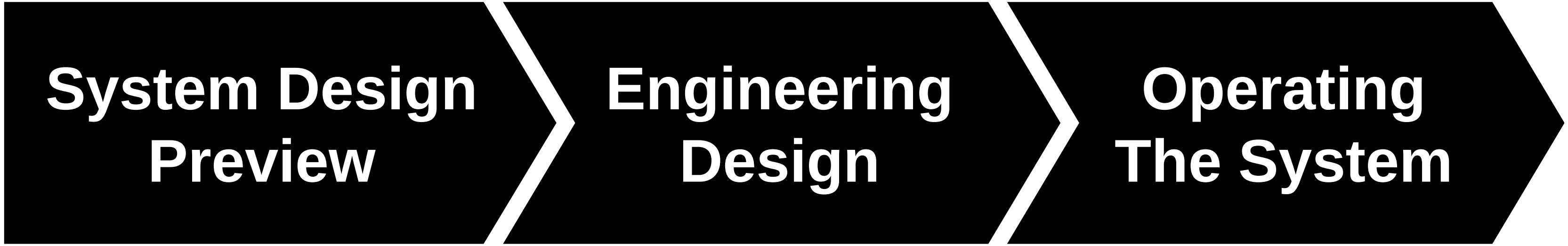
ESCALATOR

Capstone Design II
prof. 김형수, TA 이경은
Team members: 류준일, 류현준, 박지환, 조인준, 최호열, 이관협, 장준호


System Design Preview
Engineering Design
Operating The System

SYSTEM DESIGN PREVIEW

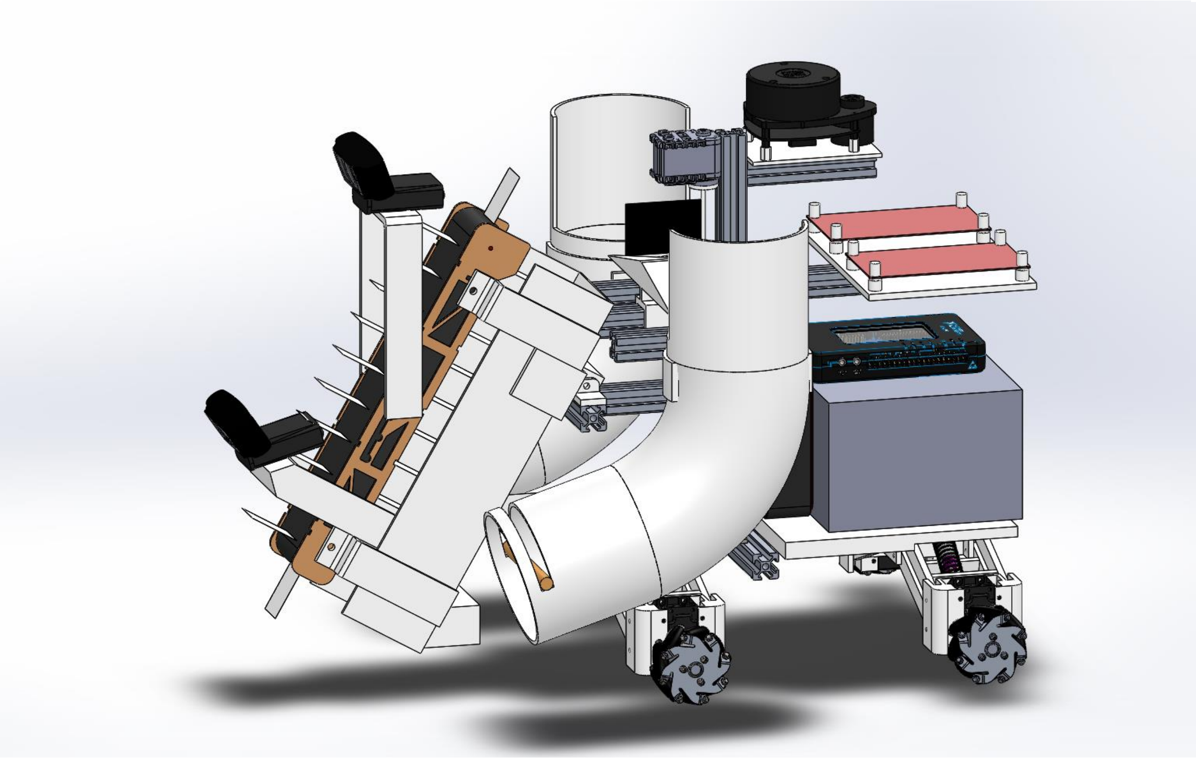
1.

CONTENTS

- Explanations on Each Parts
- Ball Collecting-Releasing Process

Ball Collecting-Releasing Process

Explanation on Each Parts



ENGINEERING DESIGN FOR CORE PARTS

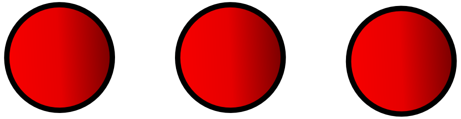
2.

