Scoping Document

Status	In progress
Assign	Daniel Johnston Michael Ross Jay Harrison Welch Ethan Shahbaz Edward Brooks Daivya Malvi
Date	@August 20, 2023
FINAL GRADE WEIGHT	18%

ScopingDoc.pdf

Rubric

Status	Section	Weight	Member Assignment
In progress	Professionalism	15%	
In progress	Document Structure	10%	
Done	Problem Definition	10%	Ethan Shahbaz
In progress	Deliverables	10%	
In progress	Requirements & Constraints	40%	
In progress	Requirements Sign off	10%	
In progress	Inclusions & Exclusions	5%	

Assignments

Name	Assign	Files & media	S
Scope	Daivya Malvi		In p
Terms & Definitions	Jay		N s

Aa Name	Assign	Files & media	
🟪 Allocations	D Daivya Malvi Ⓜ Michael Ross Ⓙ Jay Ⓗ Harrison Welch E Ethan Shahbaz Daniel Johnston Ⓔ Edward Brooks		I p
🟩 Problem Definition	E Ethan Shahbaz		D
🟩 Subsystems	Ⓙ Jay Daniel Johnston		N s
🟪 Preface	Daniel Johnston		D
🟩 Assumptions	Ⓔ Edward Brooks		D
🟦 Constraints	D Daivya Malvi Ⓜ Michael Ross		D
🟧 Final Product	Ⓗ Harrison Welch		D
🟧 Deliverables	D Daivya Malvi		D
🟦 Functional Requirements	D Daivya Malvi Daniel Johnston		D
🟥 Inclusions & Exclusions	Ⓔ Edward Brooks		D
🟦 Interface Signoffs	Ⓔ Edward Brooks		D
🟦 Performance Requirements	Ⓙ Jay		N s
🟫 Conceptual Design	Ⓗ Harrison Welch Ⓜ Michael Ross		I p
🟦 Interface Requirements	E Ethan Shahbaz		I p
🟫 Detailed Design			D
🟨 References			N s
🟨 Appendices	Daniel Johnston		N s

Scoping Document Template:

UPDATE THE REVISION HISTORY AFTER YOU ADD STUFF TY <3

Revision History

Date	Person
@August 16, 2023 2:22 PM	Jay
@August 16, 2023 2:06 PM	Edward Brooks
@August 16, 2023 1:46 PM	Edward Brooks
@August 16, 2023 1:35 PM	Edward Brooks
@August 16, 2023 1:23 PM	Michael Ross
@August 16, 2023 1:13 PM	Daivya Malvi
@August 13, 2023 3:38 PM	Ethan Shahbaz
@August 10, 2023 12:06 PM	Daivya Malvi
@August 8, 2023 11:23 PM	Daivya Malvi
@August 8, 2023 2:18 PM	Harrison Welch
@August 8, 2023 1:06 PM	Edward Brooks
@August 7, 2023 11:38 AM	Daniel Johnston
@August 6, 2023 2:20 AM	Ethan Shahbaz
@August 3, 2023 7:56 PM	Michael Ross
@August 2, 2023 2:47 PM	Daniel Johnston Michael Ross Jay Harrison Welch Ethan Shahbaz Edward Brooks Daivya Ma

Table of Contents

Intro

Preface

The following report is written by the group T4_Motion_4 (T4M4), in collaboration with T4_Struct_4 (T4S4) and T4_Comm_5 (T4C5). This report details the scope and requirements of the Marble Machine Box Motion mechanisms. See Appendix (ADD) for project timeline. The purpose of this report is to inform all stakeholders including engineers, clients, and manufacturing of the scope, constraints, requirements, interfacing, inclusions and exclusions, and a preliminary design of the Marble Machine.

Scope

The objective of this document is to detail the project's scope, which encompasses the conceptualisation and execution of a "Marble Box" by Team Motions 4. This box will receive marbles through the bottom hole of the box, guiding them along a predetermined course while meeting specified requirements, ultimately allowing the marbles to exit to the top of the box.

