Marble Sorting Challenge

Grade Level	**Target Grade 7-12**	**Difficulty**	Intermediate
Subject	Practical and Applied Arts, Science, Social, & Math		
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, protecting the environment, and career opportunities. In this challenge learners will design and construct a machine to sort marbles into different bins. Learners will sort the marbles, one at a time, by pressing a button that rotates a "selector" wheel and "sorter" wheel that will direct the marble into the correct bin. This activity involves designing and constructing the machine, as well as developing and programming the circuit.		
Outcome(s)	**PAA Electronics Modules:** ELEC01A, ELEC7A, ELEC8 **PAA Robotics Modules:** ROBA7, ROBA8A, ROBA10, ROBA11, ROBA12A, ROBA13A, ROBA14A, ROBA21, ROBA22, ROBA23A, ROBA24, ROBA28A, ROBA34A, 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, MS7.2 **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 - Using a Button to Control Lights Activity - Servo Motors (Do not need a Potentiometer. Instead, use "coding and angles" for the Servo)		
Time Frame	± 5 hours, depending on experience (Prior Learning, Design & Construction and Wiring & Programming)		
Materials	**SaskCode Arduino Classroom Kit of 15**: specifically - 2 Servos, 1 Arduino Uno, 1 Breadboard, 2-4 buttons (depending on number of sorting bins), 2-4 10k Ohm resistors, 2-4 220 Ohm resistors, 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.
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Marble Sorting Challenge

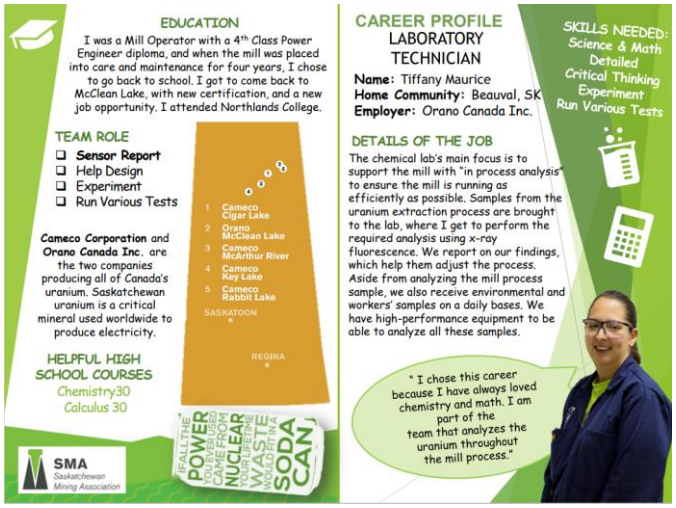
Getting Started

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 - Using a Button to Control Lights	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.

Voice for Thought



Career Cards

3. **Explore**: Groups will design, build and code a button activated marble sorter machine to sort marbles. Learners may sort marbles into two bins or challenge themselves with three or four. (Teacher Answer key)

4. Possible Extensions: use a 3D printer, try the colour sorter sensor add-on or try the Class Team Mega Mining Challenge.

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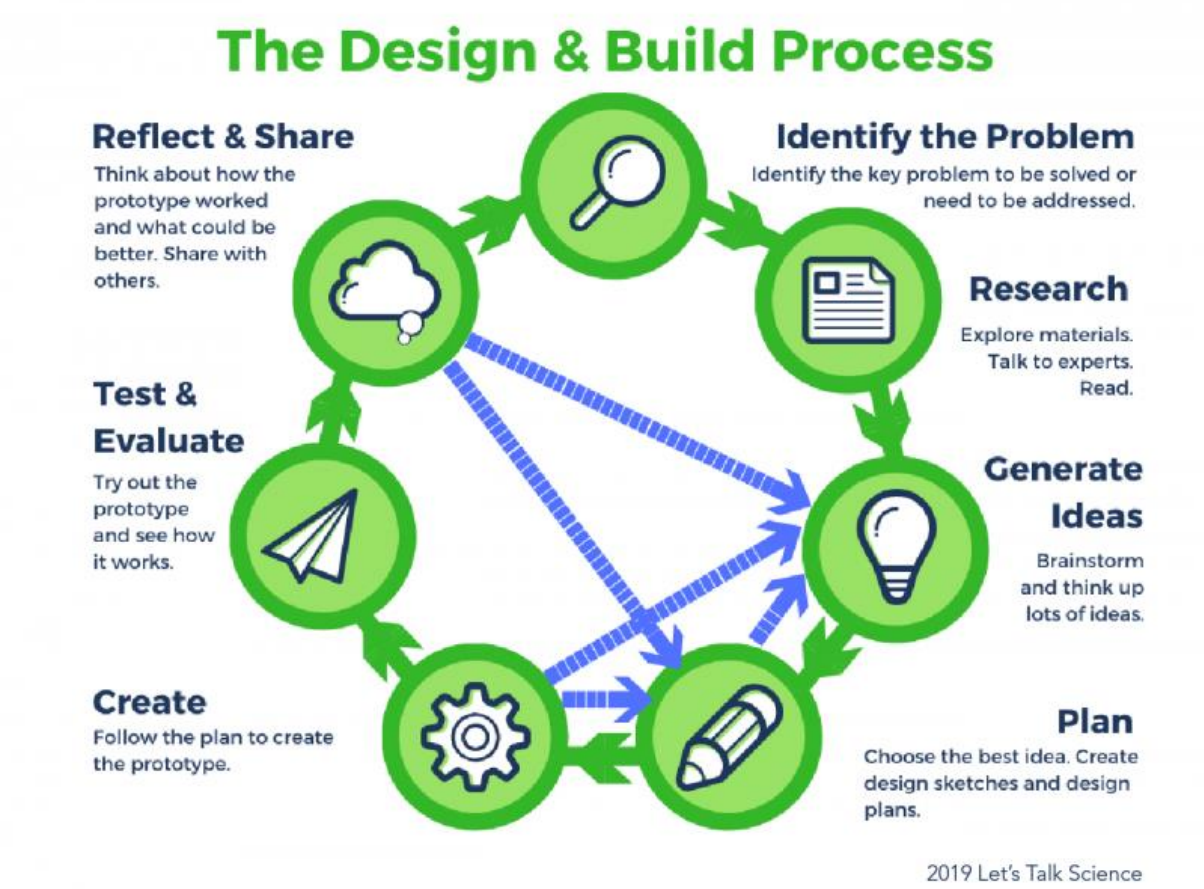
Teacher Considerations

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.

