Capstone Design 1
1st Presentation

Group 8

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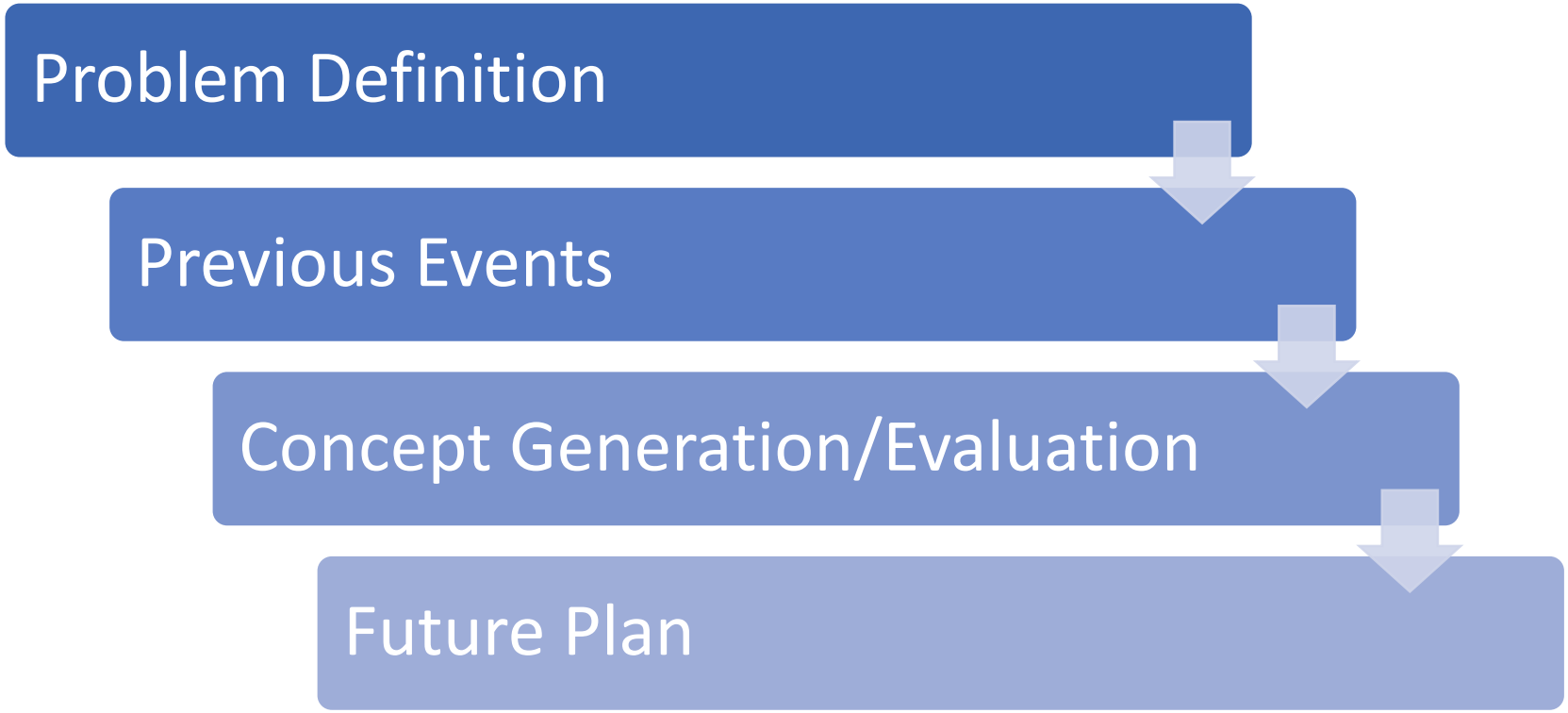
장신원 부준호 김경서 손기영

Outline


Problem Definition
Previous Events
Concept Generation/Evaluation
Future Plan

Problem Definition

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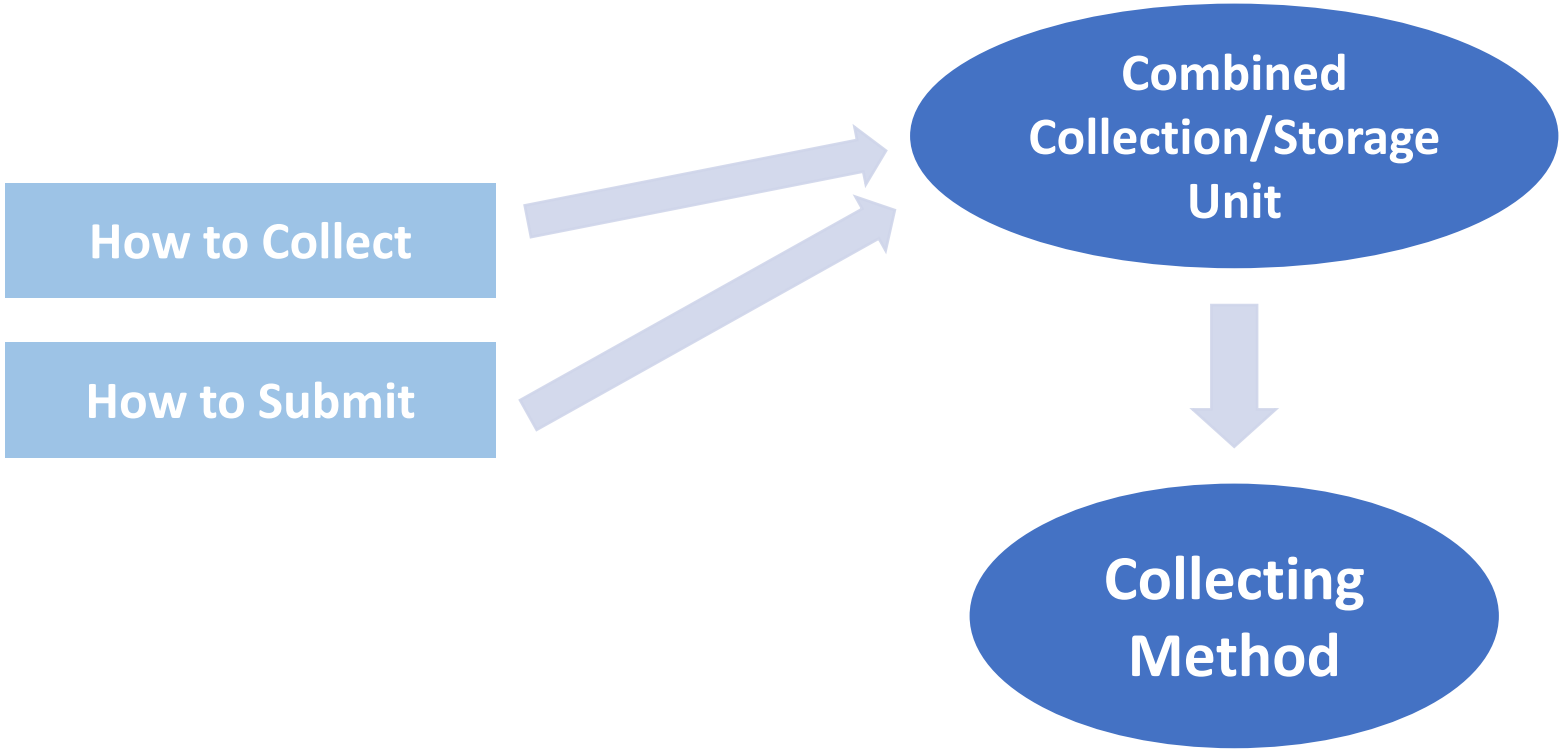

Previous Events

Previous Events

3/7	**1st meeting** with Professor Young Jin Park
3/9	Material distribution
3/12	Brainstorming
3/14	**2nd meeting** with Prof. Park
3/16	Brief meeting after ROS lecture (Deciding concept evaluation method)
3/19	**Concept evaluation** + Specifying corresponding robot concept (storage)
3/21	**3rd meeting** with Prof. Park
3/22	**Preliminary experiment & Concept Finalization**
3/26	**Review** presentation / Presentation Material / Solidworks Drawing
3/27	**4th meeting** with Prof. Park
3/28	**Revise presentation material**

Previous Events + Details

March

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Overall progress

3/7

Leader election

3/12

1. Gantt chart
2. “Collecting” brainstorming
3. Schedule check

3/16

1. Specify goal/Assignment distributed
2. Decide evaluation method

3/19

1. “Collecting” evaluation
   - Sort out best options
   - Use Pugh’s method on remaining options
2. Decide storage method related to the grip method
3. Packaging/wiring – unnecessary to make decision matrix