This document will include:

- define the problem and what requirements we will be aiming to complete
- List our systems and sub-systems
- The product we will be delivering
- The constraints we have in terms of the product
- Some conceptual designs and ideas in terms of each system

Terms/definitions

List of terms and definitions are stated in the table below:

Abbreviations	Definitions
T4M4	T4_Motions_4
T4S4	T4_Structures_4
T4C5	T4_Communications_5
PR_RQ#	Performance Requirements
FUN_RQ#	Functional Requirements

Allocation

Problem Definition

The success of the project depends on the interdependent functionality of the cubes and their subsystems. The subsystems will involve harmonic interactions between sensors, electric motors, electromagnets, LEDs and an Arduino microcontroller. As the Motions team (T4-M4), we are responsible for selecting, designing, prototyping, and integrating circuitry, electrical & mechanical components. A highly integrated, multi-layered project that requires effective teamwork between the Structures (T4-S4) and Communications (T4-C5) teams to ensure a reliable & valid product is engineered for the customer. We are required to work in junction with the Structures department to fit components and ensure a structurally sound cube when all subsystems are functioning. Furthermore, we are required to work with the Communications team to implement a reliable, dynamic interaction between the sensors, motors, LEDs and microcontroller.

The project requires acute adherence to a total of eleven **Foundational Requirements (RC1 — RC11)**. Moreover, we have agreed with The Customer, to an additional set of requirements for higher recognition; the **High Distinction Requirements (RC25 — RC28),** plus three **LEVEL Requirements (LC1 — LC4).** *(All Requirements can be located in the 'Requirements' section of this document).* These can be divided into Requirements and Constraints.

The success of the project will depend on navigating a variety of **technological**, **safety & resource constraints:**

- **Tech**: We are limited in our modern-day technology, further limited by a university-level understanding of that tech. Therefore we are scoped to an intermediate aptitude of present electrical & mechatronics devices. Applicable to our project are solenoids, electric motors, LEDs, sensors and Arduino microcontrollers.
- **Safety & Resource**: Safety constraints are imposed to negate injury during both the production and lifetime of the product. By restricting forces to gravitational & electrical, the safety hazards imposed by combustibles and water-electricity are negated. Simultaneously, **design for maintainability and sustainability** are upheld as the need for maintenance & 'refuelling' is optimised if not avoided entirely. Electromagnets & electric motors will be used to manoeuvre the ball around the cube. Limited material/component supplier pool, with a fiscal budget of $100 AUD.

The product has several key **requirements** that are imposed directly by the Customer regarding the **size & functionality**.

- **Size**: Dimensions are fixed and the customer has decided to have 8 vertical cubes by 8 horizontal cubes measuring 250mm x 250mm x 250mm, plus a 15mm gap between cubes on the final product wall. Four corner mounting points.
- **Functionality**: Handle a changing ball input frequency, with the LEVEL and HD requirements that outline specific ball control required to be performed, including path retracing, 3D movement, and stationary hold for at least half a second.

Subsystems

Entry Mechanism

Lifting Mechanism

Exit Mechanism

Stopping Mechanism

Track Mechanism (not sure)

Assumptions

Assumption	Details
All marbles are the same	Every marble is spherical, of equal mass and equal diameter
Structural components won't fail	Components have sound structural integrity
Rate of marble delivery is constant	The rate of delivery of marbles is 1 marble per second
Machine can run perpetually	Electrical energy supply is assumed to be infinite

Deliverables

Deliverables	Description	Due Date
Scoping Document	This document will highlight the project's expected outcomes and key requirements.	20/08/2023
Design Document	This document goes into detail to describe the cube's final design and how it works as well as including alternative conceptual designs.	10/09/2023
Testing Document	This document will go over the testing of the inner workings of the cube making sure the final product will be reliable.	29/10/2023
Statement of Work	This will include collective feedback which is received throughout the time of the project as well as the changes which as made regarding the feedback.	29/10/2023
Project Presentation	An in-person presentation will be conducted on the marble box which was worked on through the semester	7-8/11/2023
Marble Machine Box	The final box with internals finished will be read for demonstration.	7-8/11/2023

Final Product

The final product in the project will be required to meet the specified requirements and do so in a manner that is controlled and consistent.

Requirements

Constraints

Our Group has decided to go for the High Distinction Criteria which has the following constraints:

- RC25: The cube MUST accept a marble through the BOTTOM surface of the cube at the specified location.
- RC26: The cube MUST expel all marbles out from the TOP surface at the specified location. It is assumed that the marble will be moving upwards such that its trajectory will peak at 50mm above the outer surface of the bottom of the cube.
- RC27: The cube must not expel marbles at a speed significantly higher than the initial entry speed.