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Marble Sorting Challenge - Student Information

Design Challenge:

The goal of this challenge is to design, construct, and program a device to sort marbles into specific bins. 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, buttons, and physical construction components. Read below for some hints on getting started.

Part 1: Draw & Build a Design
Identify Phase - What is the problem?
Sort marbles into a specific bin based on a button input. Specifically, if we press button A, the marble should be sorted into bin A, and if we press button B, the marble should be sorted into bin B. What do we need to build?

1. A starting “hopper” to hold all the marbles.
2. A way to select a single marble at a time (“selector”).
3. A “sorter” mechanism to direct the marble into the correct bin.
4. The bins where the marble will be sorted.

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?
- 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!

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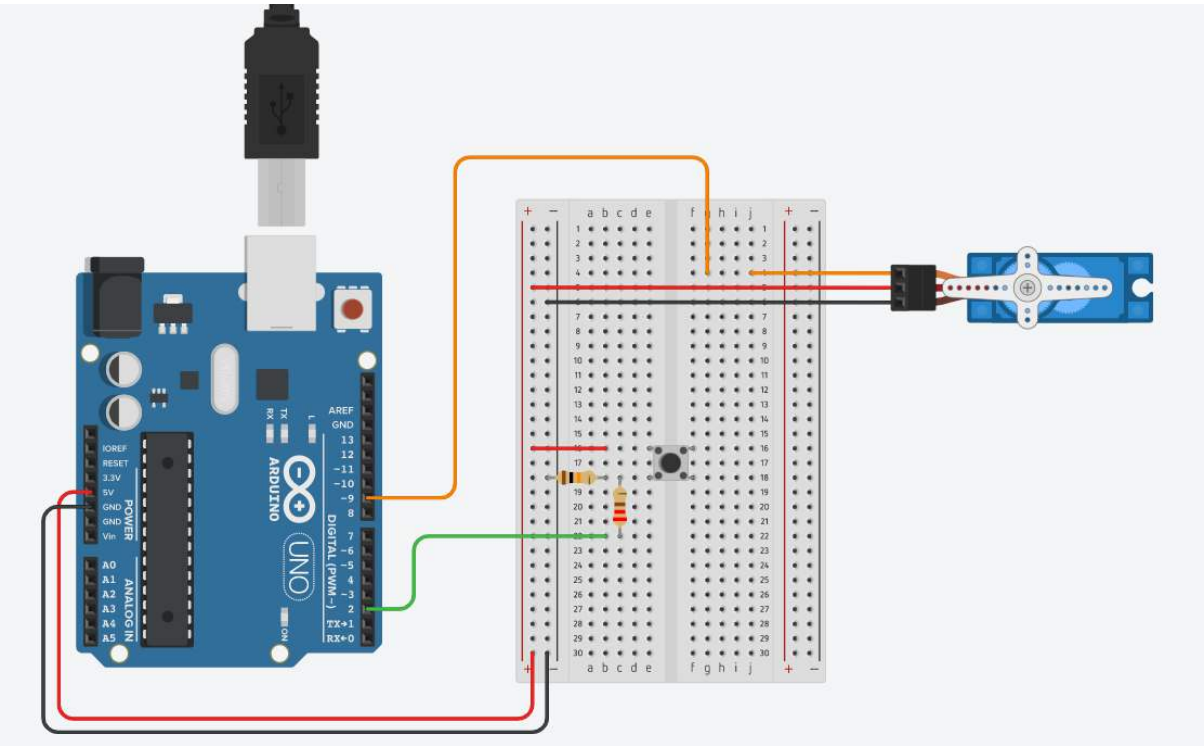
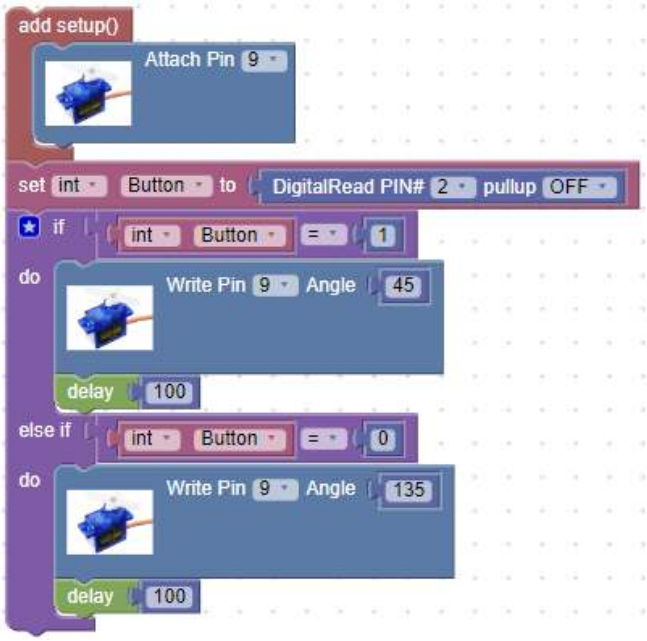
Part 2: Wire & Program

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. In general, you will want to have each button carry out a function to direct each marble into the correct bin. For this activity, we should only be using servos and buttons. Use the example schematic below as a guide.



For this refresher, this is what the program looks like to have the button control the servo. For this particular example, the servo turns to 45 degrees when the button is pressed and 135 degrees when it is not pressed. It looks like this →



Part 3: Test

Try out your marble sorter!
Does it sort the marbles properly?
Are improvements needed? If so, what can be improved?

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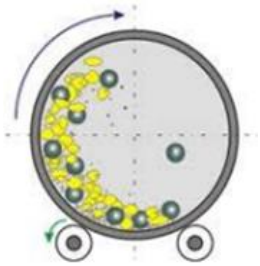
Voice for Thought – Sensor Sorting Technology

The development of mineral resources is very important for our society because we use minerals for almost everything in our lives. Minerals are essential for new technologies such as lithium batteries in electric cars and rare earth element (REE) magnets in wind turbines.

