natural resources. I was accepted into the Engineering program at the University of Saskatchewan and after my first year it was clear that Electrical Engineering was the best choice for me. I completed my Bachelor of Science degree in electrical engineering and entered directly into the potash mining industry, where I have enjoyed many challenges and exciting opportunities ever since," recounts Chad.



Samia Dewan
Nutrien

HELPFUL HIGH SCHOOL COURSES

Physical Sci 20 Physics 30 Calculus 30
Math 30 English Language Arts 30

SMA
Saskatchewan
Mining Association

CAREER PROFILE
ELECTRICAL ENGINEER

Name: Chad Binsfeld
Employer: K+S Potash Canada

DETAILS OF THE JOB

An Electrical Engineer is involved in every phase of design, construction, ordering and operation of electrical equipment. They are expected to review electrical designs, and the execution of those designs in the field. An Electrical Engineer participates on teams and assists with troubleshooting the equipment. This means interactions with other team members to gather feedback.

" It is always great to be involved in the complete lifecycle of equipment, as the designs go from paper to construction, to operation. This is the best part of my job."

TEAM ROLE

- ❑ Develop Design Plan
- ❑ **Write Block Code**
- ❑ Perform Tests
- ❑ Problem Solve

SKILLS NEEDED:

Communication
Attention to Details
Critical Thinking
Problem Solving
Math

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

SMA Saskatchewan Mining Association

CAREER PROFILE
INSTRUMENTATION TECHNOLOGIST

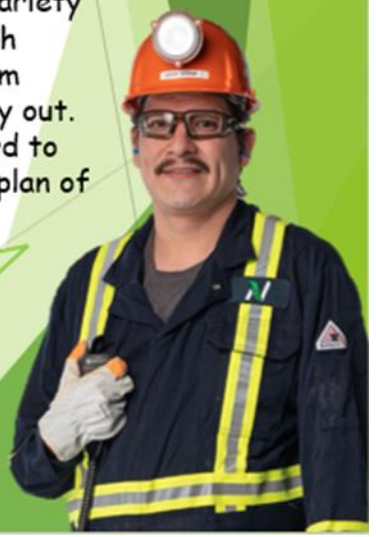
Name: Derek Worme
Home Community: Young, SK
Employer: Nutrien Ltd.

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."



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.

SMA
Saskatchewan
Mining Association

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.."

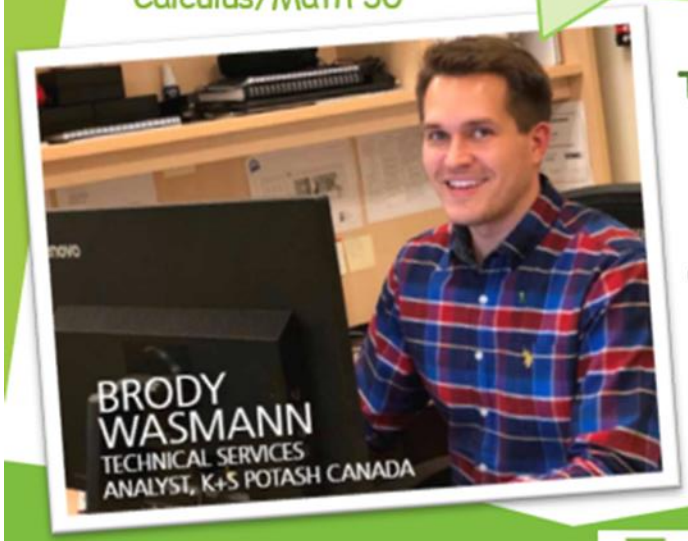
EDUCATION

After taking Computer Science in high school I knew I wanted to be involved with computers in my career. After high school I took the Computer Systems Technology course available at SIAST in Saskatoon. From there I've taken different certifications as part of my continual training in the IT industry.

HELPFUL HIGH SCHOOL COURSES

Computer Science 30
Calculus/Math 30

"One of my first projects was aligning the hardware and software needs of the designer/drafter group."