CONTENTS

- **Design for Driving**
- Designing Suspension
- Design for Ball-Collecting

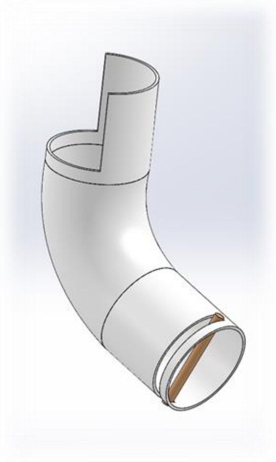
Comapact Design for Narrow Maze vs. Large Volume for Ball Collection

- **Additional Volume Needed(Constraint)**
  - ✓ 3 more balls



  - ✓ Jetson

  - ✓ Storage
  - ✓ Separator

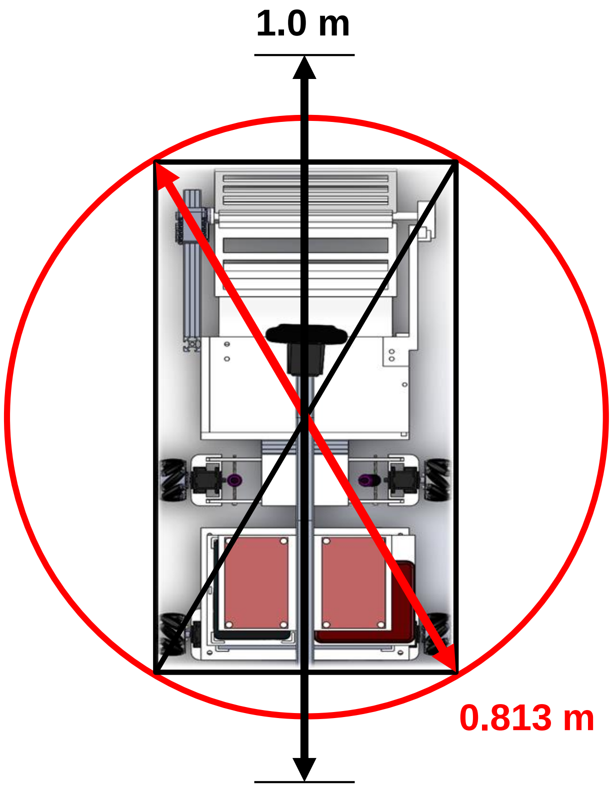


Design Goal

- **Goal : Decrease Diagonal Length to…**

  1) **Enhance movement through maze**

  2) **Minimize unnecessary touch with balls and walls**



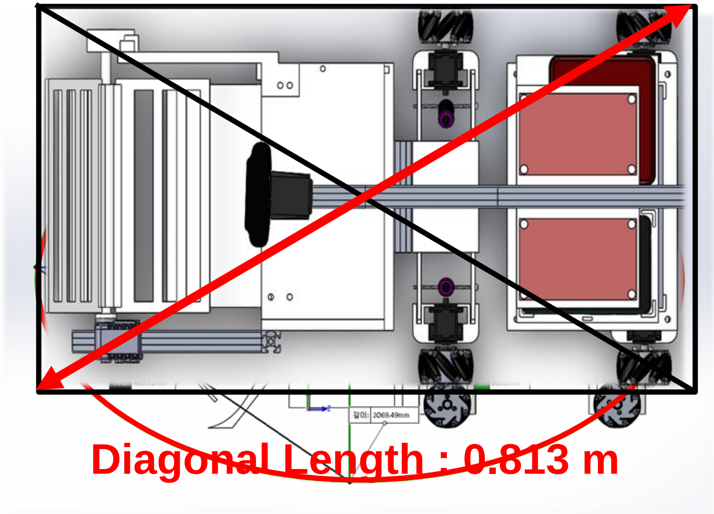
Solving Contradiction

- Problem Solving – TRIZ method
  1) 5. Area of moving object vs. 7. Volume of moving object

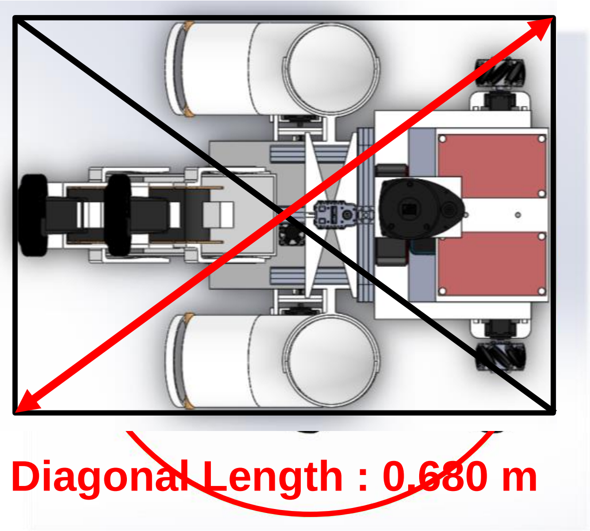
- Inventive Principles from TRIZ method
  1) 14. Spheroidality
  2) 17. Another dimension

Solution : Spheroidal Packaging by TRIZ

- Using Spheroidality & Another dimension



Diagonal Length : 0.813 m



Diagonal Length : 0.680 m

ENGINEERING DESIGN FOR CORE PARTS

2.