3/22

1. Preliminary experiment – white band
2. Concept Finalization
3. Presentation preparation

Previous Events + Details

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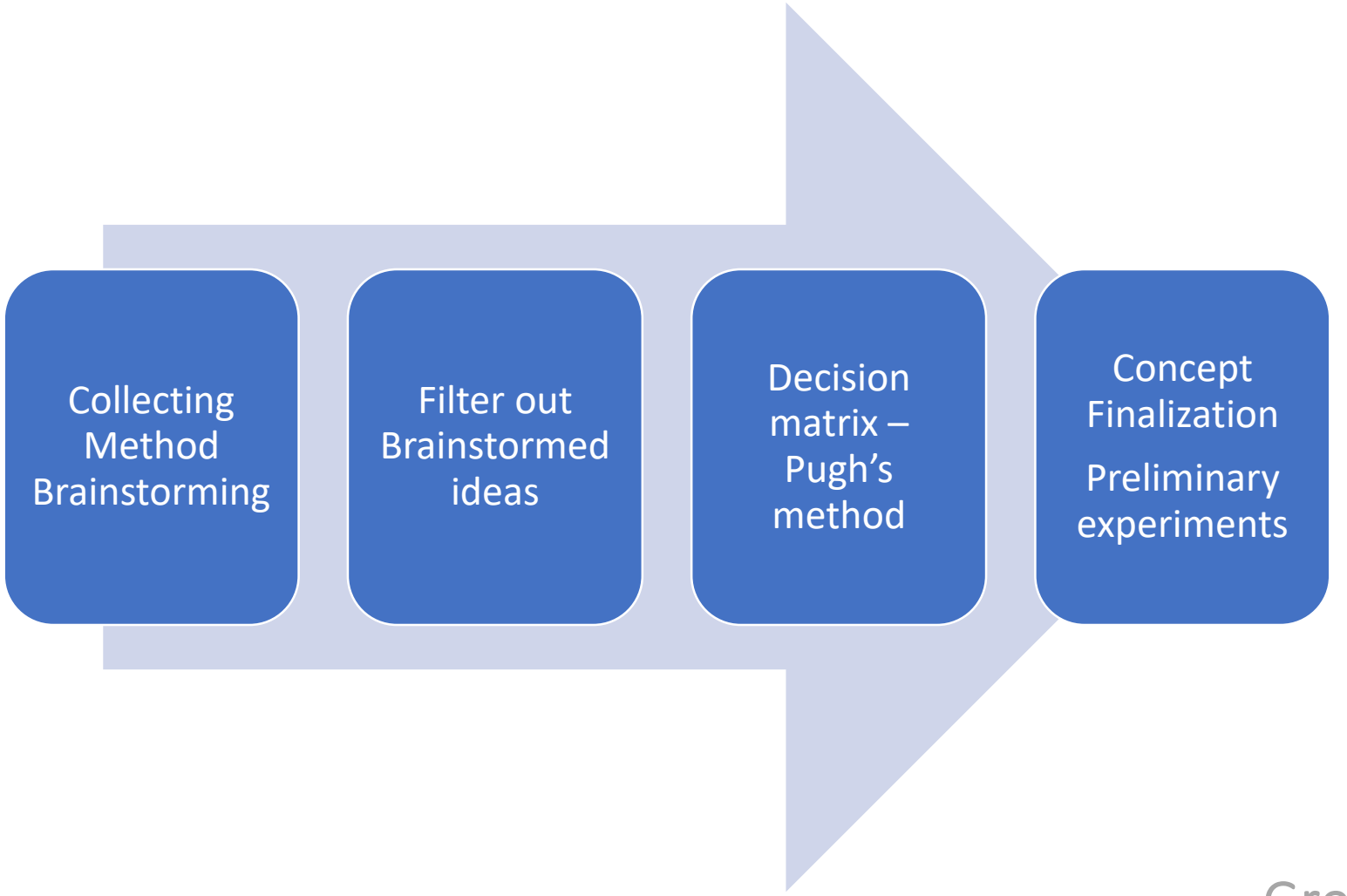
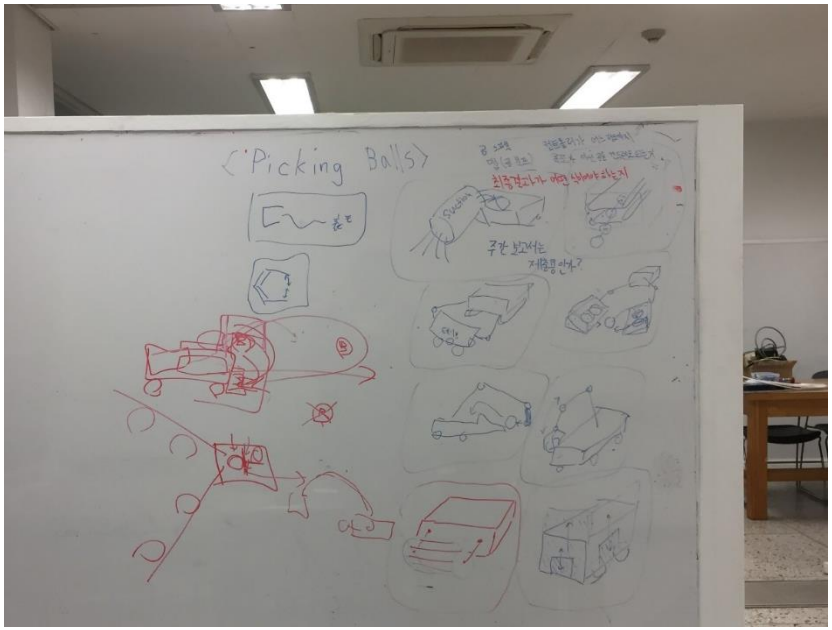
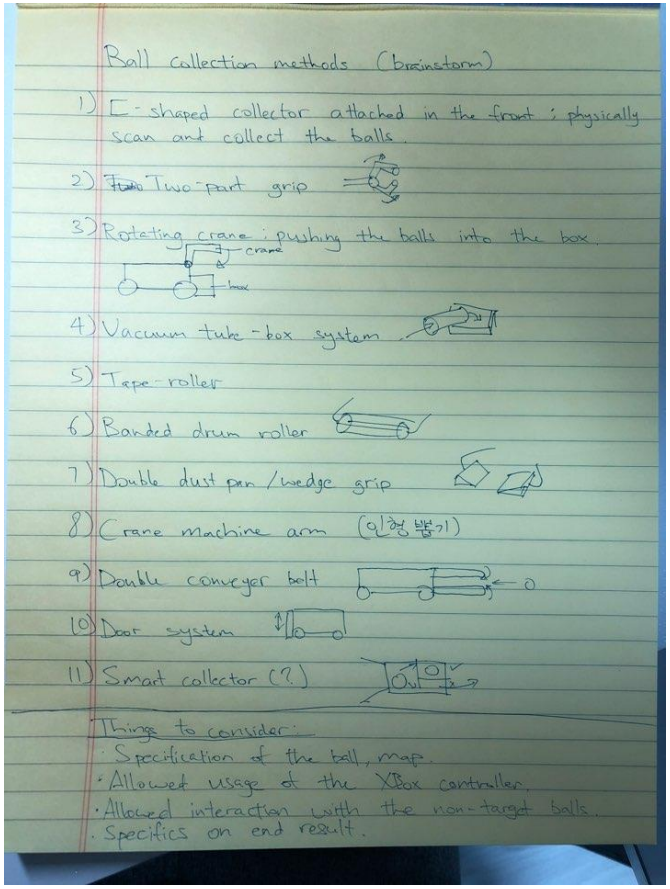
Concept Generation/Evaluation

Concept Generation/Evaluation



[Collecting Method] Brainstorming





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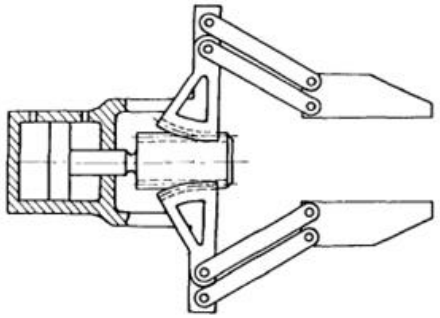
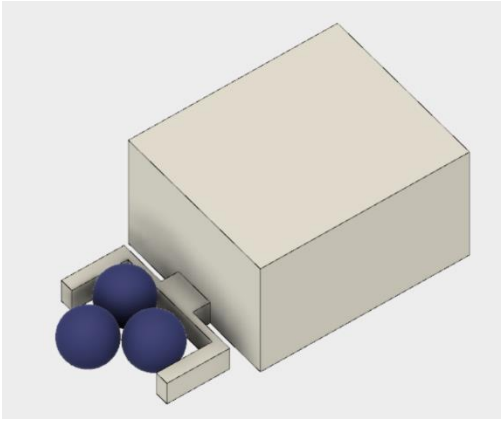
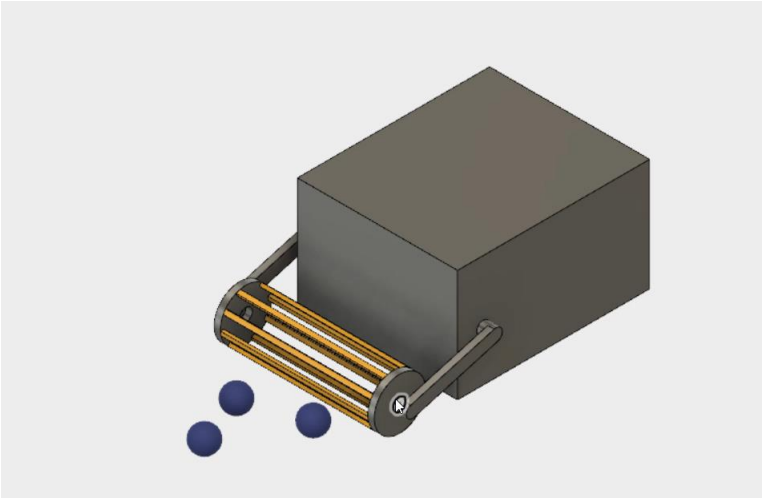
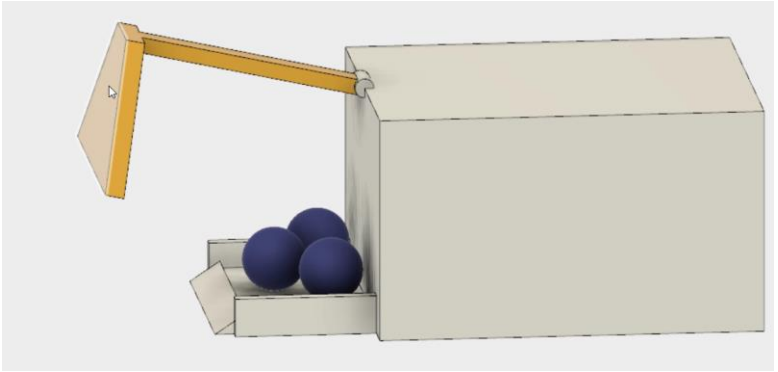








Filter out Brainstormed ideas

- ⊏-shaped collector attached in the front; physically scan and collect the balls
- Two-part (mechanical linkage) grip
- Rotating crane; pushing the balls into the box
- Adhesive tape-roller
- Elastic grid collector (inspired by tennis ball pickup tool)
- Banded drum roller (inspired by tennis ball pickup tool)
- Vacuum tube-box system
- Double dust pan/wedge grip (holes for storage included)
- Double conveyer belt
- Door system
- Sorting after collecting

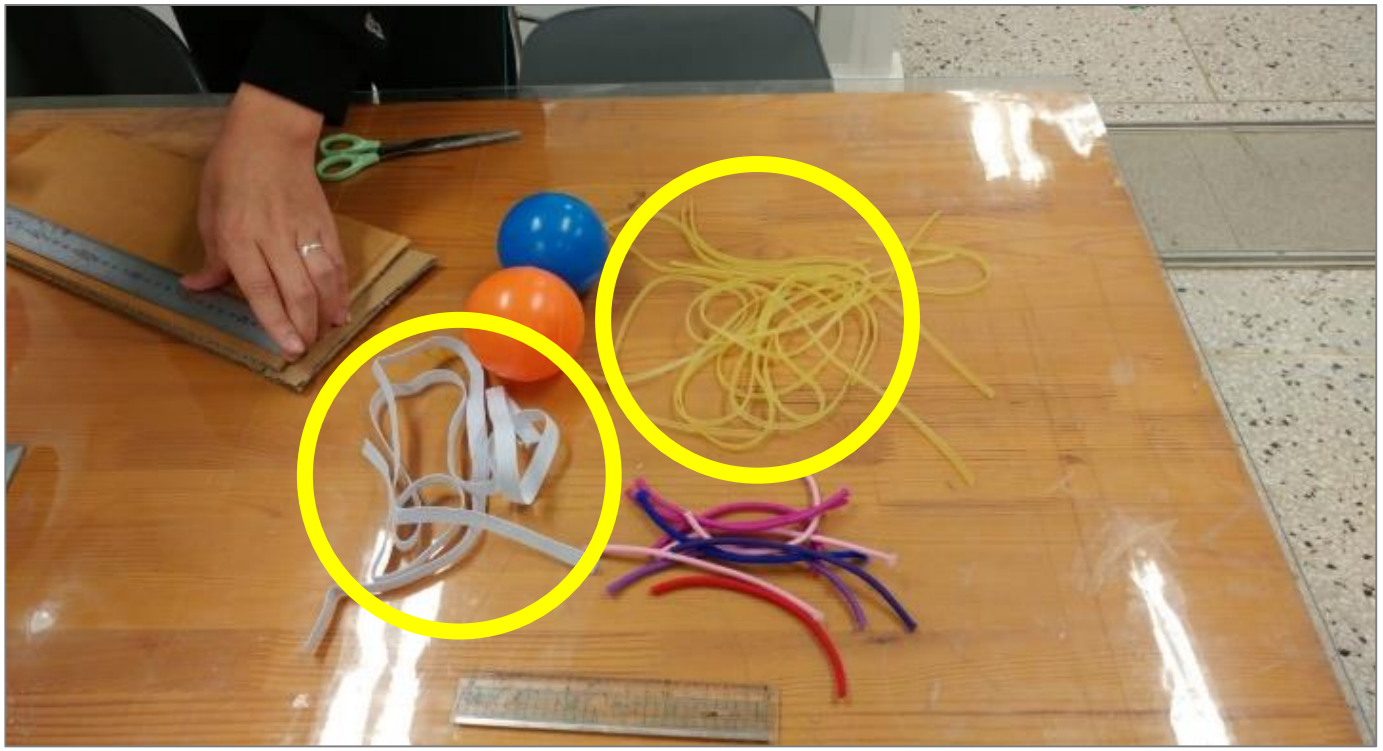
Decision Matrix (modified)

- Pugh's Method

Issue: Collecting		Baseline	Two-part (mechanical linkage) grip	**Rubber band elastic grip**	Vacuum tube	Double dust pan/wedge grip (holes for storage included)
Required Force	15	DATUM	0.53	0.69	0.44	0.33
Weight	10		0.50	0.48	0.25	0.22
Grip accuracy	25		0.59	0.70	0.81	0.83
Grip to storage acc	20		0.50	0.80	0.83	0.50
Assembly	15		0.65	0.42	0.61	0.48
Creativity	15		0.18	0.67	0.3	0.7
	Total		2.95	3.76	3.24	3.06
	Weighted total		0.5015	0.6500	0.5960	0.5560