TEAM ROLE

Download, transfer, save, assist and problem solve with Block Code

SMA
Saskatchewan
Mining Association

CAREER PROFILE

TECHNICAL SUPPORT ANALYST

Name: Steven Leveque
Home Community: Nipawin
Employer: Cameco Corp.

SKILLS NEEDED:

Communication
Research
Critical Thinking
Problem Solving

DETAILS OF THE JOB

My job mainly revolves around helping people fix issues on their computers or helping to maintain computers in the company. This job covers a wide range of things, one day you could be helping someone with their email not working and the next week you may be flying up to one of our mine sites to set people up with new computers. There are usually a dozen calls where I assist people throughout the day and when I'm not taking phone calls I'm reviewing issues emailed to our Helpdesk Inbox. When I'm not helping people with computer issues I'm usually working with many departments in the company to make sure all the computer systems have up to date software.

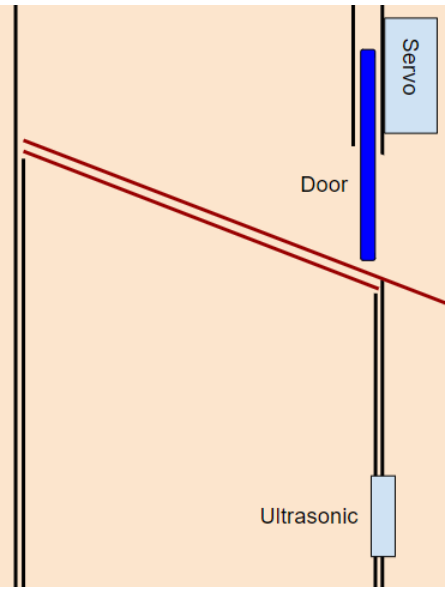
"Why is it so great? There's always something new to learn!"

Marble Hopper Challenge Answer Key

Purpose:

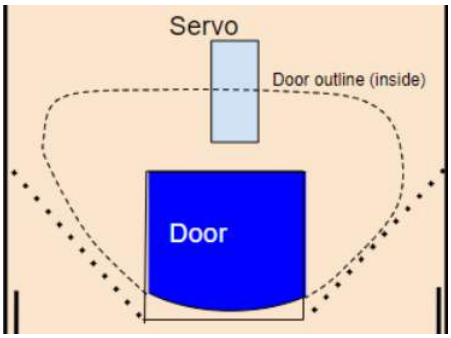
The goal of this challenge is to design, construct, and program a device to hold marbles and then drop marbles when something is detected at the desired distance. You will be designing the overall structure, various components within the structure, the electronic structure, and the program to achieve this task!

This is one possible solution to the challenge.



Part 1: Draw & Build a Design

The hopper drops all the marbles when a container is less than 4 cm away from the sensor. The hopper is a cardboard container that has a small opening for the marbles to go through. Slanted surfaces within the hopper direct marbles to the opening.

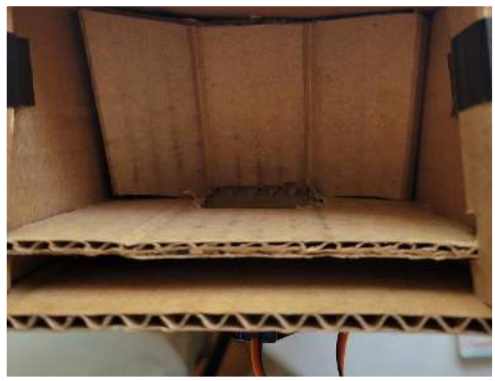


The door mechanism needs to open and close while being able to support the weight of the marbles.

The marbles need to get from the hopper, through the door, and into the container. This can be a gravity fed mechanism like a grain silo. Alternatively, it can be an arm or slide that directs the marbles into the container.