Processing

Once the rock containing minerals had been mined from the ground, the next step is processing. Processing separates the valuable ore minerals from waste material and prepares it to be used in products. A wide range of physical and chemical separation techniques exist, and are constantly being researched and adapted to improve their efficiency or reduce environmental impact. Each separation process is specific to the mineral being mined and its host rock.

Most mined materials are broken into smaller particles using a crusher before being processed. As the cylinder rotates, the balls fall onto the ore breaking it on impact.



Fact – Other separation techniques involve magnets, density, gravity, grain size (sieves), floatation, centrifuges and electroplating (chemical).

Saskatchewan Research Council

SRC is a research and technology organization that supports mining, energy, environmental, agricultural and oil/gas industries around the world. SRC provides world-leading mineral processing services from their facility in Saskatoon.

Sensor Sorting

As Jane Danoczi, Senior Process Engineer at SRC explains, "It is just sorting – but using sensors to individually measure and evaluate a particle and then either reject or recover it based on the parameters being looked at."

New mining technologies such as sensor sorting can reduce costs, reduce greenhouse gas emissions, reduce the amount of energy, reduce the amount of chemicals, reduce the size of tailings piles and reduce water usage by reducing the amount of material that needs to be processed.

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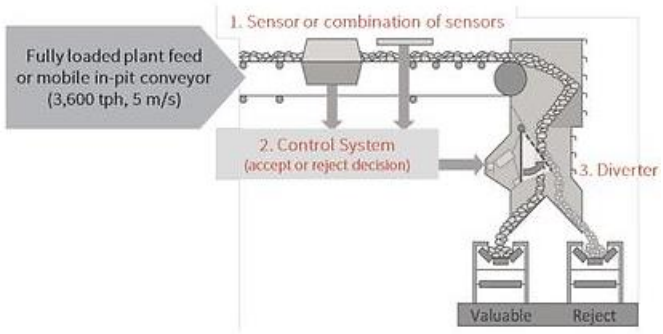


Source: Duffy, K, Valery, W, Jankovic, A, Holtham, P. (2015). Integrating Bulk Ore Sorting into a mining operation to maximise profitability, *MetPlant 2015*, Perth Australia, 7-8 September

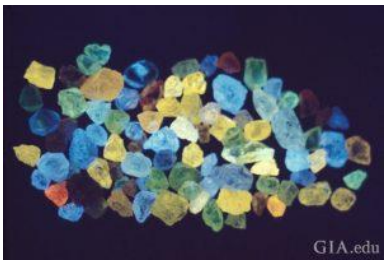
In a chute system, the material slides down an angled surface and the sensors indicate to move an arm or send a blast of air that sorts the minerals into different bins. Sensor sorting can use X-rays, colour, infrared or lasers to detect differences in the physical properties of the minerals.

Did You Know?

Sensor Sorting is used in food, waste and recycling processing.

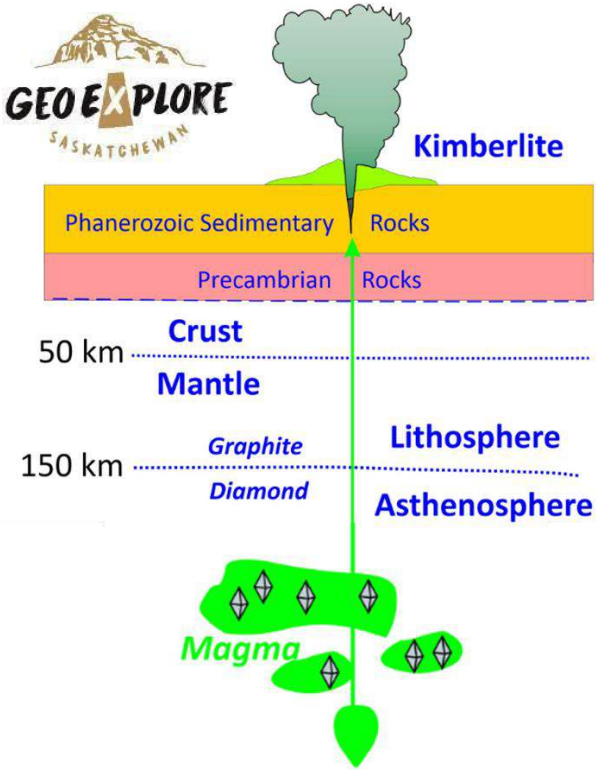
Diamond Sensor Sorting

A few minerals have an interesting physical property known as fluorescence. These minerals have the ability to temporarily absorb a small amount of light and an instant later release a small amount of light of a different wavelength. This produces a glow of a different colour which continues as long as the mineral is illuminated with light of the proper wavelength.



The diamond industry uses this form of light wave separation (x-ray fluorescence) to identify diamonds in the waste rock. A thin stream of particles falls through air under an intense beam of x-rays and when a diamond fluoresces, it activates a photodetector to trigger a jet of air that deflects the diamond in a collection box.

Not only is x-ray fluorescence used in the processing stage of the mining cycle, but it can be used in the exploration stage. A company might send a sample of the ore to SRC to be tested. They would look at the number of diamonds recovered compared to the amount of waste material to determine if it is economical to proceed to the mining stage.



Saskatchewan Diamonds

Diamond is the hardest mineral. It is made up of atoms of carbon that are very strongly bonded together. Around 100 mya diamond bearing kimberlite volcanos erupted into the Earth's crust that is now the area of Fort a la Corne and east of La Ronge. Exploration has discovered over 80 diamond deposits, making Saskatchewan an essential part in the diamond world industry. Rock samples from all around the world are processed at SRC's lab for diamonds. The very final step is visually separating the diamonds by hand with "astronaut gloves" and special tweezers. Do you have a steady hand?

EDUCATION

Chemical engineering is offered through the University of Saskatchewan in Saskatoon. The program begins with a general year of engineering before you choose your specialization. I also have my professional engineering designation (P.Eng) from the Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS).