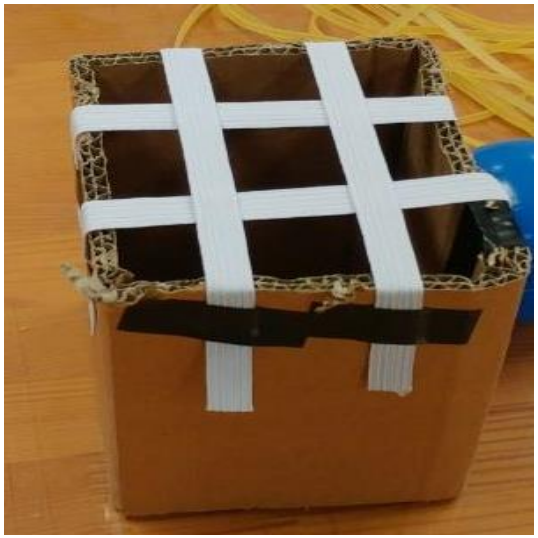
Preliminary Experiment

- Preparation

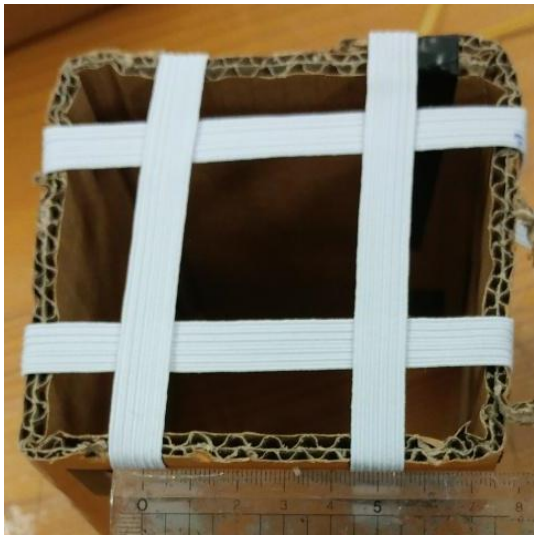


Preliminary Experiment

- Grid structure with white band



4cm
(band gap)

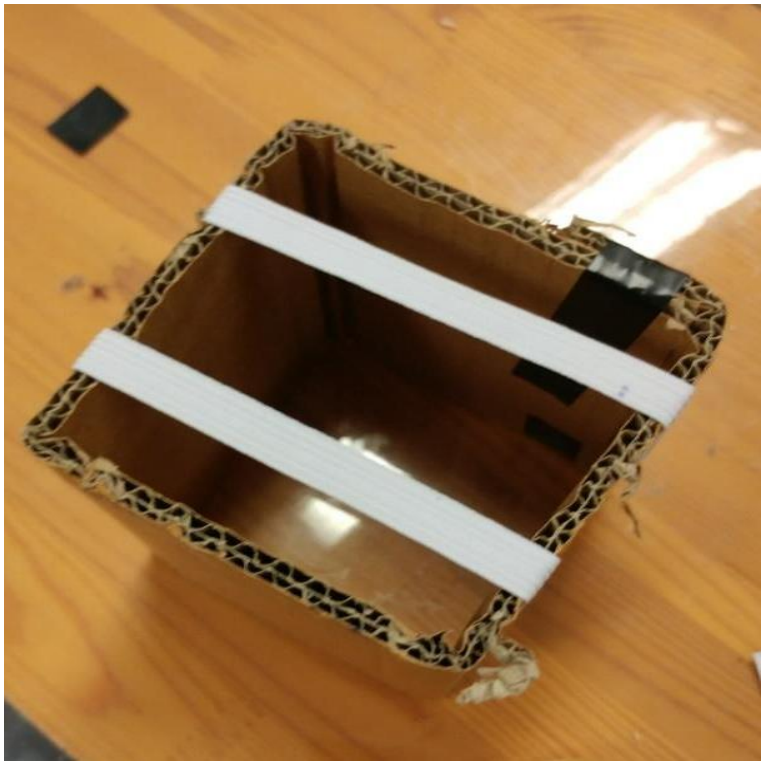


5cm

6cm

Preliminary Experiment

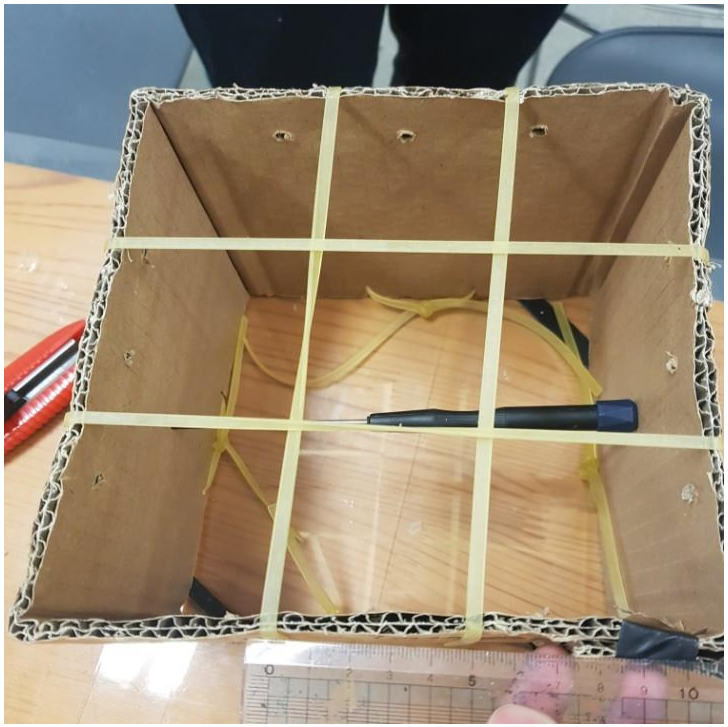
- Parallel structure with white band



5cm of center to center distance

Preliminary Experiment

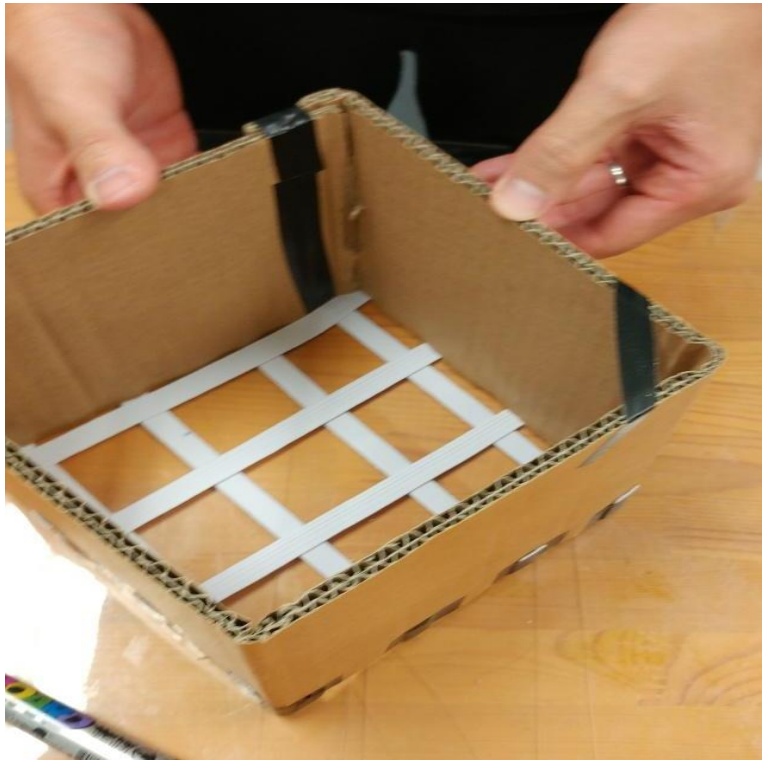
- Grid structure with rubber band



5cm of center to center distance

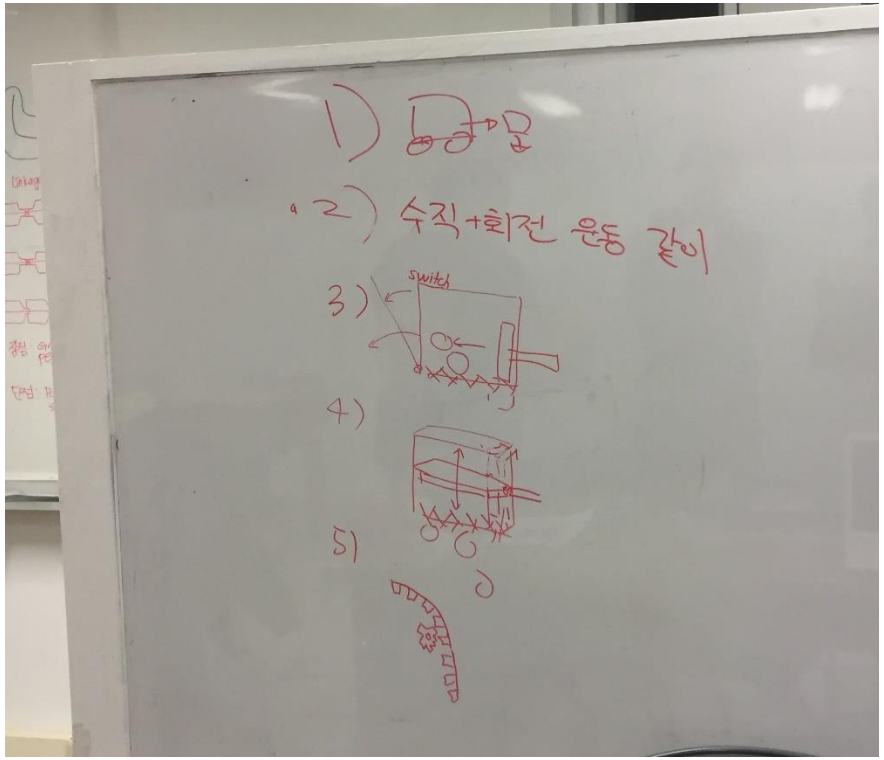
Preliminary Experiment

- Experiment Result



- Grid structure
- White band
- 5cm of center to center distance

Concept Details/Finalization



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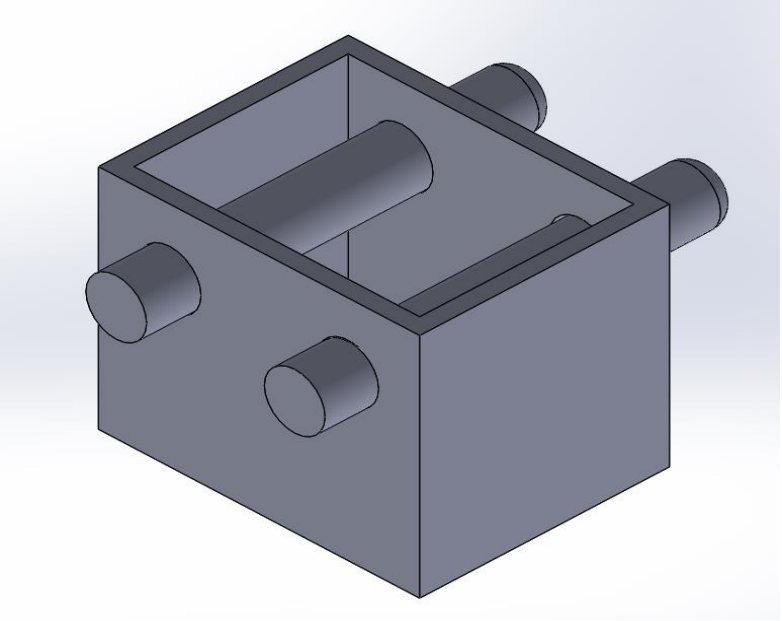
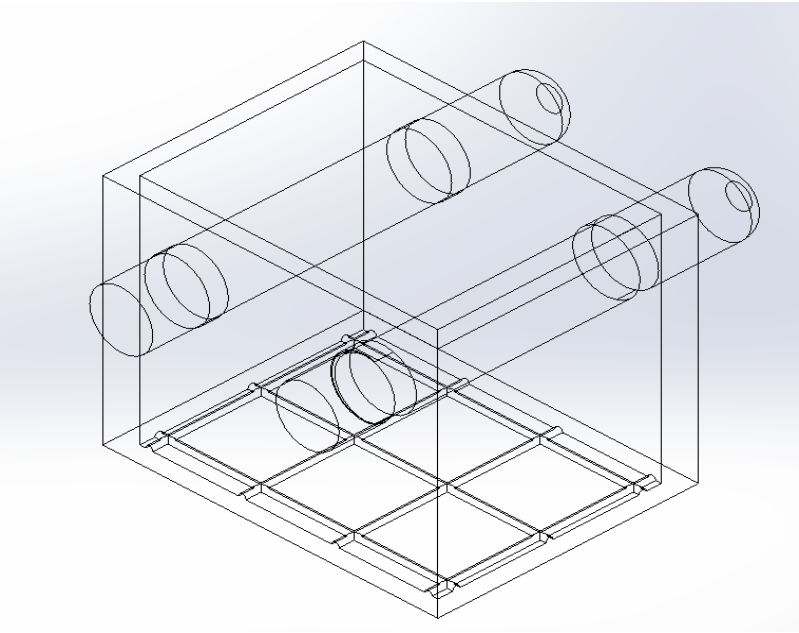