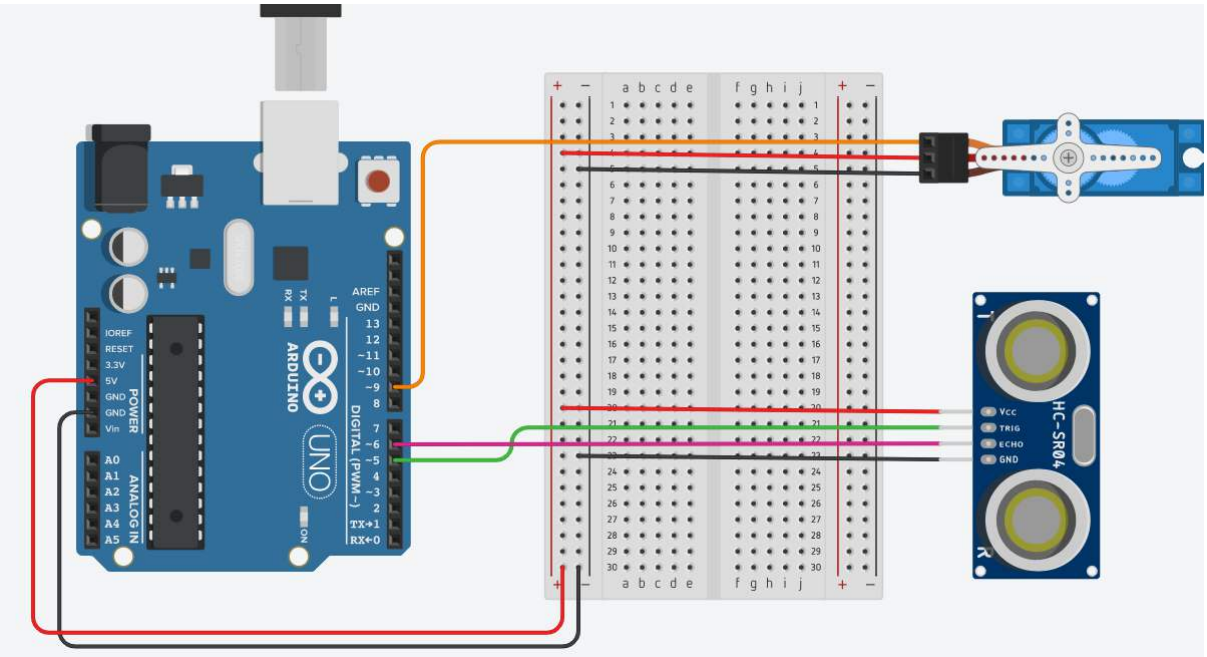
Note, multiple layers of cardboard provide reinforcement. Extra layers were added to the base and door.

Inside view of hopper without inner Barrier wall protecting door



Barrier Wall

Part 2: Wire & Program



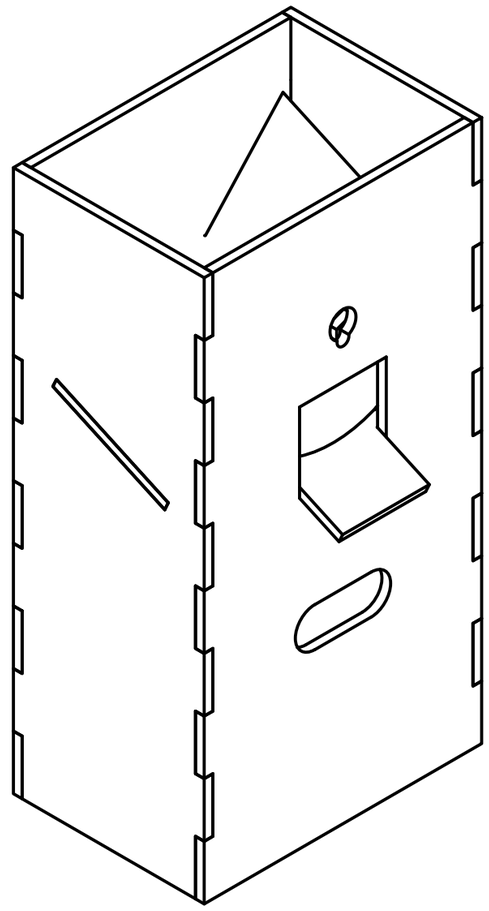
Door servo pin 9, 1 deg closed, 160 deg open, Ultrasonic trig pin 5 echo pin 6

Attach servo and write them to their beginning states. Also, attach the ultrasonic sensor.