HELPFUL HIGH SCHOOL COURSES

Chemistry 30
Physics 30
Precalculus 30

TEAM ROLE

- ❑ **Sensor Report**
- ❑ Research
- ❑ Problem Solve
- ❑ Make Improvements

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CAREER PROFILE

PROCESSING SUPERVISOR

Name: Zachary Lang
Employer: Saskatchewan Research Council (SRC)
Education: M.Sc Chemical Engineering at U of S

DETAILS OF THE JOB

I am a **SRC** Processing Supervisor on the Geoanalytical Laboratories Diamond Services team. When a mining company needs to figure out how to get valuable minerals out of their ore, they need to do testing. Whether it's diamonds, lithium, or rare earth ores, SRC performs that testing. I make sure that different ores are processed properly through our various labs and facilities. I am always looking for ways to improve our testing in order to help SRC and our clients save energy, reduce water usage and lower costs. This can involve researching and developing new technologies or finding ways to repurpose the waste.

" I completed an internship in university which allowed me to gain experience working in the mining industry. "

SKILLS NEEDED:

Communication
Research
Critical Thinking
Leader
Problem Solver

EDUCATION

I was a Mill Operator with a 4th Class Power Engineer diploma, and when the mill was placed into care and maintenance for four years, I chose to go back to school. I got to come back to McClean Lake, with new certification, and a new job opportunity. I attended Northlands College.

TEAM ROLE

- ❑ **Sensor Report**
- ❑ Help Design
- ❑ Experiment
- ❑ Run Various Tests

Cameco Corporation and **Orano Canada Inc.** are the two companies producing all of Canada's uranium. Saskatchewan uranium is a critical mineral used worldwide to produce electricity.

HELPFUL HIGH SCHOOL COURSES

Chemistry 30
Calculus 30

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CAREER PROFILE

LABORATORY TECHNICIAN

Name: Tiffany Maurice
Home Community: Beauval, SK
Employer: Orano Canada Inc.

SKILLS NEEDED:
Science & Math
Detailed
Critical Thinking
Experiment
Run Various Tests

DETAILS OF THE JOB

The chemical lab's main focus is to support the mill with "in process analysis" to ensure the mill is running as efficiently as possible. Samples from the uranium extraction process are brought to the lab, where I get to perform the required analysis using x-ray fluorescence. We report on our findings, which help them adjust the process. Aside from analyzing the mill process sample, we also receive environmental and workers' samples on a daily bases. We have high-performance equipment to be able to analyze all these samples.

"I chose this career because I have always loved chemistry and math. I am part of the team that analyzes the uranium throughout the mill process."

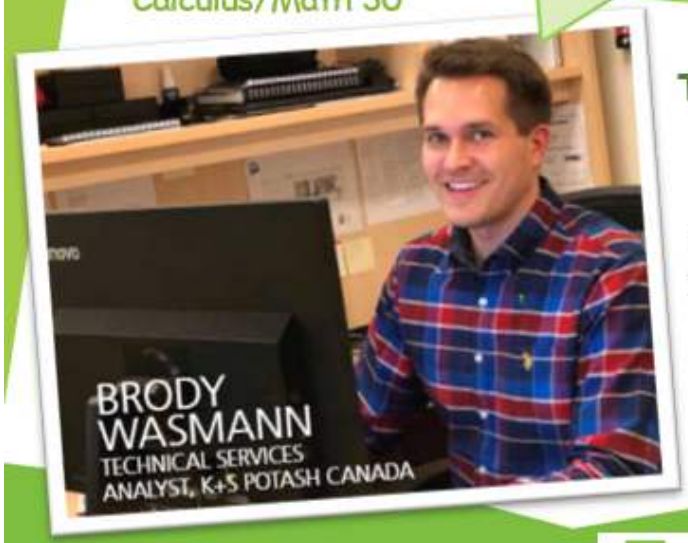
EDUCATION

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

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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!"

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

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

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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:

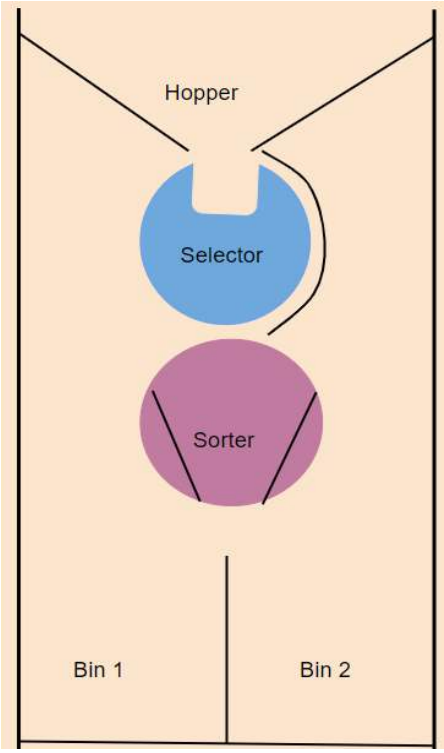
Communication
Attention to Details
Critical Thinking
Problem Solving
Math

Marble Sorter Challenge Answer Key

Purpose:

The goal of this activity is to design, construct, and program a device to sort marbles into specific bins. 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.



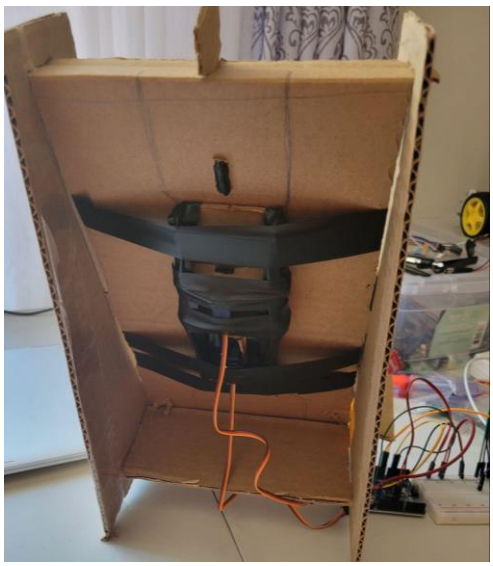
Part 1: Draw & Build a Design

The hopper is a slanted sided box, which directs the marbles to the small hole at the bottom.