- RC28:The cube MUST control the marble in such a fashion that satisfies a minimum of THREE of the LEVEL conditions.

Our group decided to fulfill: LC1, LC2, LC3 and LC4 conditions.

- LC1: The marble makes a full rotation around an imaginary line that MUST NOT intersect the marble, drawn through the cube. In other words, the marble's direction must change in at least two dimensions by the size of the marble.

- LC2: The marble is held stationary in all physical dimensions for a minimum of 0.5 seconds in time.

- LC3: The marble retraces its exact path in reverse for a length of at least 50mm.

- LC4: The marble moves upward against gravity for a minimum of 100mm in one action.

Functional requirements

Reference	Requirements
FUN_REQ_1	Each cube MUST accept a marble through the BOTTOM surface of the cube at the location specified. It is assumed that the marble will be moving upwards such that its trajectory will peak at 50mm above the outer surface of the bottom of the cube.
FUN_REQ_2	All marbles must experience a change in direction in at least 2 dimensions.
FUN_REQ_3	The marble is held stationary in all physical dimensions for a minimum of 0.5 seconds in time.
FUN_REQ_4	The marble moves upward against gravity for a minimum of 100mm in one action.
FUN_REQ_5	The marble makes a full rotation around an imaginary line that MUST NOT intersect the marble, drawn through the cube. In other words, the marble's direction must change in at least two dimensions by the size of the marble.
FUN_REQ_6	Each cube MUST expel all marbles out from the TOP surface in the location specified
FUN_REQ_7	Cubes SHALL NOT deliberately expel marbles at a speed significantly higher than required to satisfy FUN_REQ_1 in the cube above.
FUN_REQ_8	All cabling must be routed through the designated service hole
FUN_REQ_9	Cube SHOULD accept marbles of materials other than steel, as long as they are 16mm diameter.
FUN_REQ_10	The bill of materials for the cube and its subsystems MUST not exceed $100 AUD
FUN_REQ_11	The Arduino Uno will be used as the main control board of the box
FUN_REQ_12	Cube MUST be able to detect marble on track
FUN_REQ_13	LED lighting SHOULD correlate to the position of the marble
FUN_REQ_14	Cube MUST be able to be supported on the wall via the back panel only
FUN_REQ_15	Cube MUST NOT create excess vibration or noise to disrupt other cubes when integrated as part of a sculpture

FUN_REQ_16	Cube MUST NOT draw more than 5V 2A
FUN_REQ_17	Cube MUST NOT utilise other external services other than power specified in FUN_REQ_16

Performance Requirements

ID	Requirements Name	Description
PR_RQ1	Marble Detection	Sensors will be used to detect the marble entering from the bottom and entering the elevator mechanism as well as for the last propulsion mechanism.
PR_RQ2	Minimum Stationary Time	The minimum stationary time requirement will be met by the delaying mechanism which will stop the movement of the marble doe 0.5 seconds.
PR_RQ3	Elevator Mechanism	The requirement regarding the full rotation of the marble around an imaginary line will be met by this mechanism.
PR_RQ4	LED Visual	The LED light show will be activated once the entry sensor detects a marble entry.
PR_RQ5	Marble Exit Mechanism	A propulsion mechanism will be used to meet the exit requirements
PR_RQ6	Marble Enter & Exit Speed	The marble exit speed should not exceed the initial marble entry speed.
PR_RQ7	Marble Receiving Mechanism	A marble collector mechanism will be used to control the marbles entering the cube from the bottom.

Interface Requirements

T4M4 DSM	Subsystem ⬇️						
Dependants ➡️		**Arduino Uno**	**Sensors**	**Sensor Communications**	**Sensor Mounting**	**Motors** (Elevation & Salt-grinder System)	**Solenoid** (Expulsion System)
	Arduino Uno	***X***					
	Sensors	X	***X***				
	Sensor Communications	X	X	***X***			
	Sensor Mounting		X	X	***X***		
	Motors (Elevation & Salt-grinder System)	X				***X***	
	Solenoid (Expulsion System)	X	X	X	X		***X***

Figure above depicts T4M4's Design Structure Matrix (DSM).