CONTENTS

Ground Contact

Assumption

1. Mass of the sub-parts = 0
2. 2D Motion
3. Robust gap of 20mm

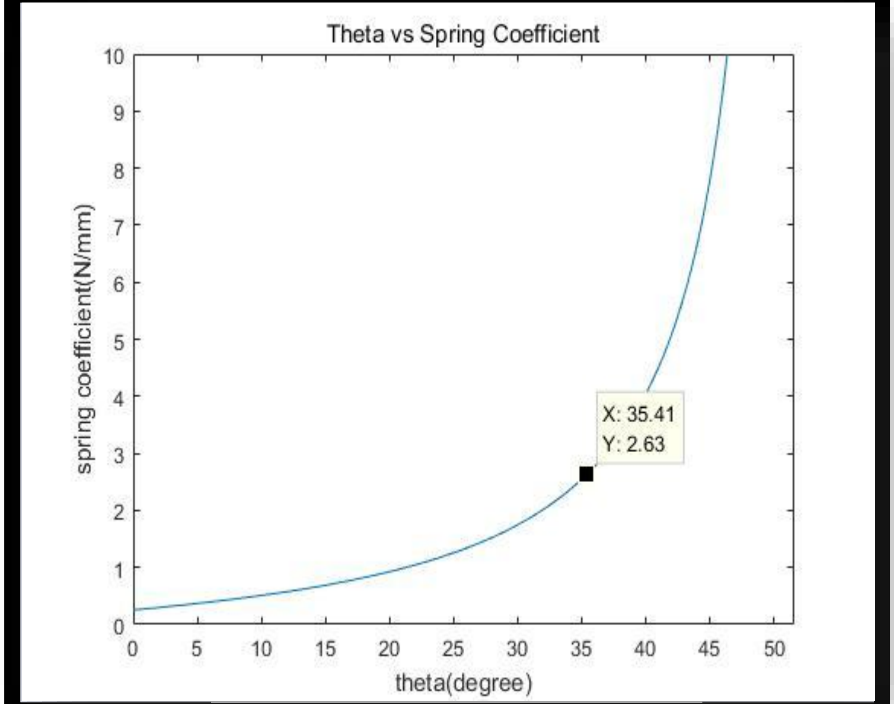
Governing Equation

$$k(y_0 - y) = \frac{Nl}{l'\sin(\emptyset - \theta)}\left(\cos\theta + \frac{2(c+a)}{b}\sin\theta\right)$$