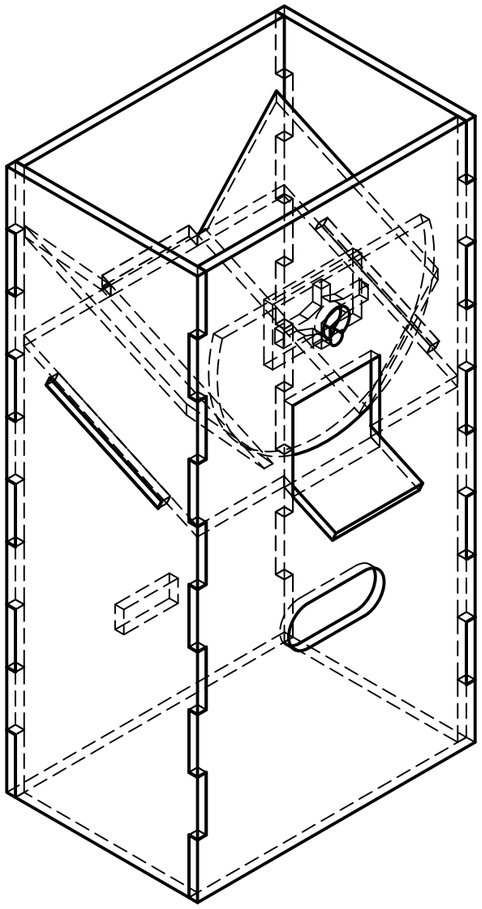
We read the distance in front of the sensor. If it is less than 4 cm away, then we open the door (write the servo to 160 degrees). If not, then we close the door (write the servo to 1 degree).

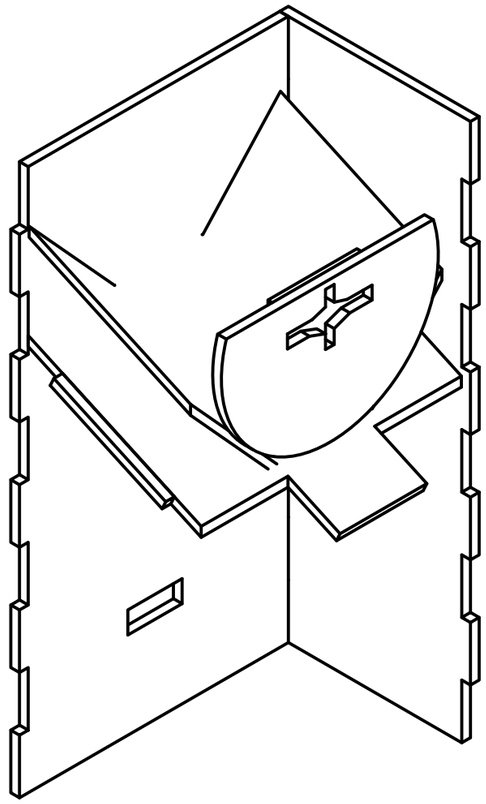
At the end of the loop, before repeating, we add a short delay!

This results in an automatic loader system, which will open the door when a container is within 4 cm of the front of the hopper structure!!