Interface Signoffs

Group	Name	Contact	Signed
T4S4	Jordan Totenhofer	jordan.totenhofer@students.mq.edu.au	16/08/23
T4C5	Luke Glover	luke.glover@students.mq.edu.au	16/08/23

Inclusions/Exclusions

Inclusions

Inclusion ID	Inclusion	Description
T4M4_IN_01	Marble collection mechanism	Collects marbles upon entry to the bottom of the cube
T4M4_IN_02	Elevator mechanism	Fulfil LC1
T4M4_IN_03	Delay mechanism	Fulfil LC2
T4M4_IN_04	Marble expulsion mechanism	Fulfil LC4

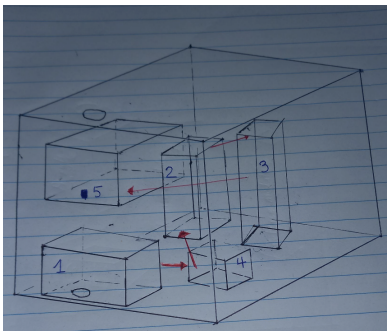
Exclusions

Exclusion ID	Exclusion	Description
T4M4_EX_01	Sensor mounts	Purpose-built mounts for solenoids and electronics
T4M4_EX_02	Sensor communications	Smooth operation of motors and solenoids using sensor inputs

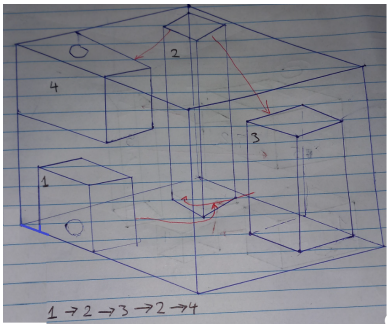
Design Specificaiton

Conceptual Design

Before attempting the conceptual design the team identified the limitations and constraints of the project. This led to the creation of a cube with 5 sections. For each section, we wrote down the requirements we wanted to fulfill in that section. This type of approach made it easy to brainstorm and identify systems that match the criteria we allocated for each specific section.



After discussing the design with the other groups, we decided: section 4 was not required and the elevator mechanism must have 2 pathways.



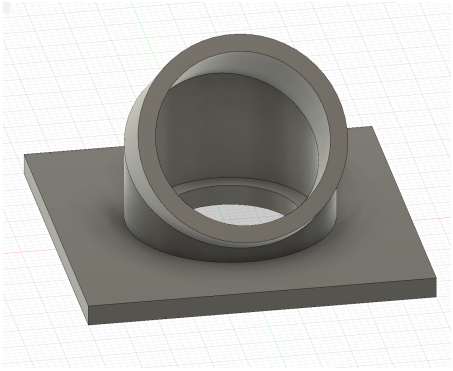
Section 1:Marble Collection Mechanism

Requirements:

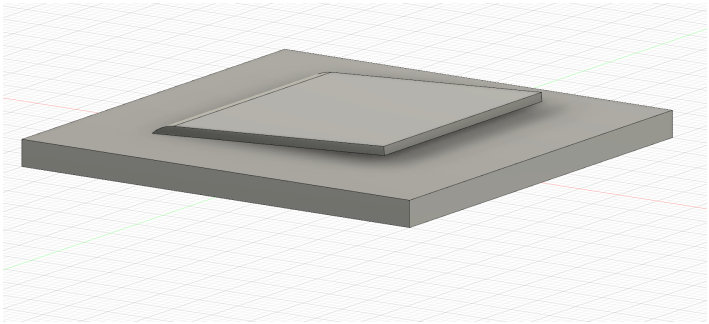
- Collects the marble that enters the box.

Ideas:

- piston with a scooping mechanism
- right-angled pipe



- wheel with magnets
- rubber latch



Section 2: Elevator Mechanism

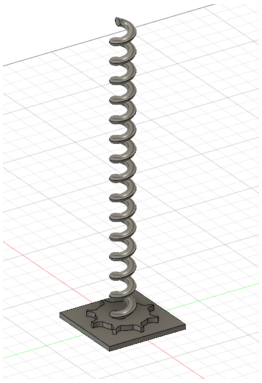
Requirements:

- LC1

Ideas:

- Stair Case

- Conveyer belt with magnets
- Archimedes screw



….

Section 3: Delay mechanism

Requirements:

- LC2

Ideas:

- gate system
- salt shaker mechanism
- ping pong mechanism

Section 4: Marble expulsion mechanism

Requirements:

- LC4
- expel all marbles out from the TOP surface at the specified location so that the marble goes 50 mm above the exit hole.

References

Appendicies