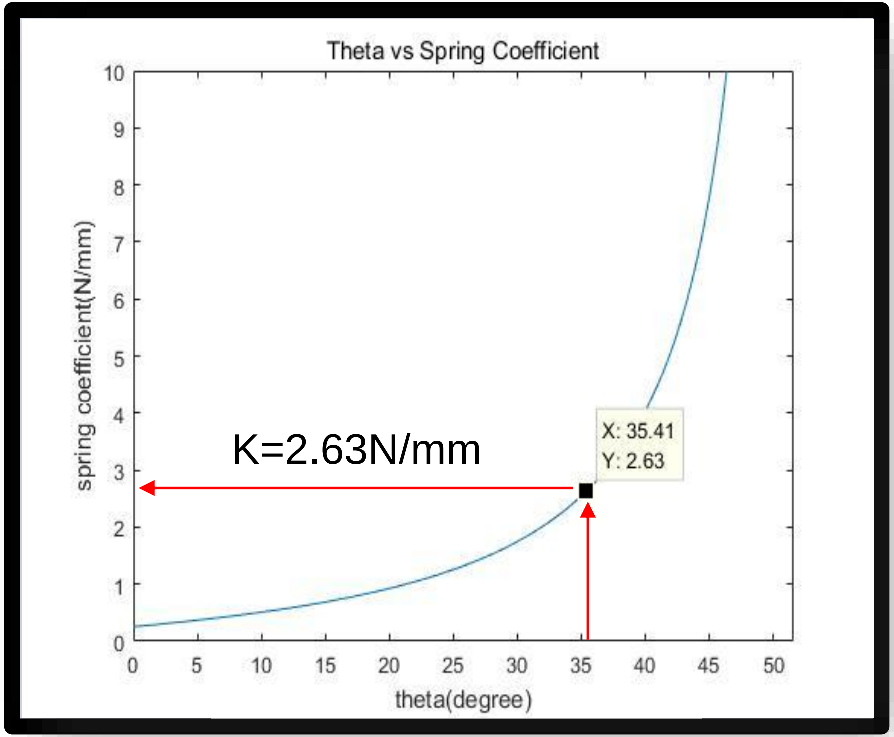
$$y\sin\emptyset = l'\sin\theta + b$$

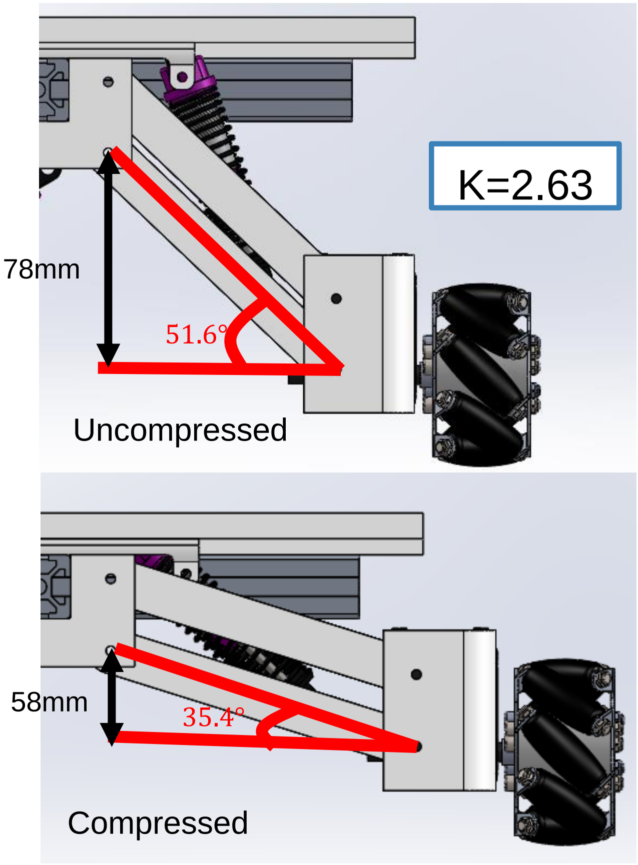
$$y\cos\emptyset = l'\cos\theta - d$$

$$\emptyset = tan^{-1}\left(\frac{l'\sin\theta + b}{l'\cos\theta - d}\right)$$



Ground Contact





Anti-Dive

Assumption

1. 2D Motion
2. COM angular acc. zero on dive
3. Uniform traction force
4. β very small