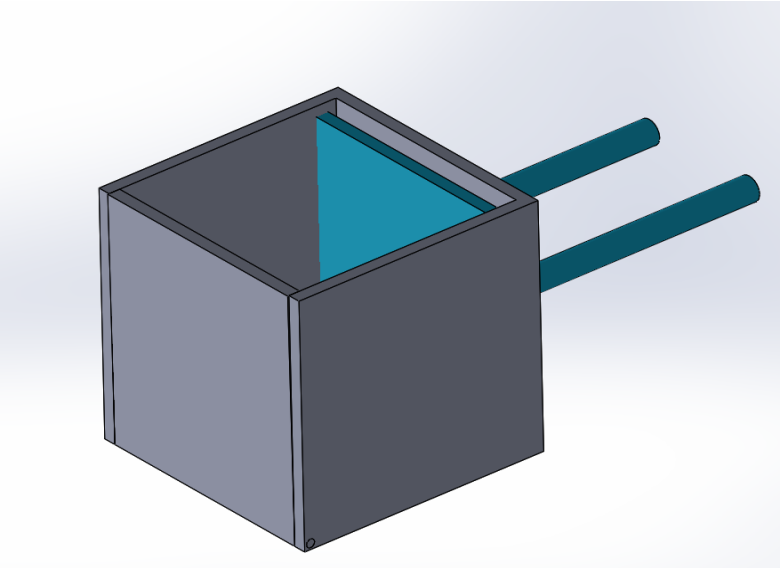


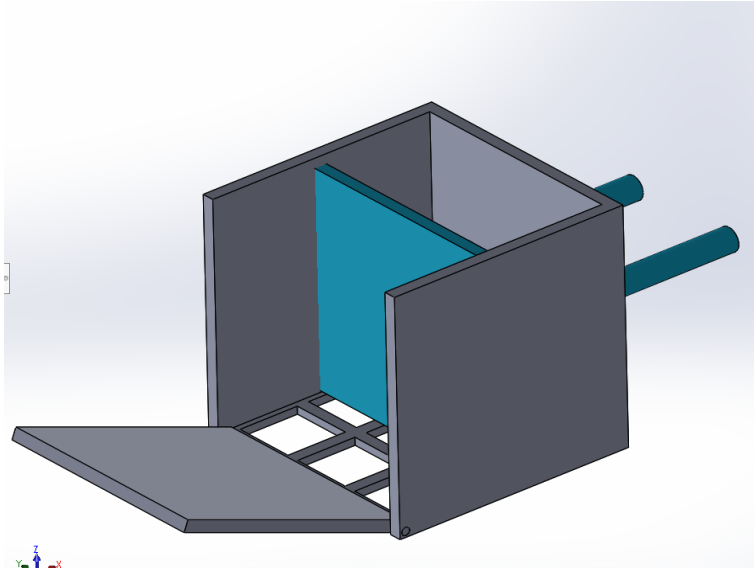
1) Abort internal storage
    1) Collect the balls
    2) Drop the whole storage on basket

Tuck the internal storage on the edge of basket, and back up

Quite risky (creative or pathetic)

Concept Details



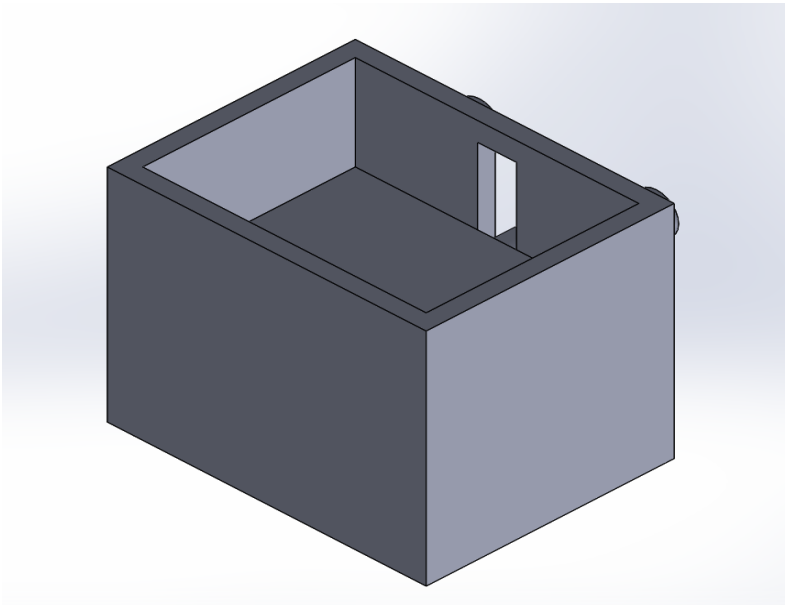


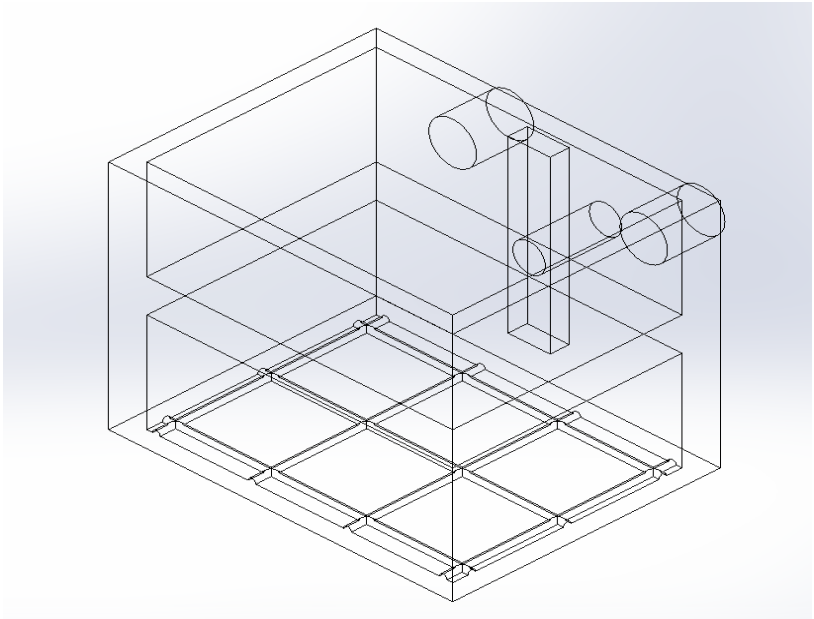
3) Vertical plate in internal storage
    1) Collect the balls
    2) Push the vertical plate forward
    3) Front door of the storage opens and balls spill out

Requires two motors

Requires switch mechanism

Concept Details





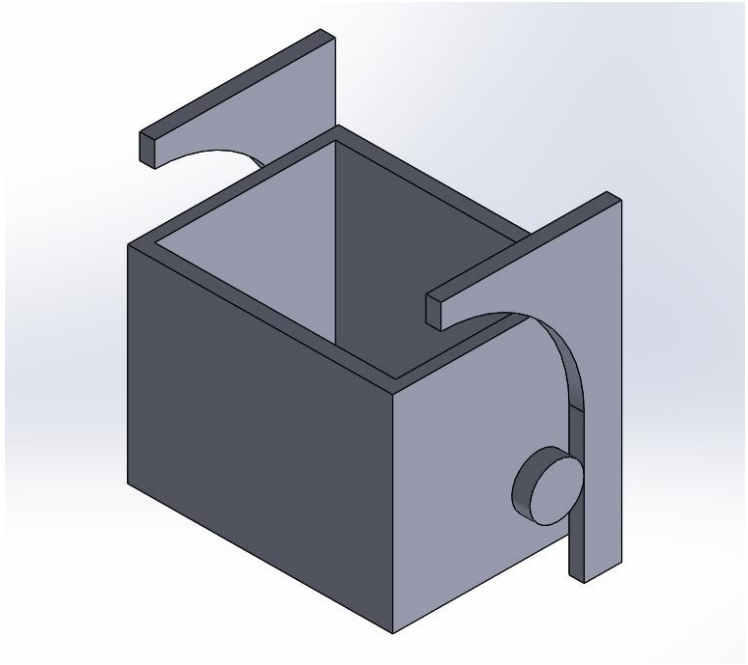
4) Horizontal plate in internal storage
    1) Collect the balls
    2) Locate the storage above the basket
    3) Let go the horizontal plate
    4) Balls penetrate the net below