The selector (driven by a servo) is a wheel with a single cut out area that is just big enough for a single marble. It rotates clockwise with the marble, dropping it into the sorter, and then rotates counterclockwise back to pick up another marble.

The sorter (driven by a servo) is a wheel with 2 angled sides, which rotates to direct the marble into the appropriate bin.

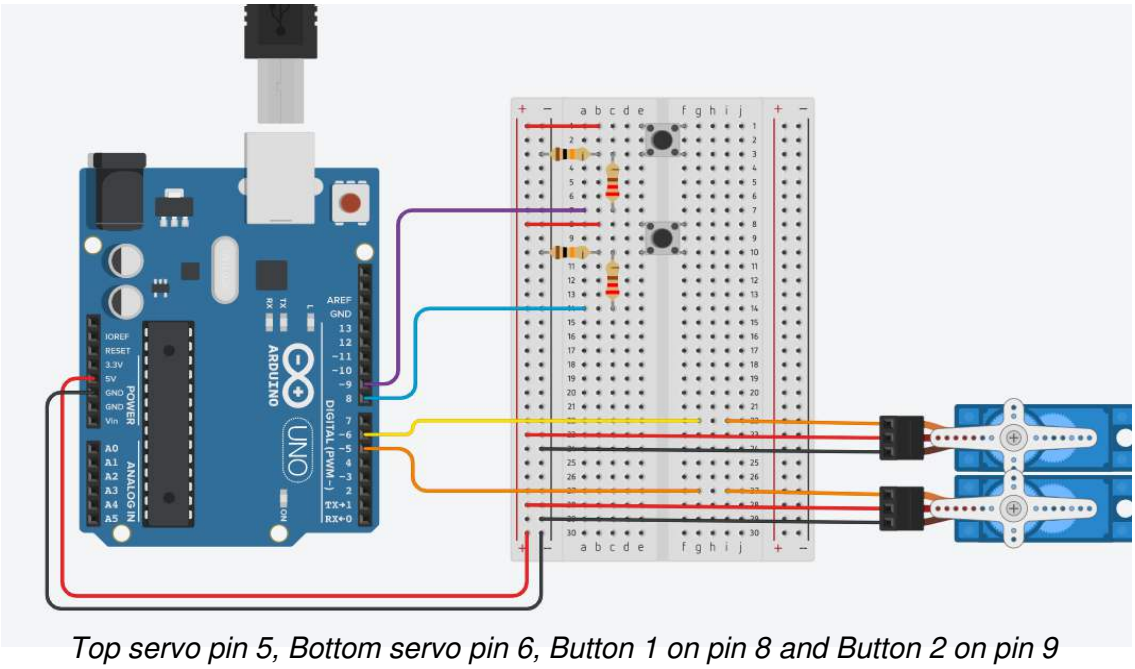
The bins are just simple catchers for the marbles, divided by a single wall.



BACK VIEW

FRONT VIEW

Part 2: Wire & Program

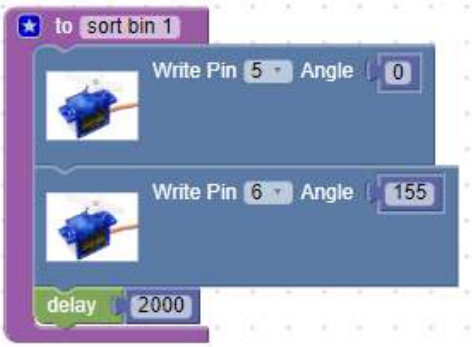


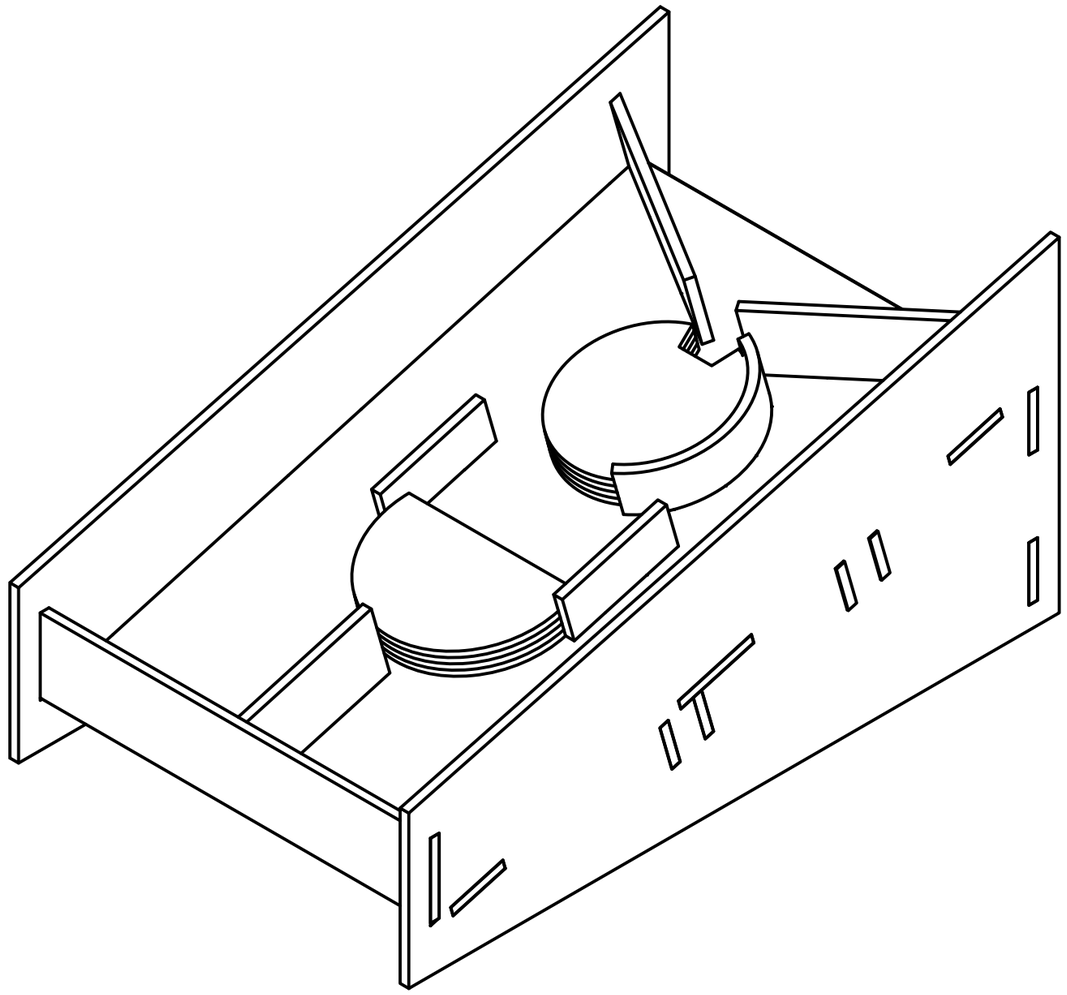
Top servo pin 5, Bottom servo pin 6, Button 1 on pin 8 and Button 2 on pin 9