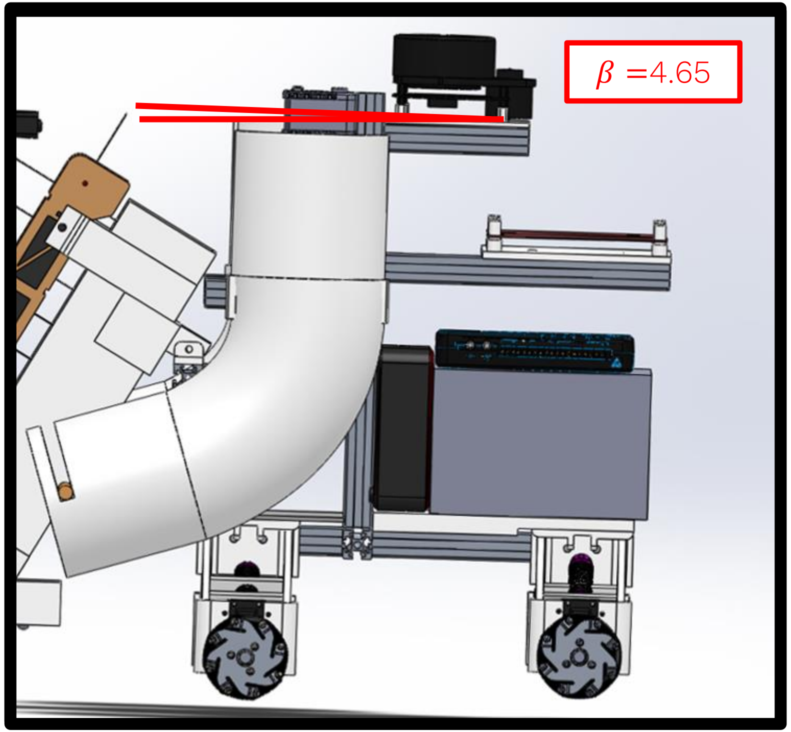
Equation Of Motion

$$\Sigma F_x = f_1 + f_2 = Ma_x$$

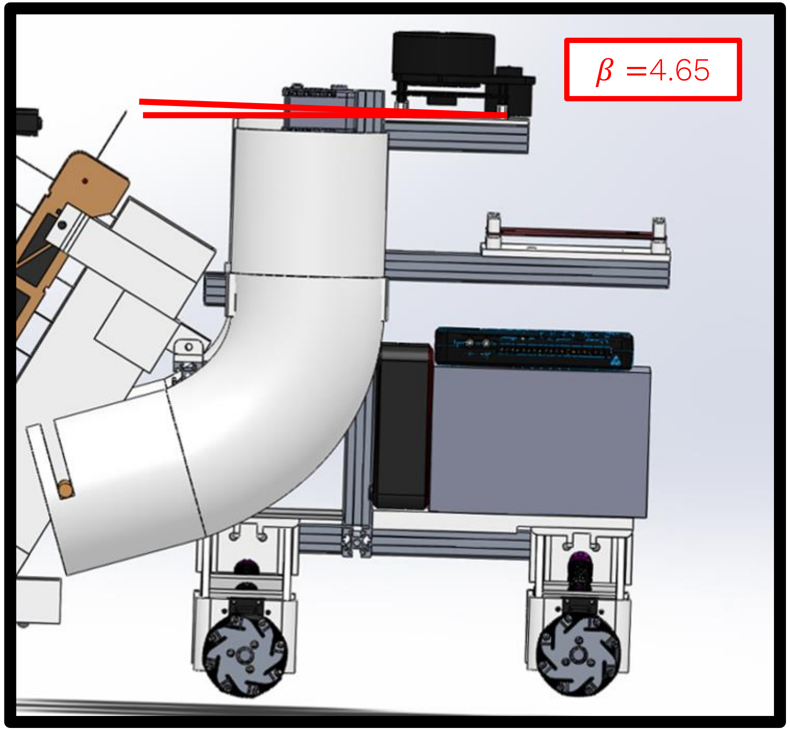
$$\Sigma F_y = N_1 + N_2 - Mg = 0$$

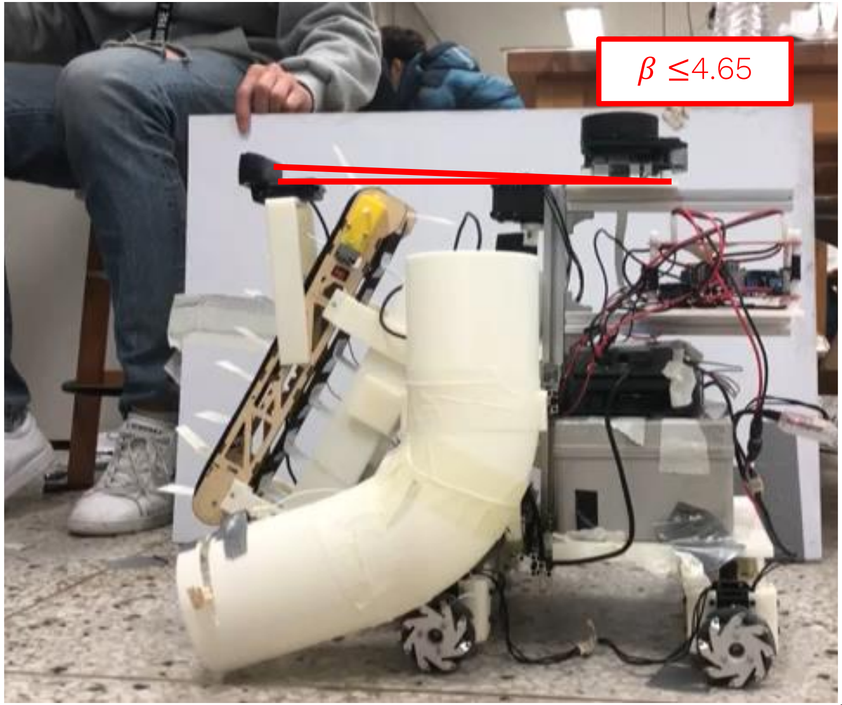
$$\begin{aligned}\Sigma M_G = & -N_1 l_1 + N_2 l_2 - N_1 \sin\beta h_1 - N_2 \sin\beta h_2 \\ & -f_1 \sin\beta l_1 + f_2 \sin\beta l_2 + f_1 h_1 + f_2 h_2 = 0\end{aligned}$$

$$\sin\beta = \frac{h_1 - h_2}{l},\ N_i = k_e h_i (i = 1,2), f_1 = f_2 = \frac{1}{2} Ma_x$$



Anti-Dive





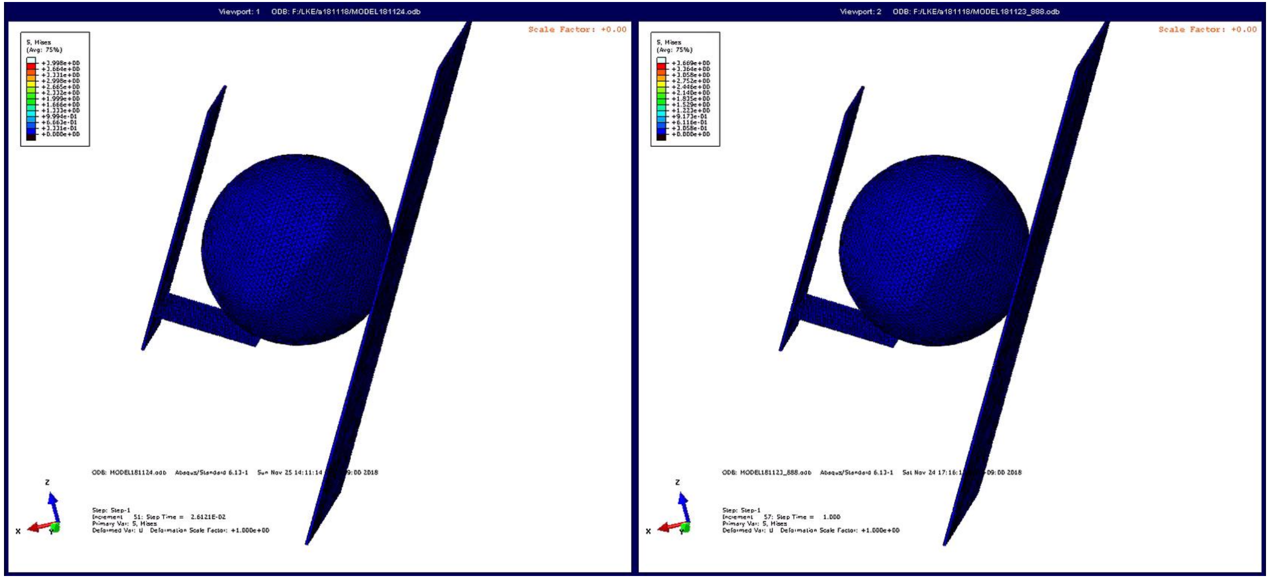
ENGINEERING DESIGN FOR CORE PARTS

2.