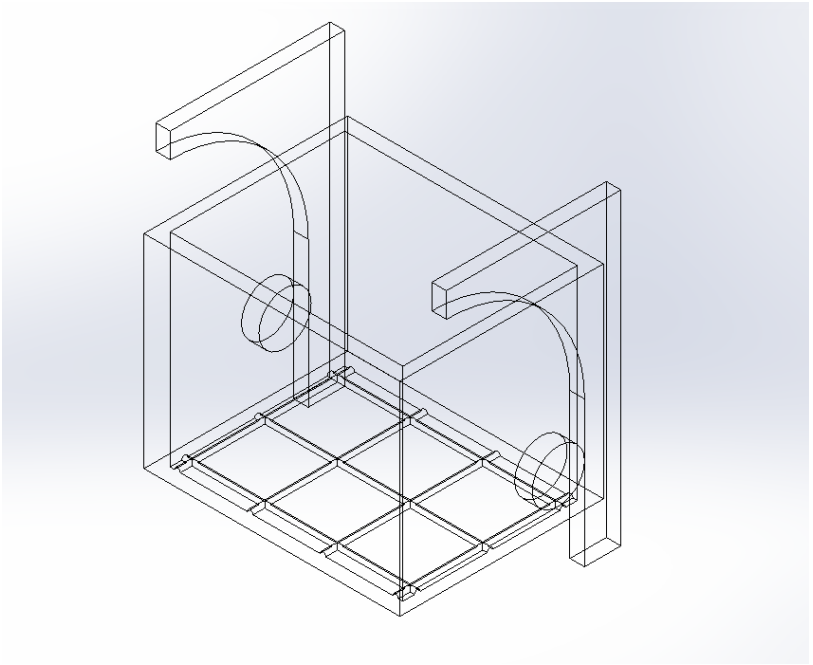
Requires two motors

Balls might get stuck

Horizontal plate may not drop evenly

Concept Details

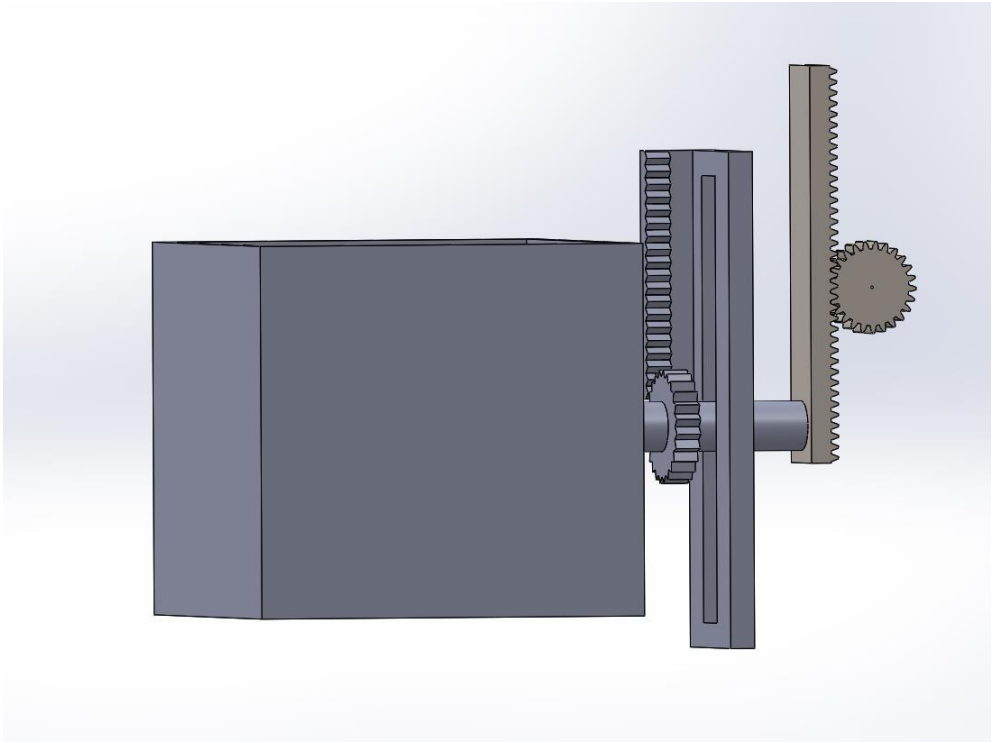




5) Two gears
    1) Collect the balls
    2) Lower portion of gear : vertical motion only
    3) Upper portion of gear : rotational motion
    4) Internal storage tilts and the balls fall out

Big workspace, bulky

Concept Details



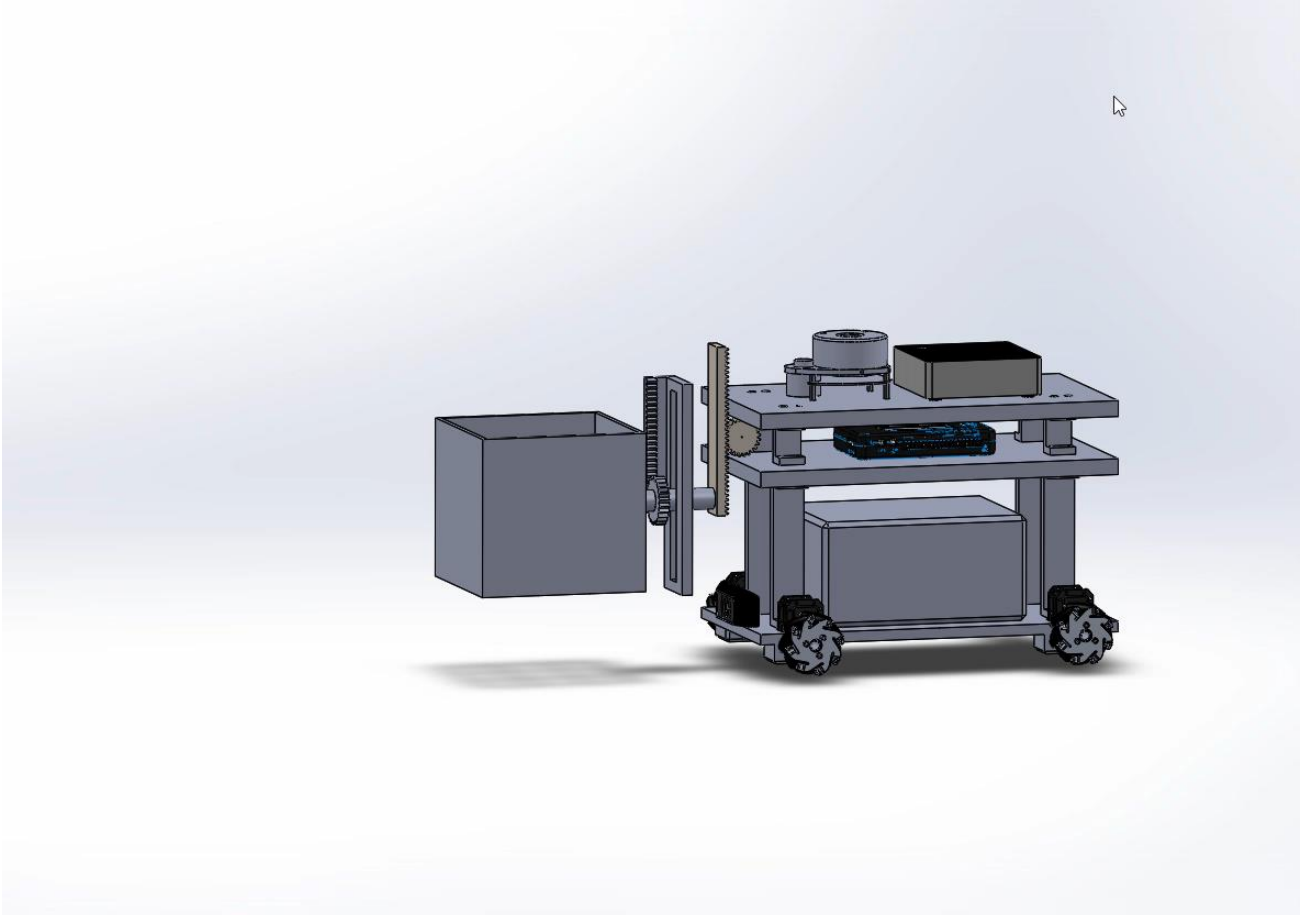
2) Rotate the internal storage
+ Rack and Pinion

Translational + Rotational movement

Gear manufacture

Rack and Pinion

Concept Finalization



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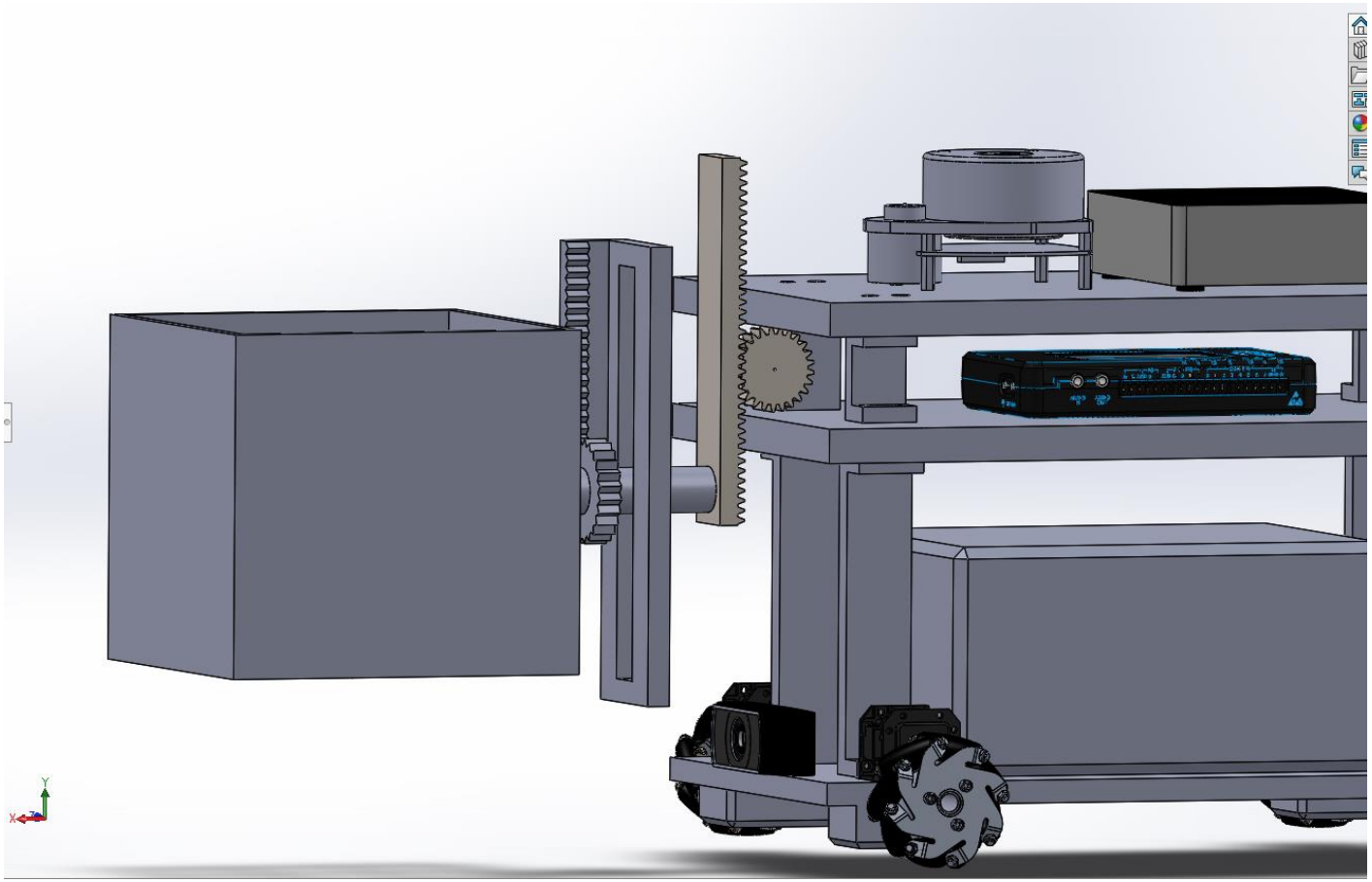

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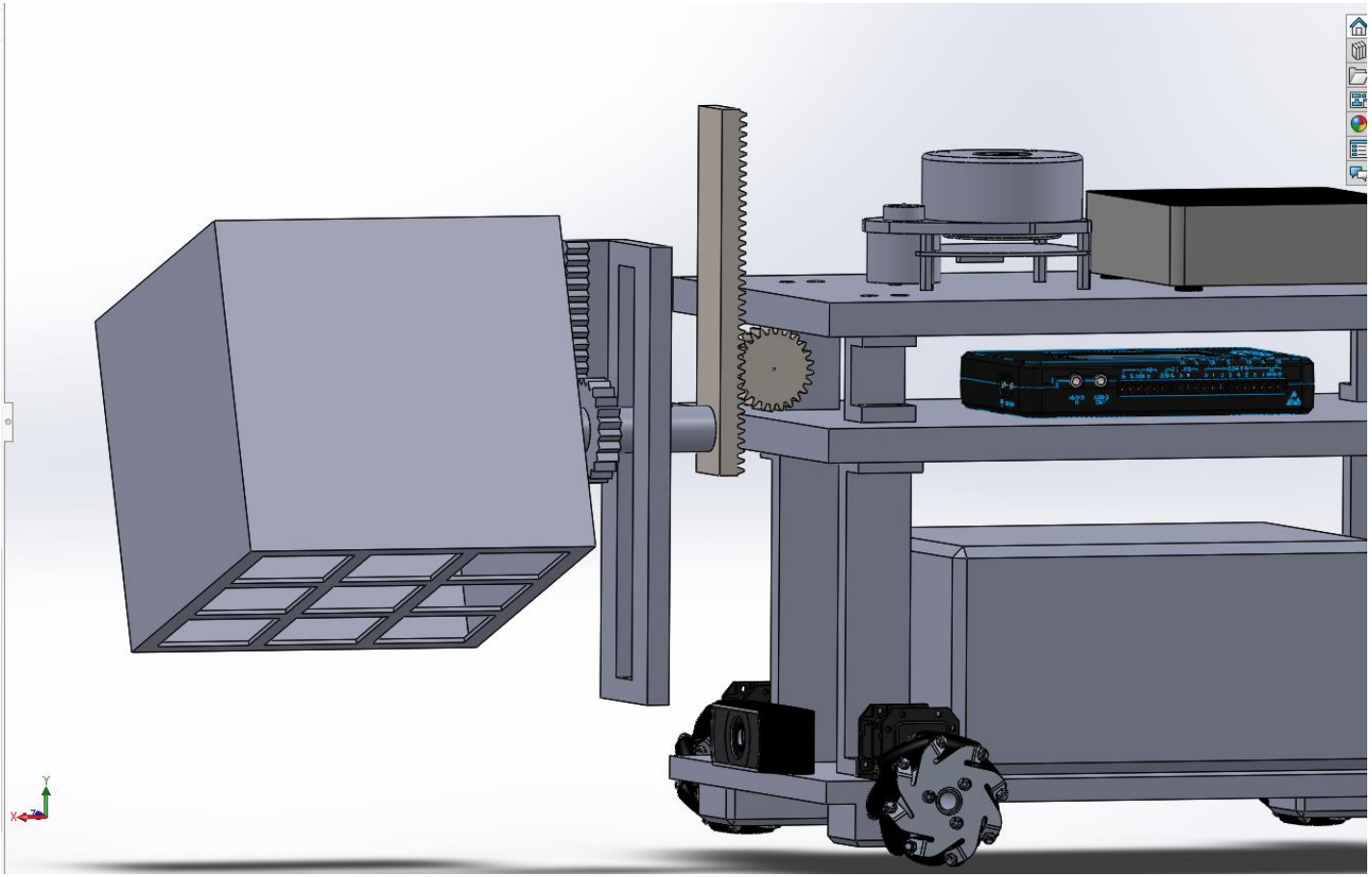