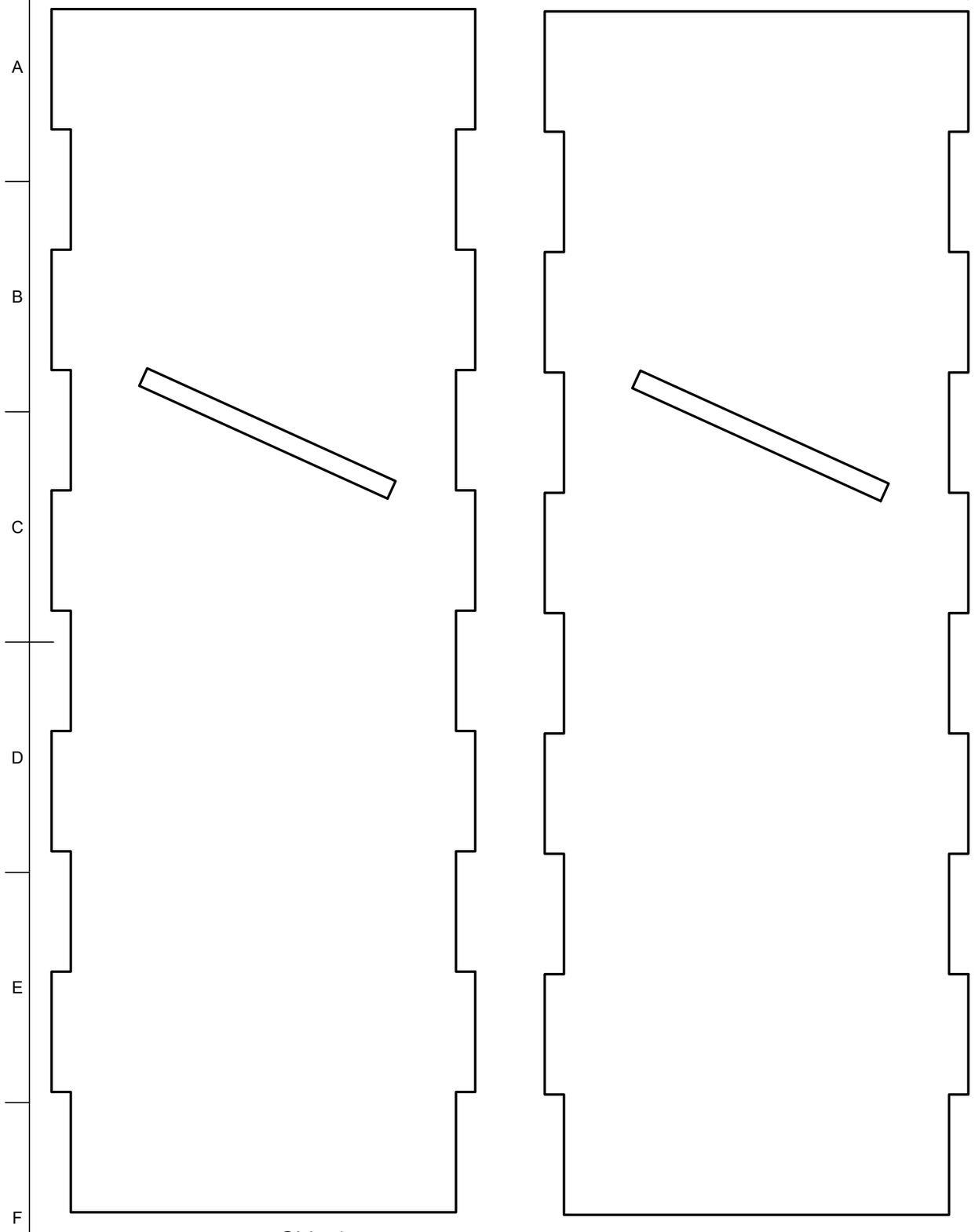


Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
		Document type	Document status
SMA		Title **Marble Hopper Challenge** Template for Cardboard & Laser OVERALL VIEW	DWG No.
			Rev. / Date of issue 5/10/2023 / Sheet 1/5