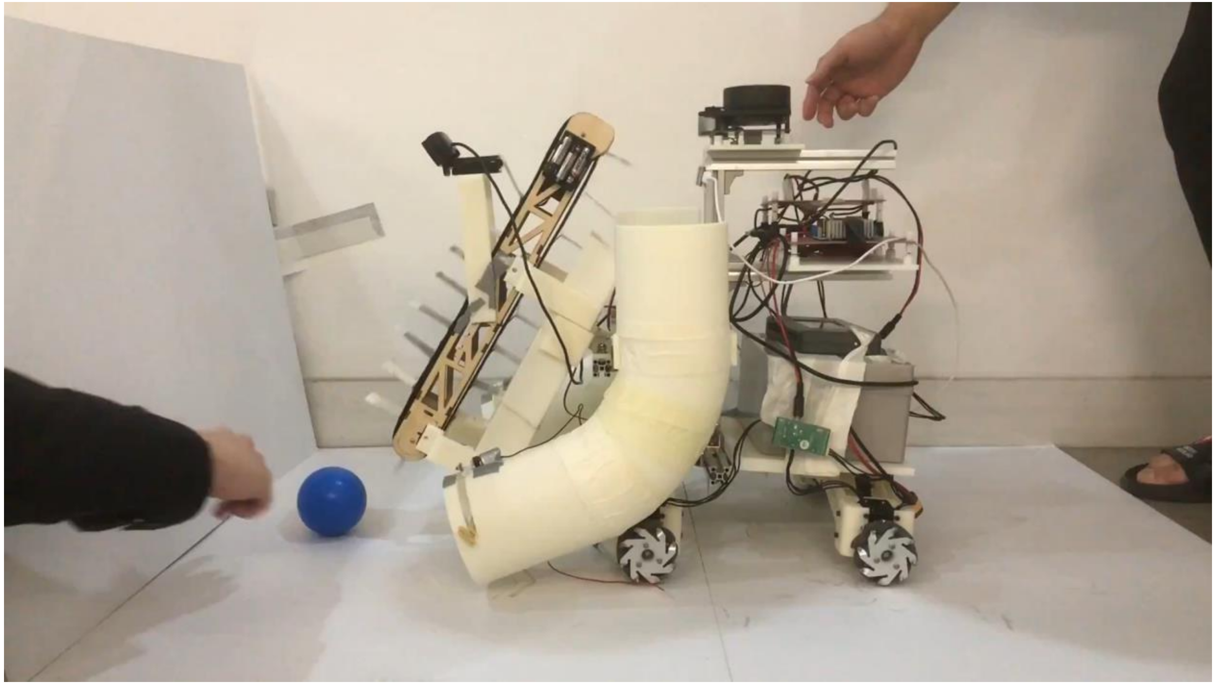
CONTENTS

- Design for Driving
- Designing Suspension
- Design for Ball-Collecting

Engineering Design (2):
Material Selection to Roll up the Ball



Result



OPERATING THE SYSTEM

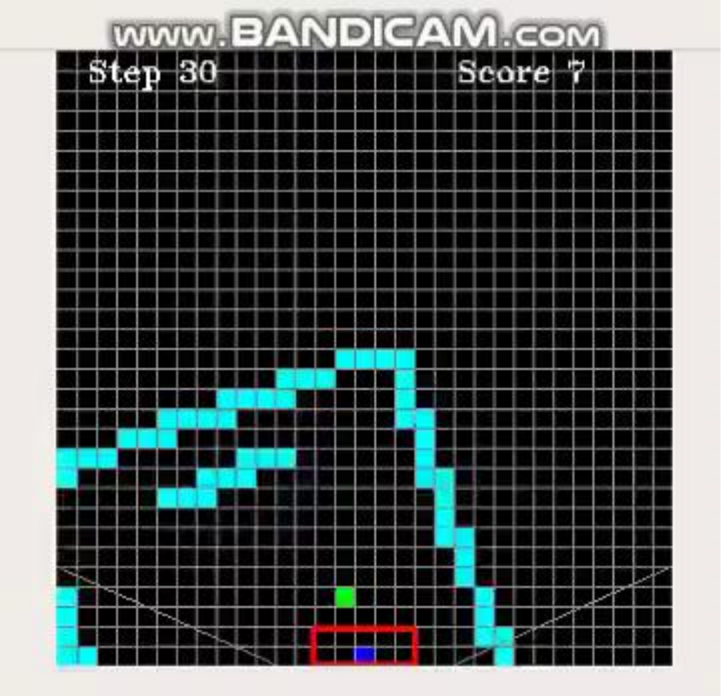
3.