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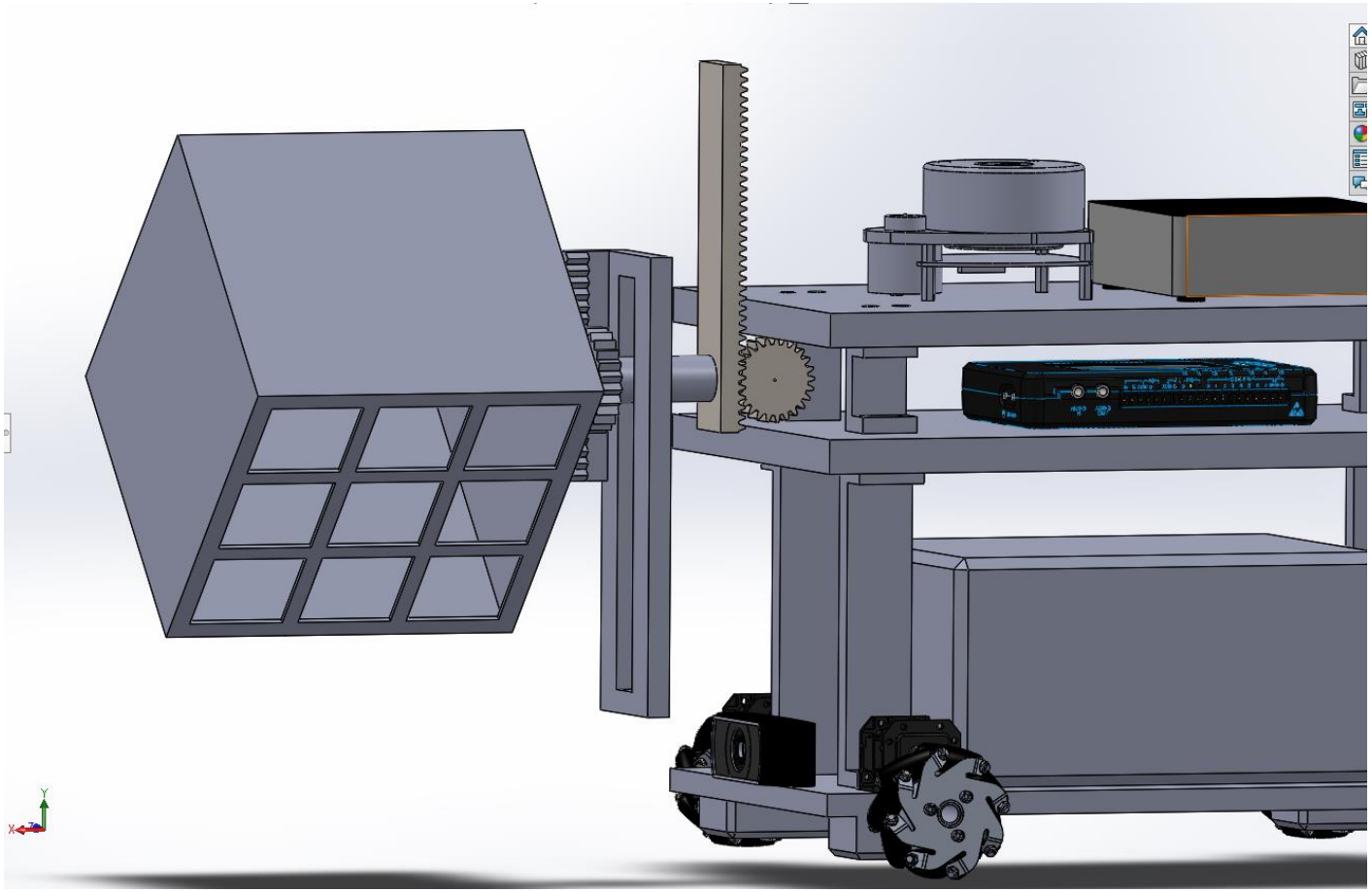

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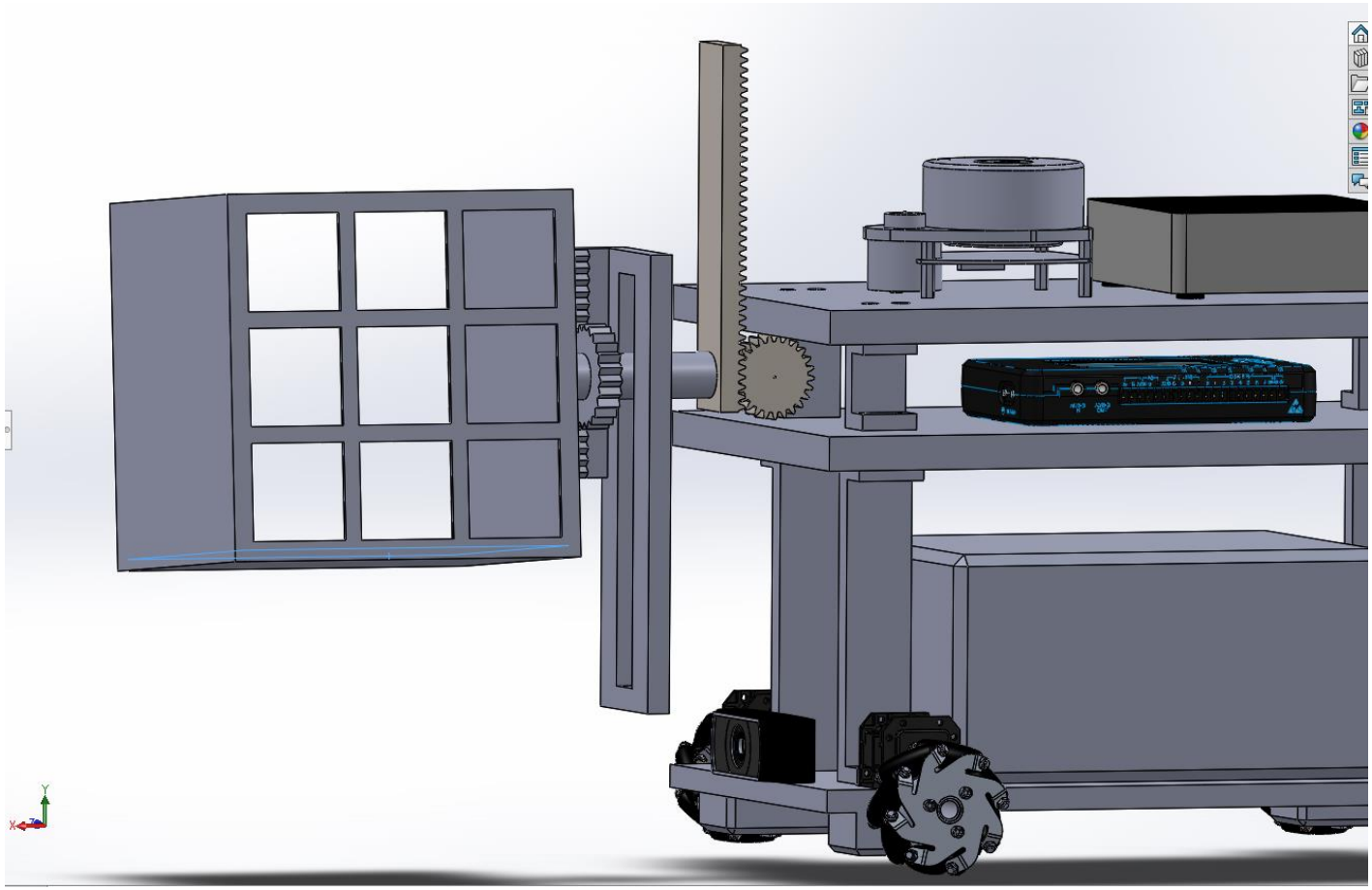


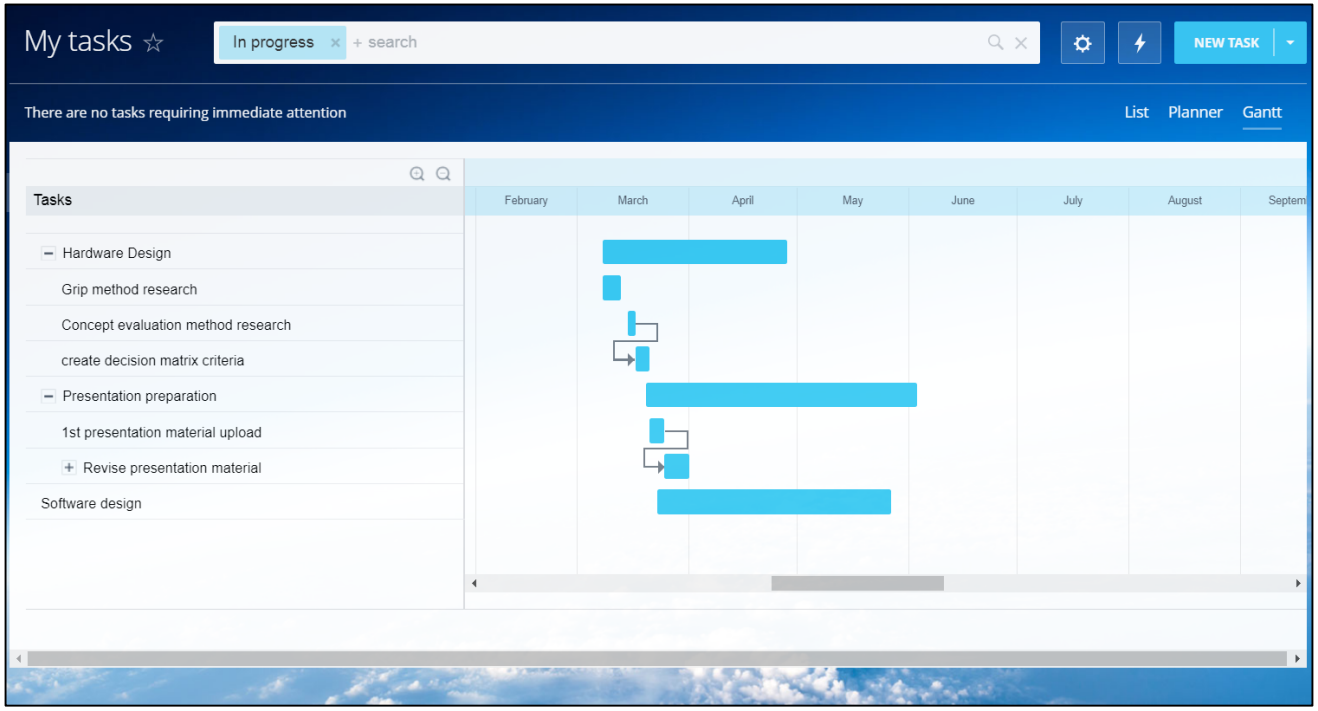
Future Plan

Future Plan

- Improve Scheduling
- Separate plans on each part
- Improve final concept
- Engineering Problems