Attach servos and write them to their beginning states.

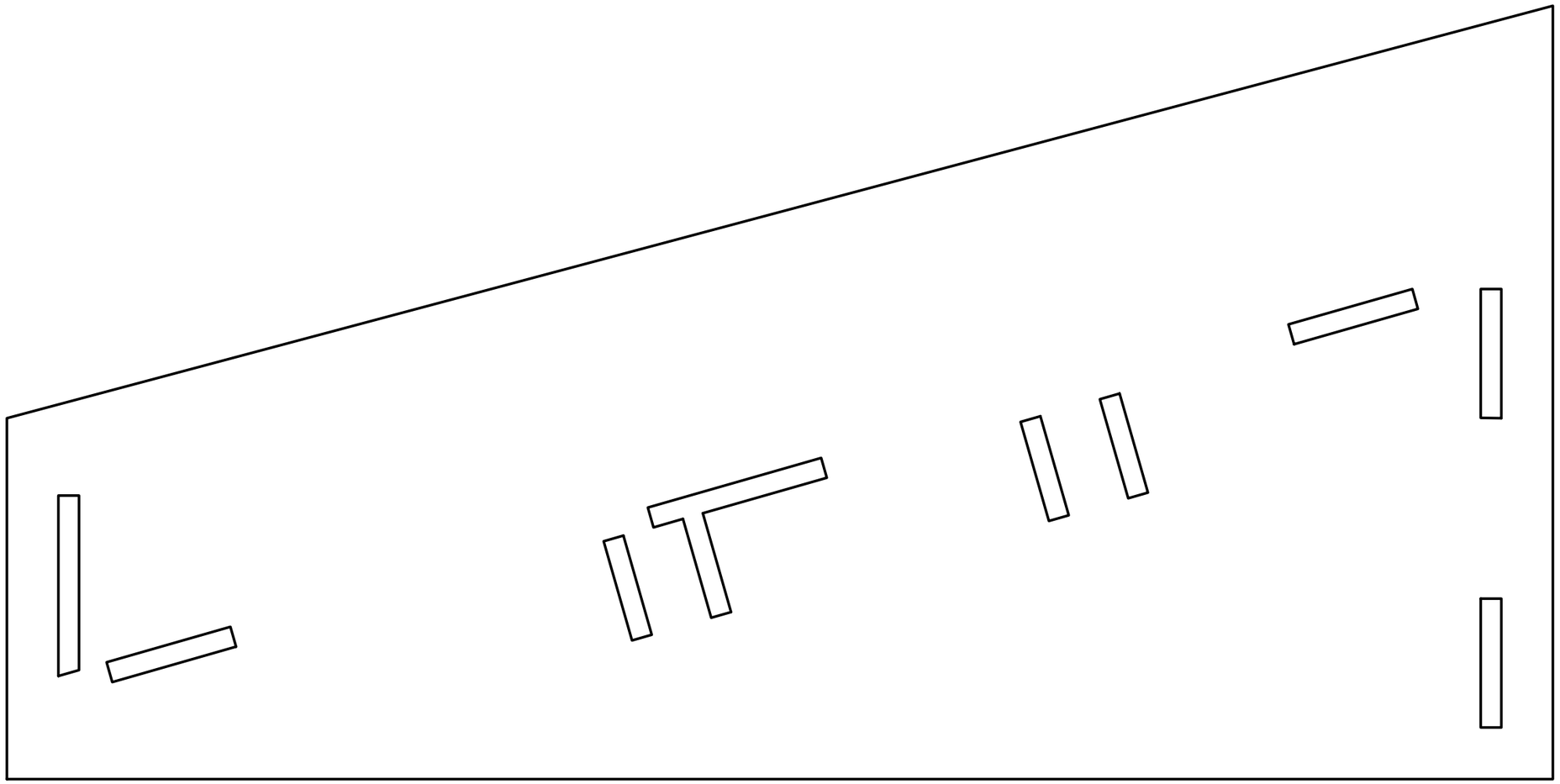
Then read the buttons. Based on what buttons are pressed, we either sort the marble into a bin, or we wiggle (if both buttons are pressed). I decided to use functions here for each of these for clarity and ease of adjustment.

Example of a Function:





Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Sorting Challenge** — Template for Cardboard Overview	DWG No.
			Rev. / Date of issue: 5/10/2023 / Sheet: 1/6