Ball Collecting Using DQN

- Detect ball → Motor control → Drive
- Machine Learning → Finding ball location → Optimal route

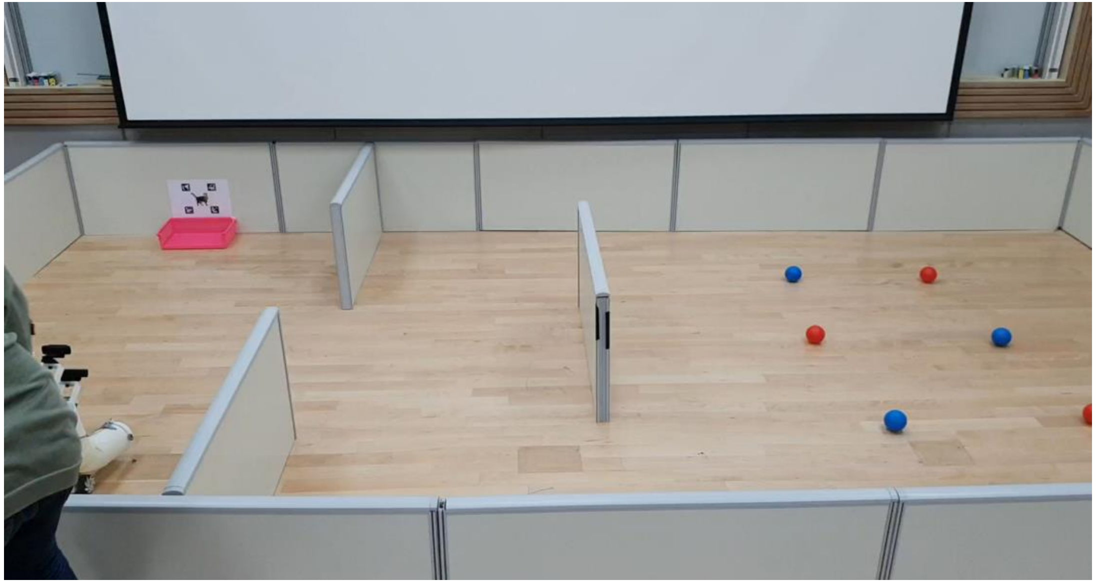
- Camera moving with the system → Not much change
  - Existence of the camera with whole view

Change In System After Using DQN



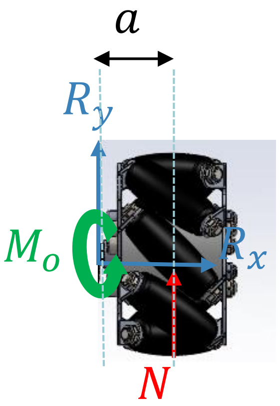
Thank you ☻

Any questions?



Appendix-FBD of Ground Contact

1. Wheel EOM



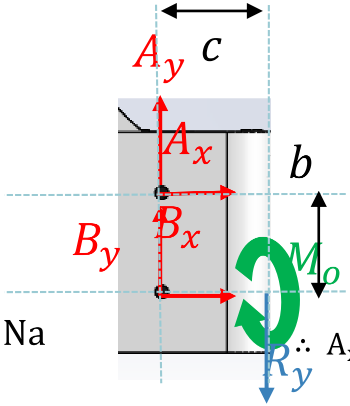
$$\Sigma F_x = R_x = 0$$

$$\Sigma F_y = R_y + N = 0$$

$$\Sigma M = N \bullet a + M_o = 0$$

$$\therefore\ R_x = 0,\ \ R_y = -N,\ \ M = -Na$$

2. Servo motor attaching part EOM



$$\Sigma F_x = A_x + B_x = 0$$

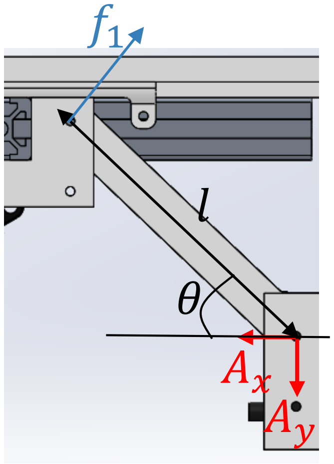
$$\Sigma F_y = A_y + B_y - R_y = 0$$

$$\Sigma M = -A_y c - B_y c - A_x b - M_o = 0$$

$$\therefore\ A_x = \frac{N(c+a)}{b},\ B_x = -\frac{N(c+a)}{b},\ A_y + B_y = -N$$

Appendix-FBD of Ground Contact

3. Upper Link EOM

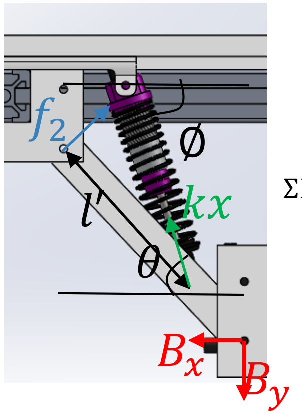


$$\Sigma M = -A_x l \sin\theta - A_y l \cos\theta = 0$$

$$\therefore\ A_y = -A_x \tan\theta = -\frac{N(c+a)}{b}\tan\theta$$

$$\therefore\ B_y = -N\left(1 + \frac{(c+a)}{b}\tan\theta\right)$$

4. Lower Link EOM

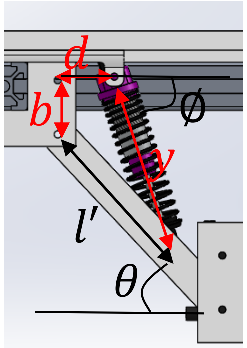


$$\Sigma M = -B_x l \sin\theta - B_y l \cos\theta - kxl' \sin(\varphi - \theta) = 0$$

$$\therefore\ kx = \frac{Nl}{l'\sin(\varphi-\theta)}\left(\cos\theta + \frac{2(c+a)}{b}\sin\theta\right)$$