Improve Scheduling

- Bitrix24



Future Plan

Improve Scheduling

Separate plans on each part

Improve final concept

Engineering Problems

Engineering Problems

Gear Ratio

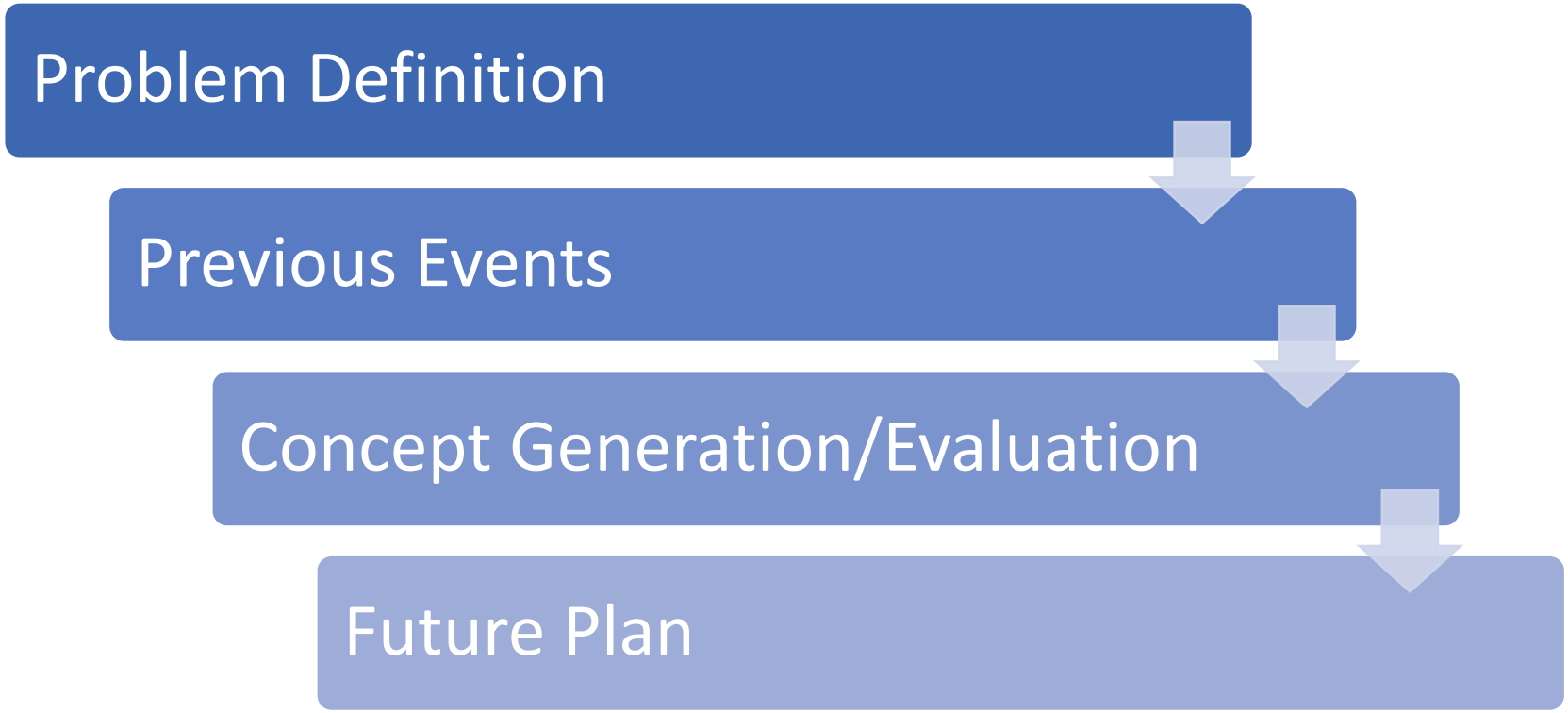
Required force to collect balls

Robot vibration control

Collector shape

Battery pack, PMS heat management

Outline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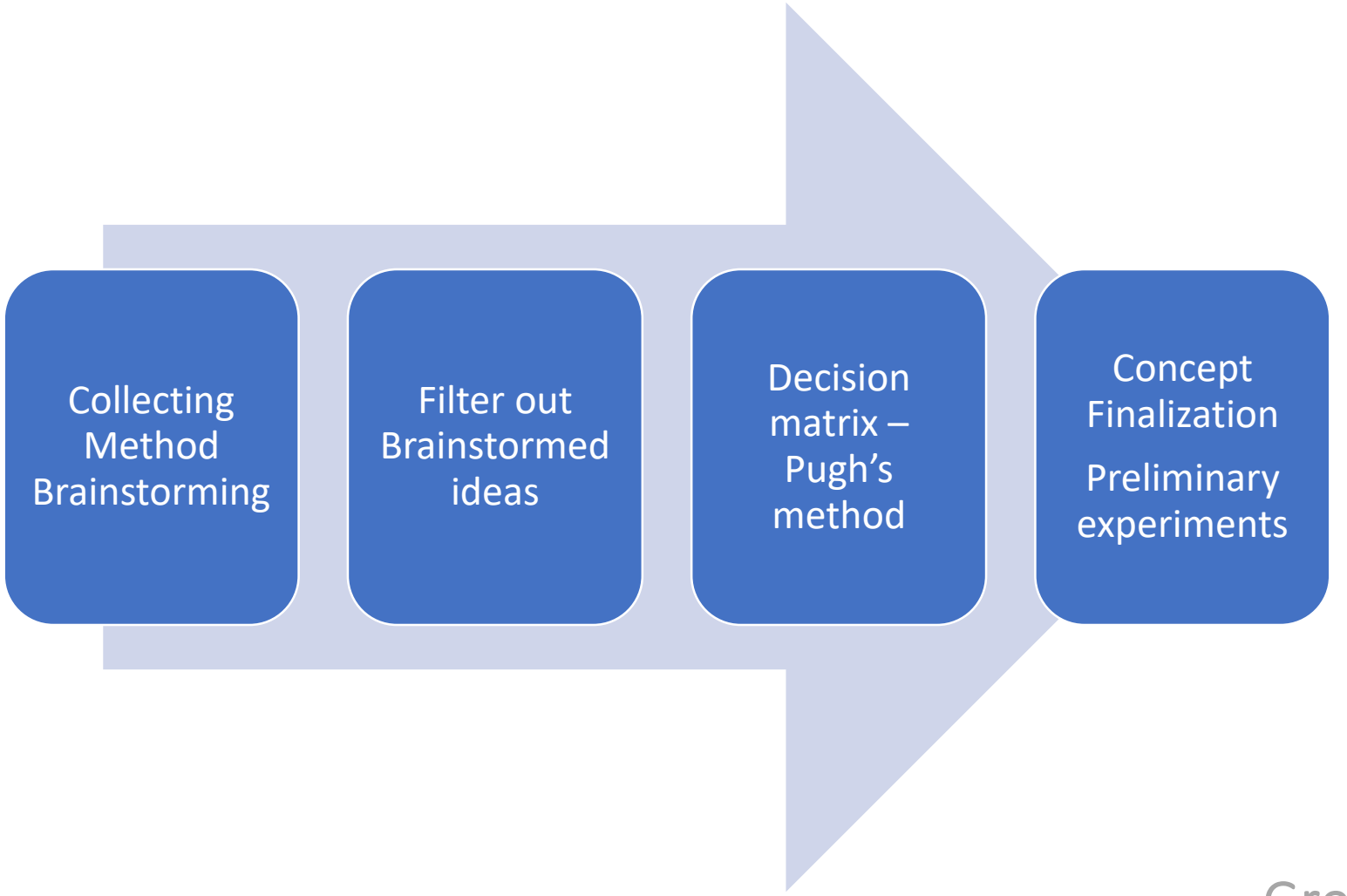
Thank you

Concept Generation/Evaluation



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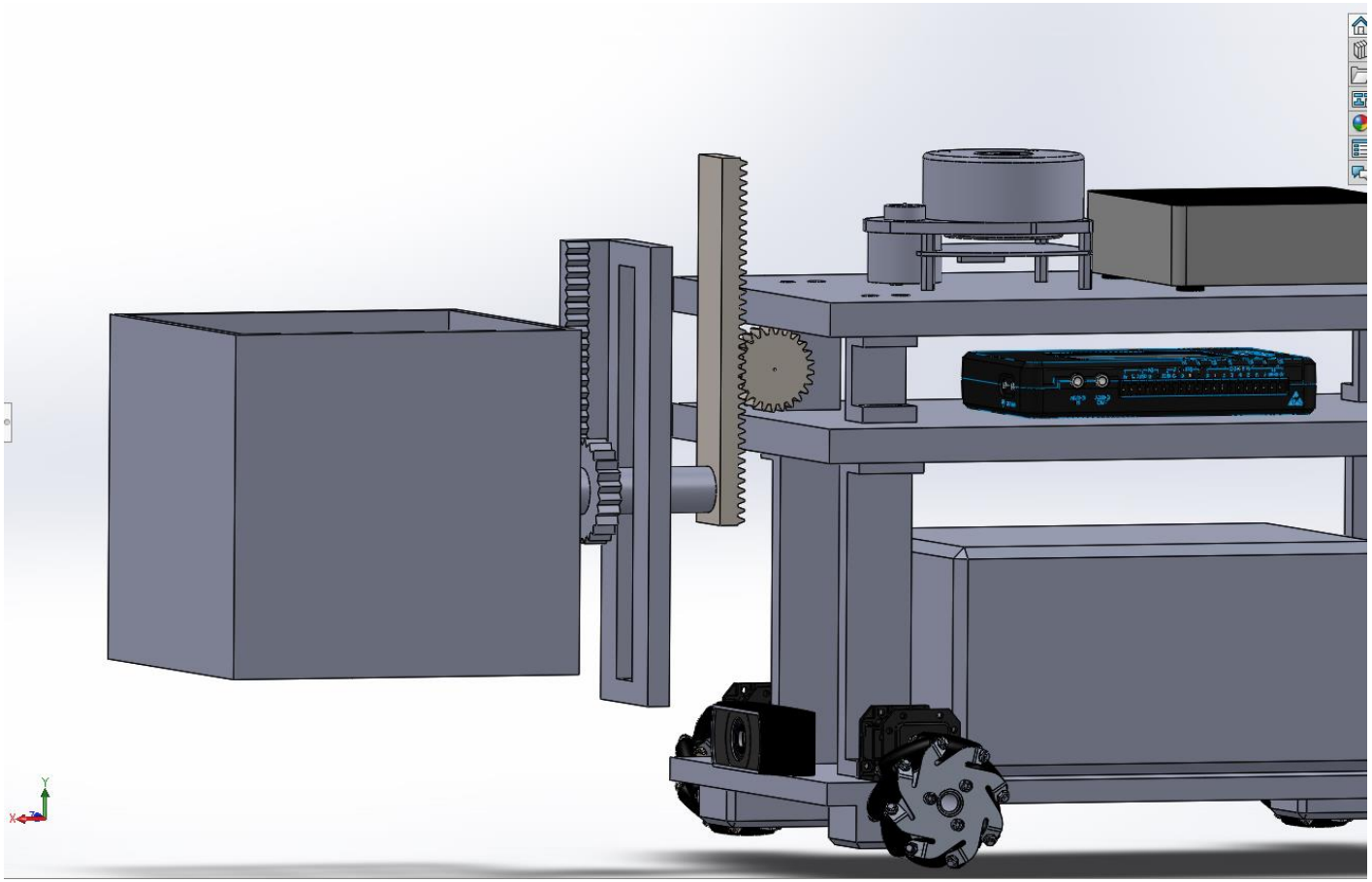