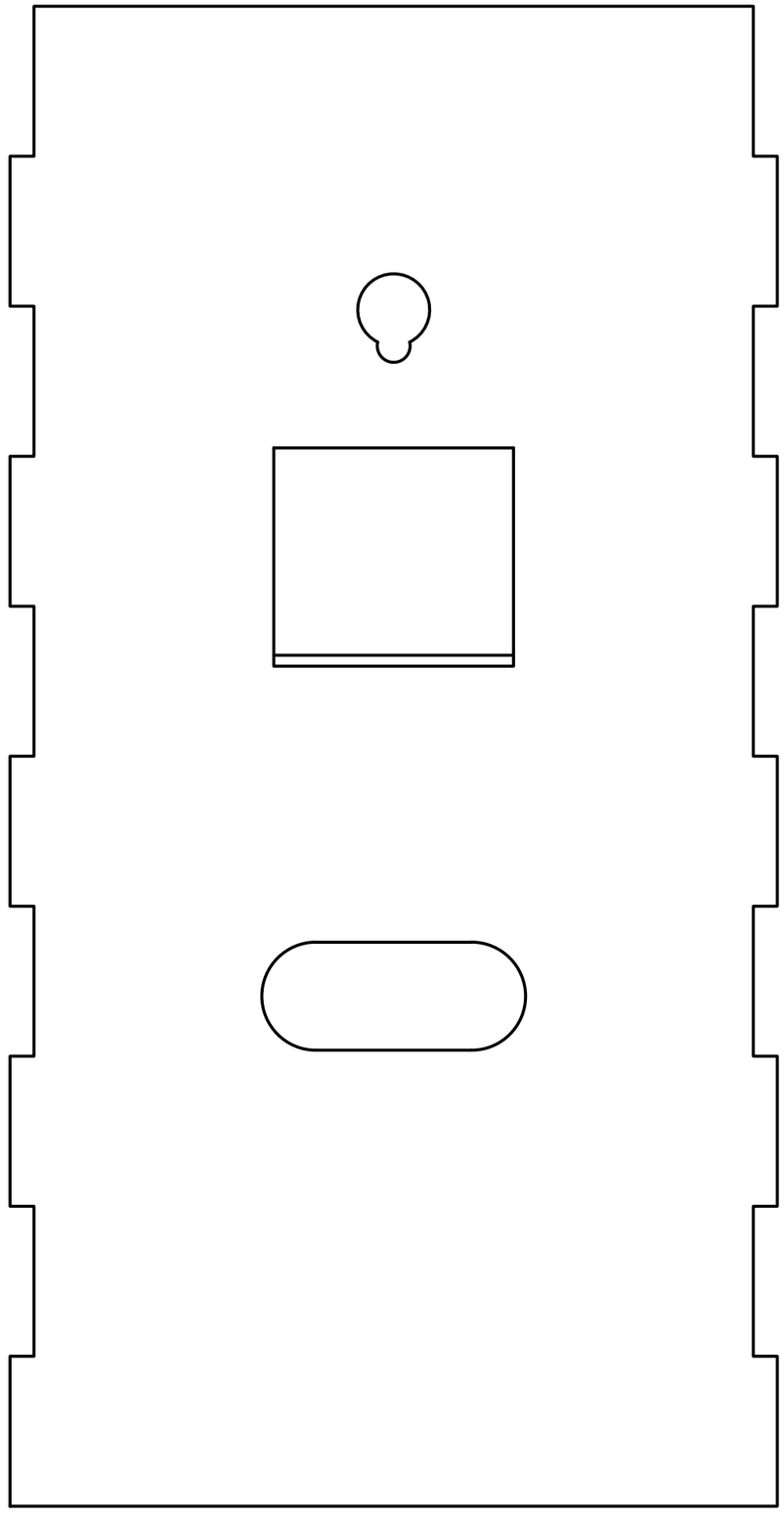
Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Hopper Challenge** Template for Cardboard & Laser INSIDE VIEW	DWG No.
			Rev. / Date of issue: 5/10/2023 / Sheet: 2/5



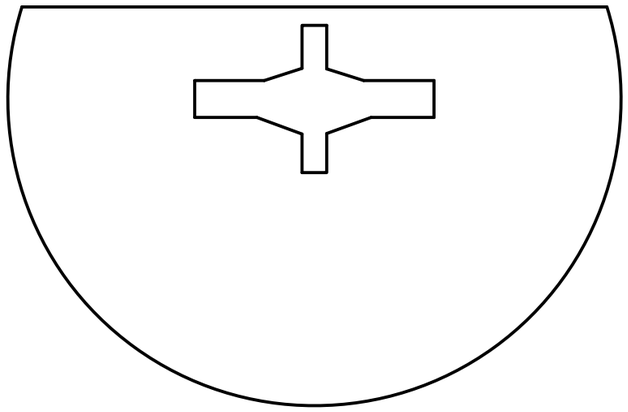
Side 1

Side 2

Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Hopper Challenge** Template for Cardboard & Laser SIDES	DWG No.
			ev. / Date of issue: 5/10/2023 / Sheet: 3/5