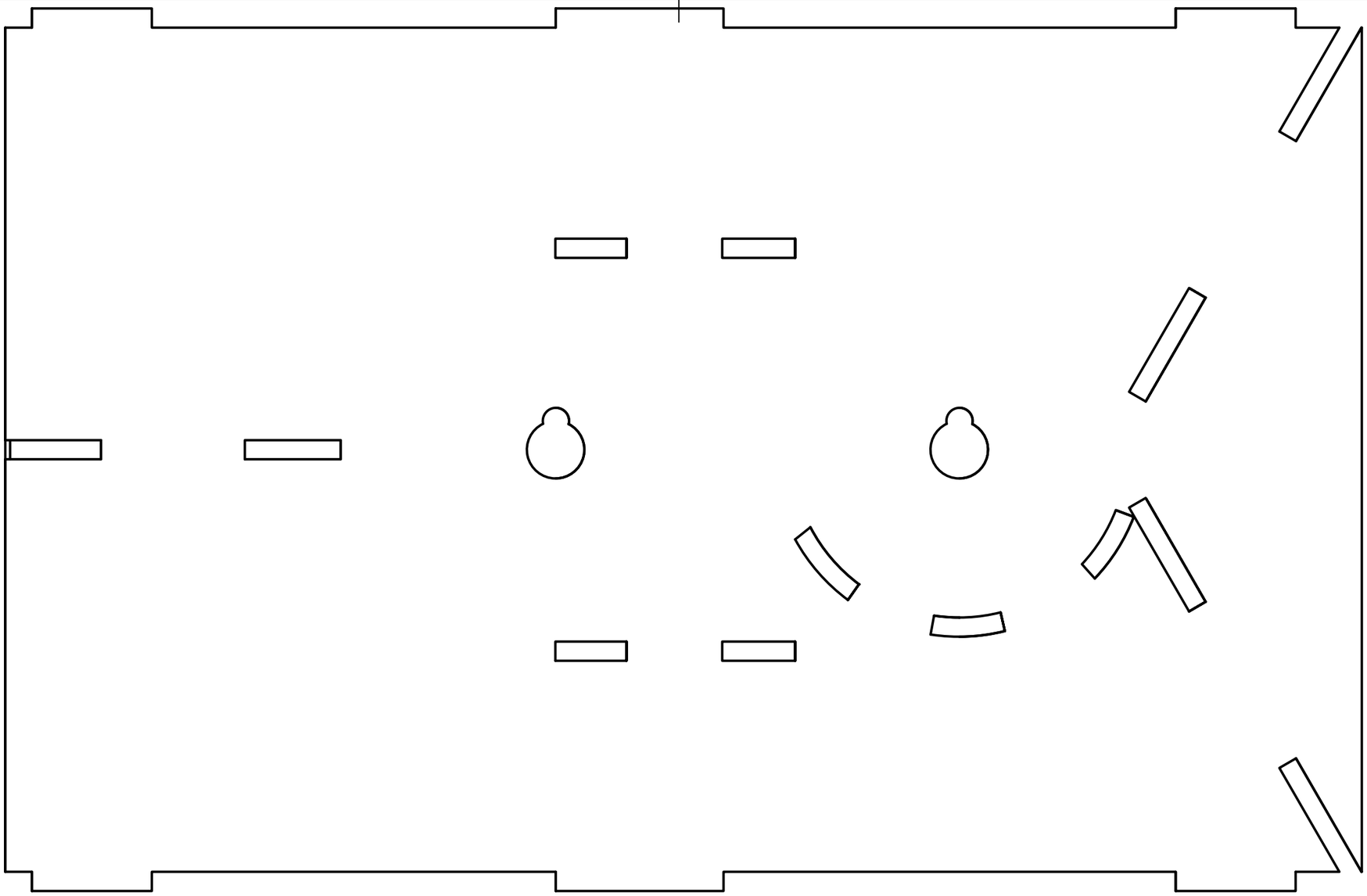


Sorter Side (4mm Thick) (x2)

Note: If using thinner material, see 2.85mm Thick version of the "Sorter Sides"

Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Sorting Challenge** Template for Cardboard Sides	DWG No.
			Rev. / Date of issue: 5/10/2023 / Sheet: 2/6

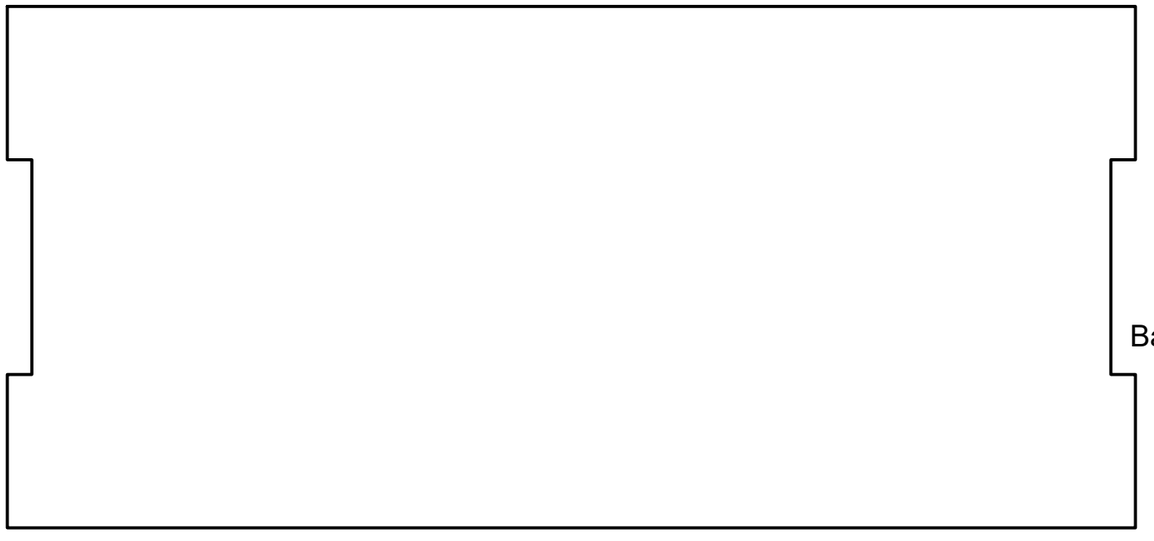
Sorter Base
(4mm Thick)
(x1)



Note: If using thinner material, see 2.85mm Thick version of the "Sorter base"

Front (x1)

Back (x1)