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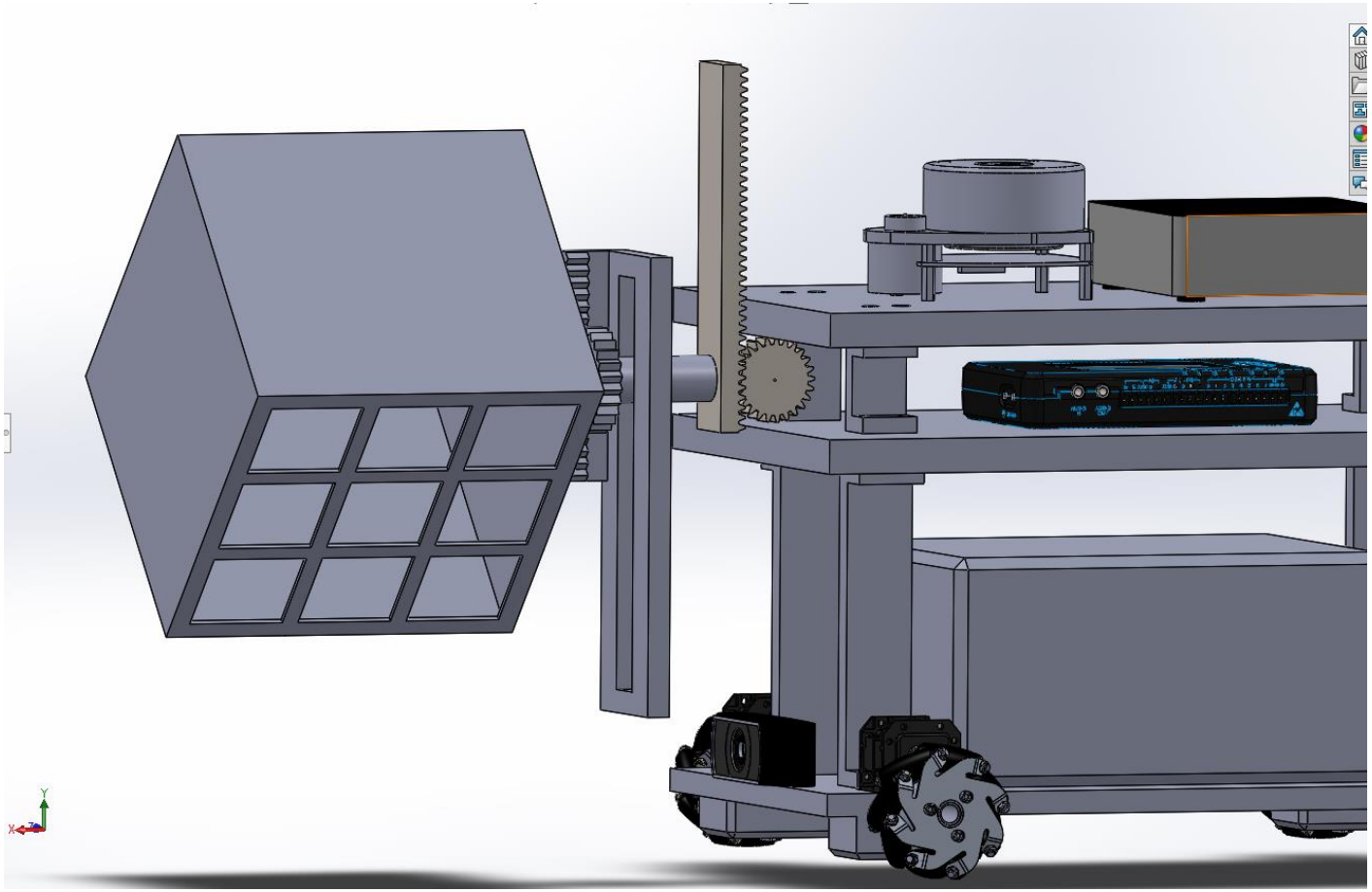
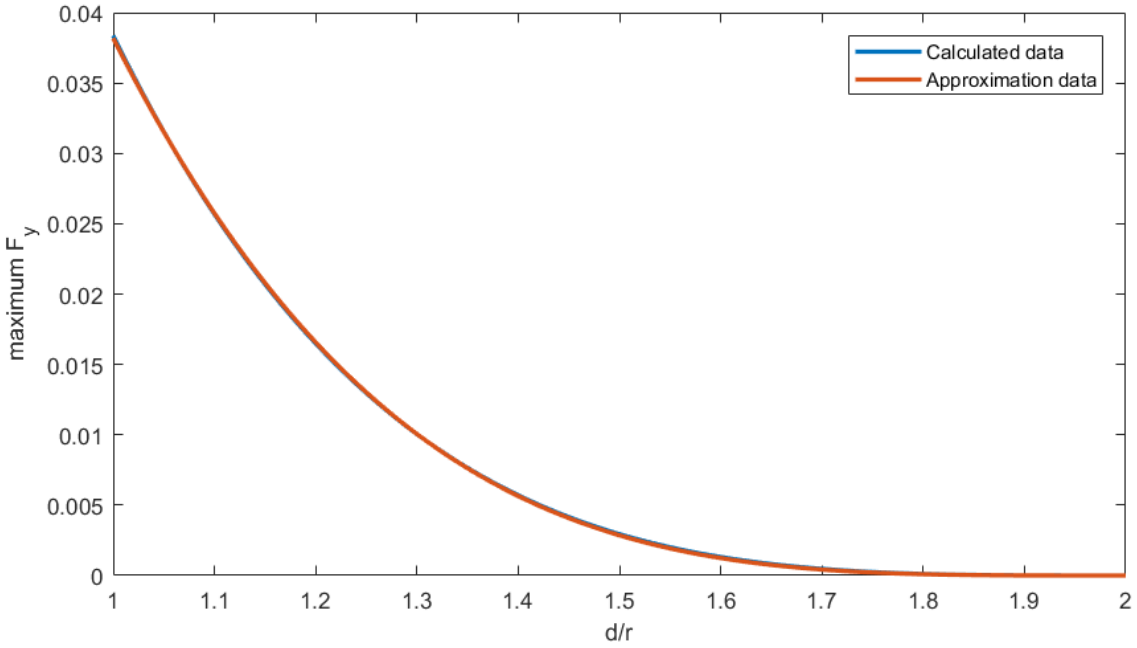


Required force to collect the balls

$$\mathrm{F_{y,max}}(d) = \frac{16kr^3}{L^2} \times 0.0382 \times \left(2 - \frac{d}{r}\right)^{3.7419}$$

k : Spring constant
r : radius of ball
L : length of band
d : band gap



Calculation for collecting ball with elastic band

조현근

1. Assumptions

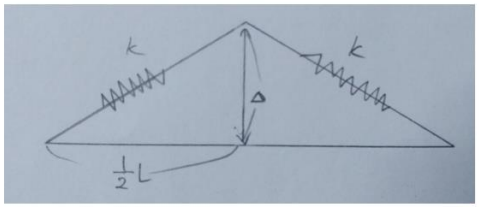


Figure 1 Structure Assumption

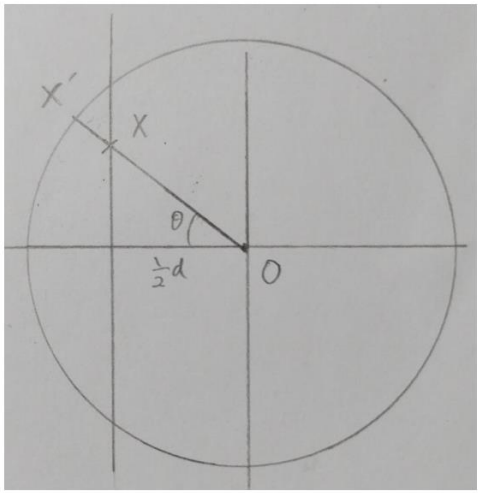


Figure 2 Band Direction assumption

Assumption 1 - Ball is small enough to assume the 2-springs structure like Fig.1

Assumption 2 – Band will move to the point on the surface of the ball which is nearest from its original position, X'.

Assumption 3 – $\Delta << L$

2. Structure estimation

From assumption 1, the length change of each spring is $\sqrt{L^2/4+\Delta^2}-L/2$. From assumption 3, it can changed into

$$\frac{L}{2}\left(1+\frac{4\Delta^2}{\mathrm{L}^2}\right)^{\frac{1}{2}}-\frac{\mathrm{L}}{2}\cong\frac{L}{2}\left(\frac{1}{2}\frac{4\Delta^2}{L^2}\right)=\frac{\Delta^2}{L}$$

Net force occurs to the direction of Δ, so net force is

$$2k\frac{\Delta^2}{L}\cdot\frac{2\Delta}{L}=4k\frac{\Delta^3}{L^2}$$

3. Force estimation

From figure 2, we can know that the nearest point on the ball surface from the original position X is X′. So Δ is $\mathrm{r}-(\mathrm{d}/2)\cdot\sec\theta$. Thinking 4 elastic bands, the force applies to the moving direction F_y is:

$$\mathrm{F_y}=4\times4k\frac{\Delta^3}{L^2}\sin\theta=\frac{16k}{L^2}\left(r-\frac{d}{2}\sec\theta\right)^3\sin\theta$$

To get maximum force,

$$\frac{L^2}{16k}\cdot\frac{\partial F_y}{\partial\theta}=\left(\mathrm{r}-\frac{\mathrm{d}}{2}\sec\theta\right)^2\left[\cos\theta\left(r-\frac{d}{2}\sec\theta\right)-\frac{3}{2}d\tan^2\theta\right]=0$$

$$\mathrm{r}\cos\theta-\frac{d}{2}-\frac{3}{2}d\tan^2\theta=\mathrm{r}\cos\theta+d-\frac{3}{2}d\sec^2\theta=0$$

$$\therefore\cos^3\theta+\frac{d}{r}\cos^2\theta-\frac{3}{2}\frac{d}{r}=0$$

Getting $\cos\theta$ by each value of d/r by Matlab, F_y can be re-written as

$$\mathrm{F_y}=\frac{16kr^3}{L^2}\left(1-\frac{\mathrm{d}}{2\mathrm{r}}\frac{1}{\cos\theta}\right)^3\sqrt{1-\cos^2\theta}$$

Assuming $\mathrm{F_y}=A\left(2-\frac{d}{r}\right)^B$, from least square method with Matlab, we could get

$$\mathrm{F_{y,max}}(d)=\frac{16kr^3}{L^2}\times0.0382\times\left(2-\frac{d}{r}\right)^{3.7419}$$

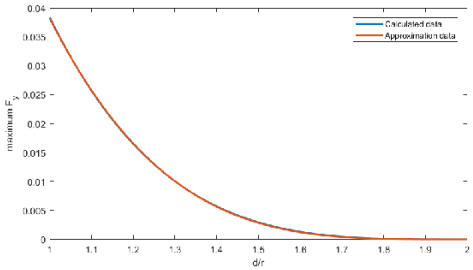


Figure 3 Plot of calculated F_y and F_y driven from least square method

4. Escape energy estimation

From assumption 2, the ball can escape when the ball approach to the θ=0. As the vertical movement of the ball y is $y = \frac{1}{2}d\tan\theta$, we can get energy equation as:

$$W = \int F_{y,\max} dy = \int_{\theta_0}^{0} \frac{16kr^3}{L^2}\left(1 - \frac{d}{2r}\sec\theta\right)^3 \sin\theta \cdot \frac{1}{2}d\sec^2\theta\, d\theta$$

$$\tau = \sec\theta, d\tau = \sin\theta\sec^2\theta\, d\theta$$

$$W = \int_{\frac{2r}{d}}^{1} \frac{8kr^3 d}{L^2}\left(1 - \frac{d}{2r}\tau\right)^3 d\tau$$

$$t = 1 - \frac{d}{2r}\tau, -2r \cdot dt = d \cdot d\tau$$

$$\therefore W = \int_0^{1-\frac{d}{2r}} -\frac{16kr^4}{L^2} t^3 dt = -\frac{4k}{L^2}\left(r - \frac{d}{2}\right)^4$$

So, the ball need to have the kinetic energy more than $-W$ to escape from the elastic band structure.