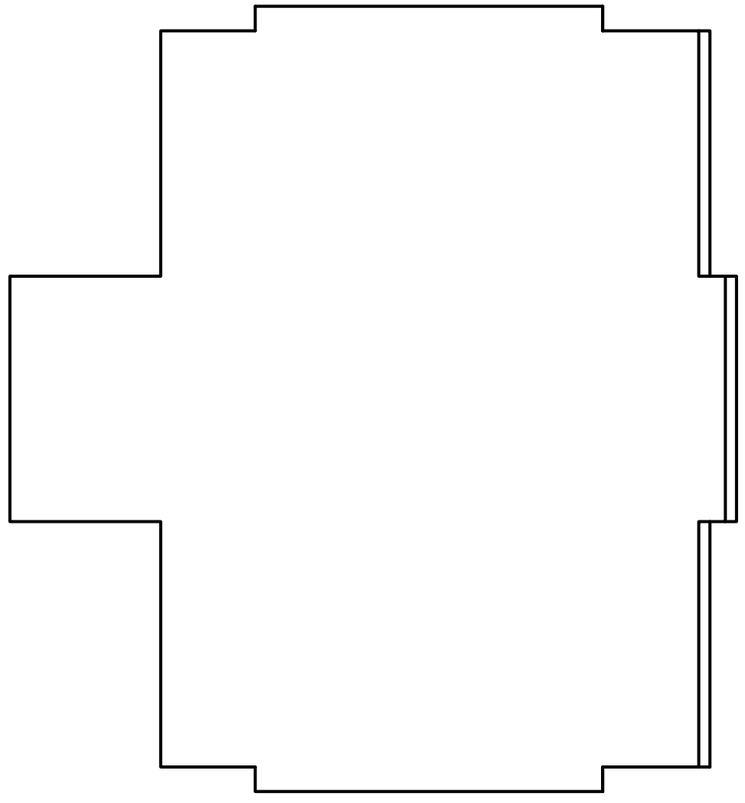


Front



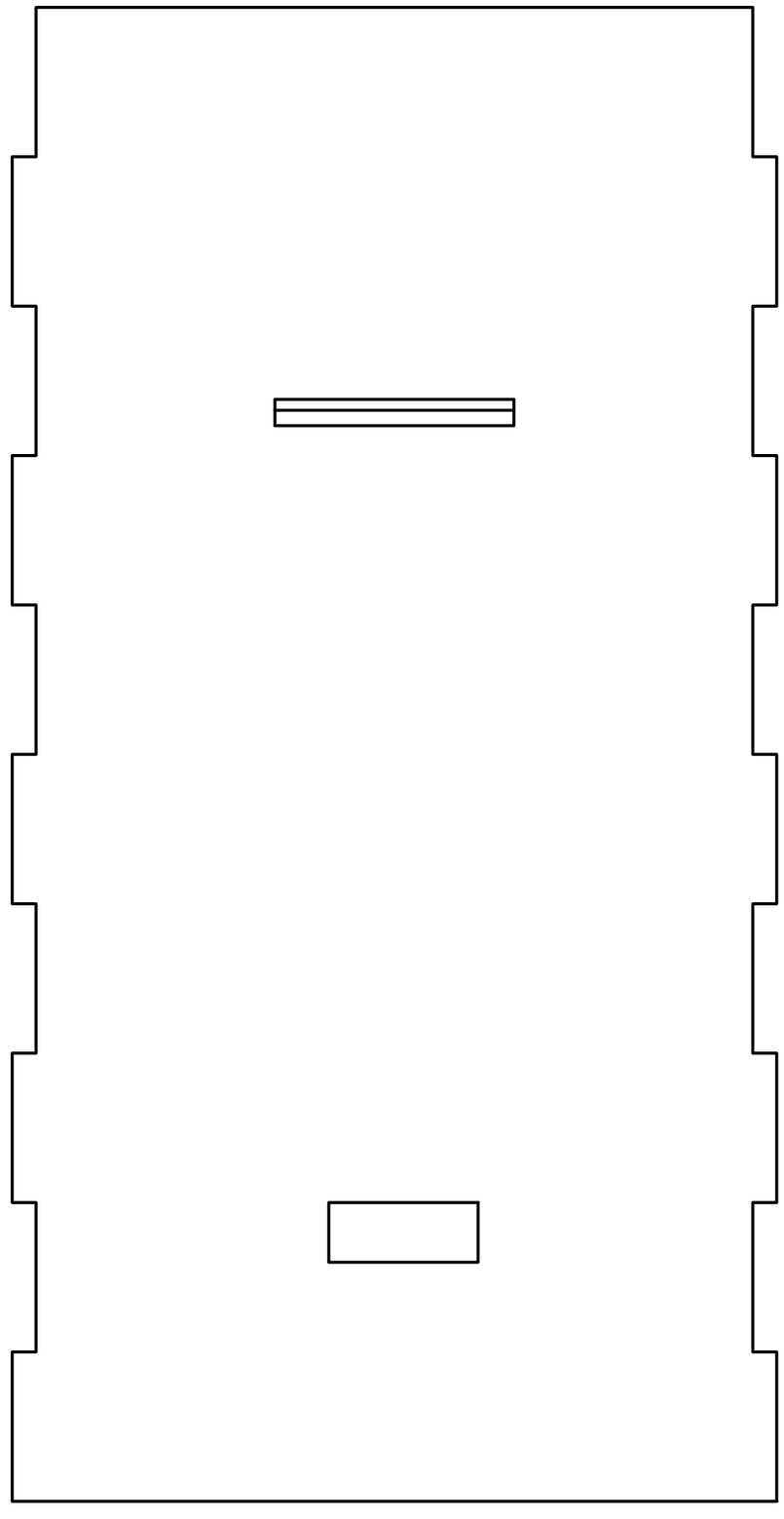
Hopper Door

Hopper Door Servo Support

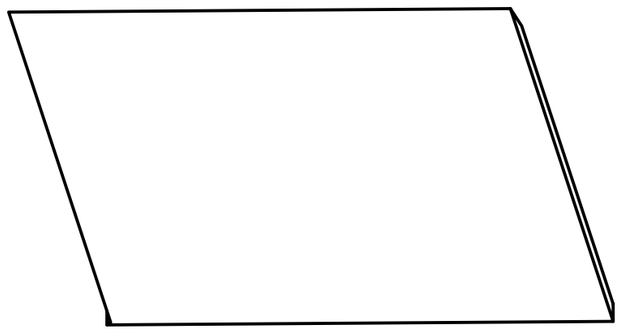


Hopper Ramp

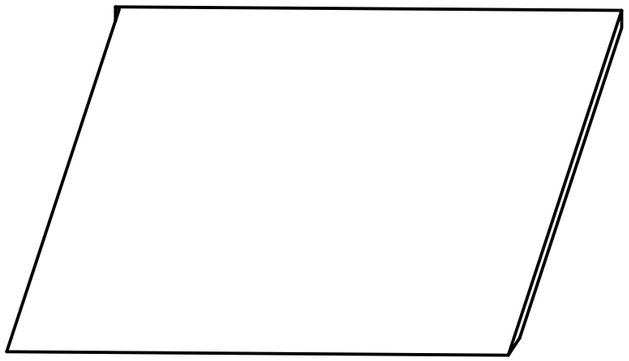
Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Hopper Challenge** Template for Cardboard & Laser FRONT and INSIDE	DWG No.
			Rev. / Date of issue: 5/10/2023 / Sheet: 4/5



Back



Hopper Sides (Inside)



Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Hopper Challenge** Template for Cardboard & Laser BACK and INSIDES	DWG No.
			Rev. / Date of issue: 5/10/2023 / Sheet: 5/5