Appendix-FBD of Ground Contact

5. Geometry & Result

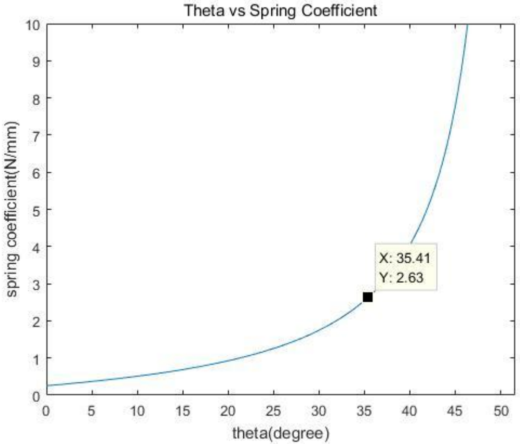


$$y\sin\varphi = l'\sin\theta + b$$

$$y\cos\varphi = l'\cos\theta - d$$

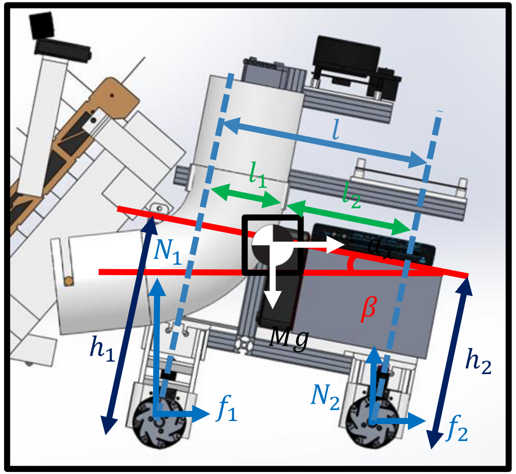
$$\therefore\ k(y_0 - y) = \frac{Nl}{l'\sin(\varphi-\theta)}\left(\cos\theta + \frac{2(c+a)}{b}\sin\theta\right)$$

$$\varphi = \tan^{-1}\left(\frac{l'\sin\theta + b}{l'\cos\theta - d}\right)$$



Appendix-FBD of Anti-Dive

EOM of Anti-Dive Motion



$$\Sigma F_x = f_1 + f_2 = Ma_x$$

$$\Sigma F_y = N_1 + N_2 - Mg = 0$$

$$\Sigma M_G = -N_1 l_1 + N_2 l_2 - N_1 \sin\beta h_1 - N_2 \sin\beta h_2 - f_1 \sin\beta l_1 + f_2 \sin\beta l_2 + f_1 h_1 + f_2 h_2 = 0$$

$$\sin\beta = \frac{h_1 - h_2}{l}$$

$$N_1 = k_e h_1$$

$$N_2 = k_e h_2$$

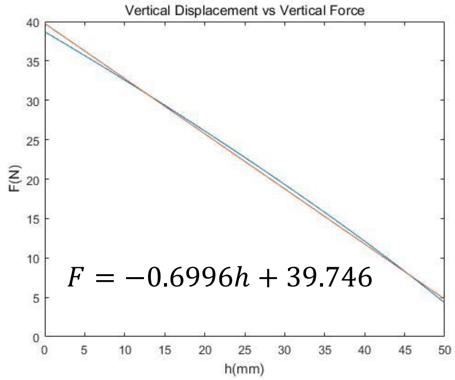
$$f_1 = f_2 = \frac{1}{2} Ma_x$$

Appendix-FBD of Anti-Dive

Derive Equation with respect to h_1

$$\left[\frac{M^2 g a_x}{2k_e} + Mgl_2 - k_e h_1 l_2 - k_e h_1 l_1\right] \times \frac{1}{k_e\left\{{h_1}^2 + \left(\frac{Mg}{k_e} - h_1\right)^2\right\} + \frac{1}{2} M a_x (l_2 - l_1)} = \frac{h_1}{l}\left(1 - \frac{Mg}{k_e} - h_1\right)$$

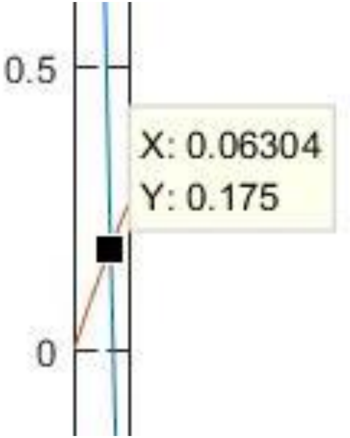
Find equivalent vertical spring coefficient k_e



$$k_e = -0.6996 N/mm$$

Appendix-FBD of Anti-Dive

Find h_1 numerically by plotting graph in matlab



Finally we calculate $\beta = 4.2136°$