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SMA		Document type	Document status
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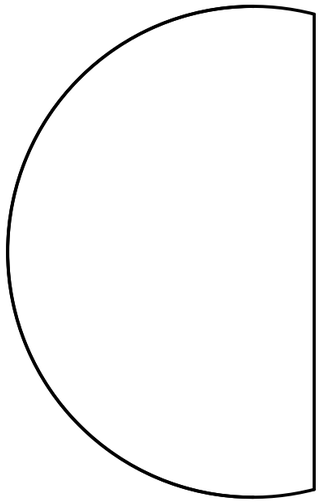
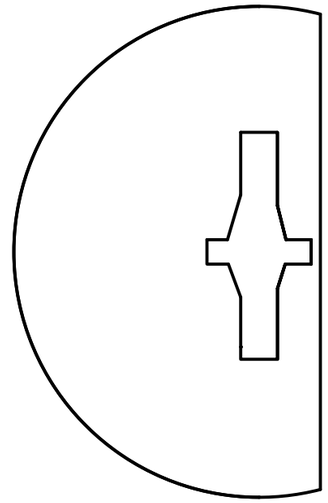
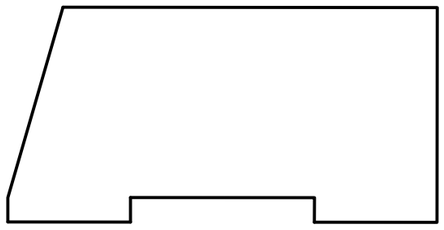
			Rev. / Date of issue: 5/10/2023 / Sheet: 3/6



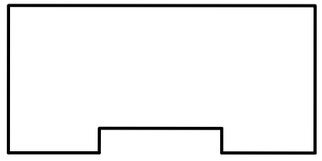
Bottom Sorter (x2)



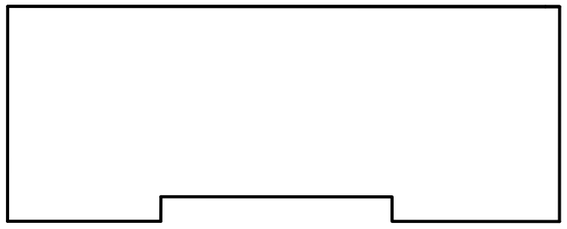
Bottom Sorter Servo (x2)



Sorter bin (x1)



Sorter Barrier (x2)

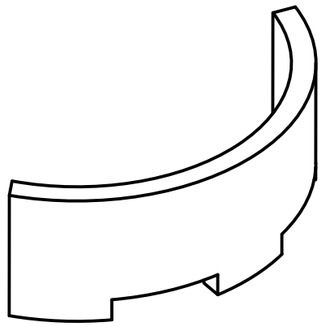


Hopper Wall (x2)

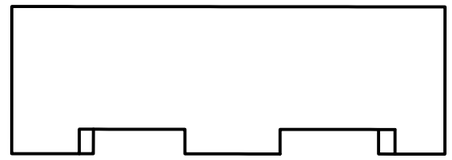
Bottom Support (x4)

Dept.	Technical reference: Scale 1:1	Created by: D Dalton	Approved by
SMA		Document type	Document status
		Title: **Marble Sorting Challenge** Template for Cardboard Sorter	DWG No.
			Rev. / Date of issue: 5/10/2023 / Sheet: 4/6

Top View



Overall Part



Side View

Note:
This piece will need to curve to the arch of the marble picker. This is a difficult piece to accurately represent in a drawing.

Hopefully you are able to create this piece.

You only need 1!

Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
		Title: **Marble Sorting Challenge** Template for Cardboard Curved Piece	DWG No.
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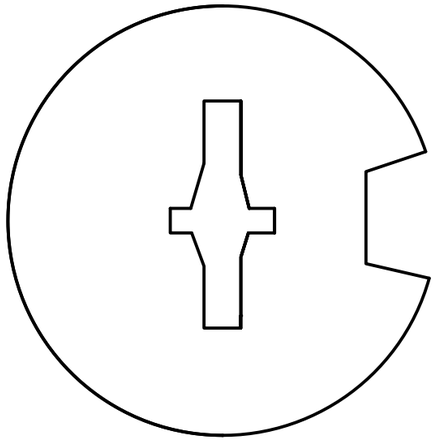
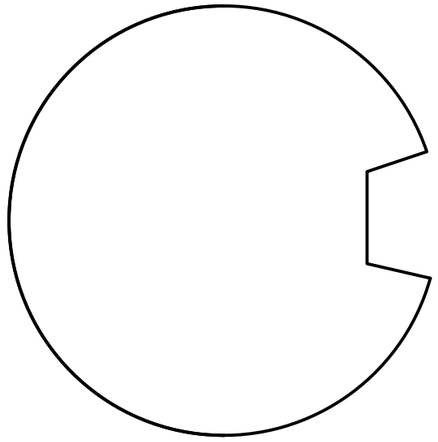


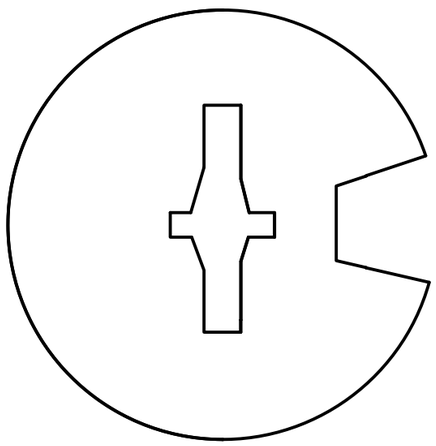
Marble Picker
Servo Piece (x2)

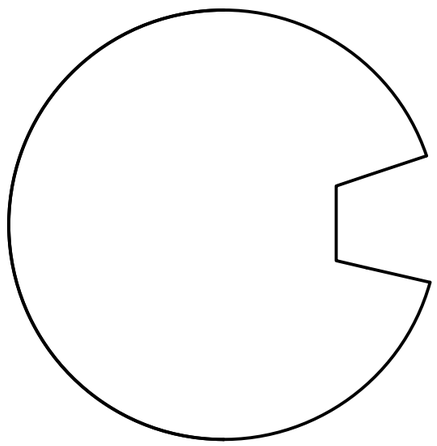


Marble Picker (x2)

Note: You will need 2 Marble Picker Servo Pieces and 2 Marble Picker pieces.

Note: 2 Versions are provided here, you will need to choose one based on the size of your marble/piece to be sorted.





Dept.	Technical reference	Created by	Approved by
	Scale 1:1	D Dalton	
SMA		Document type	Document status
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			Rev. / Date of issue: 5/10/2023 / Sheet: 6/6