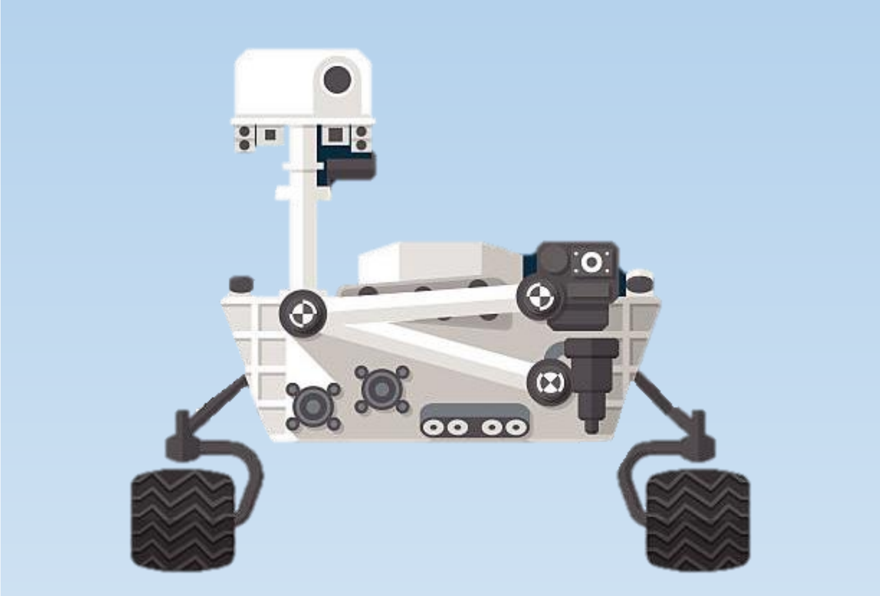


Hybrid System

Advisory Professor : 김형수 교수님

Advisory TA : 정문경 TA

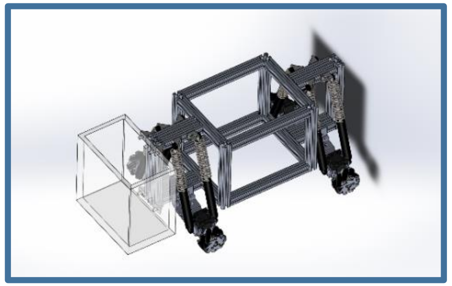
Team Members : Ashar Alam, Mahshid Khodadad, 류준일, 류현준, 박지환, 조인준, 최지훈, 최호열

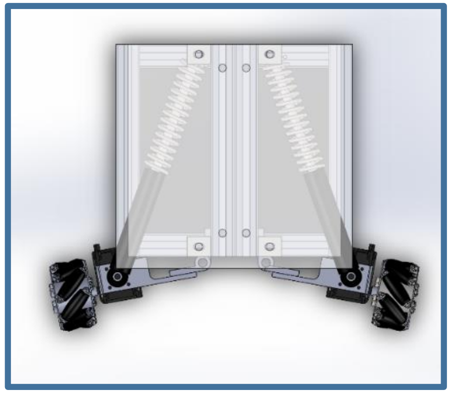
KAIST

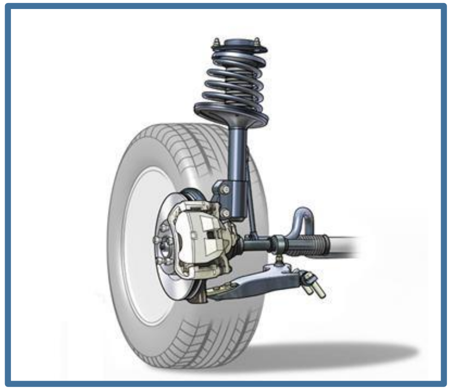
Department of Mechanical Engineering

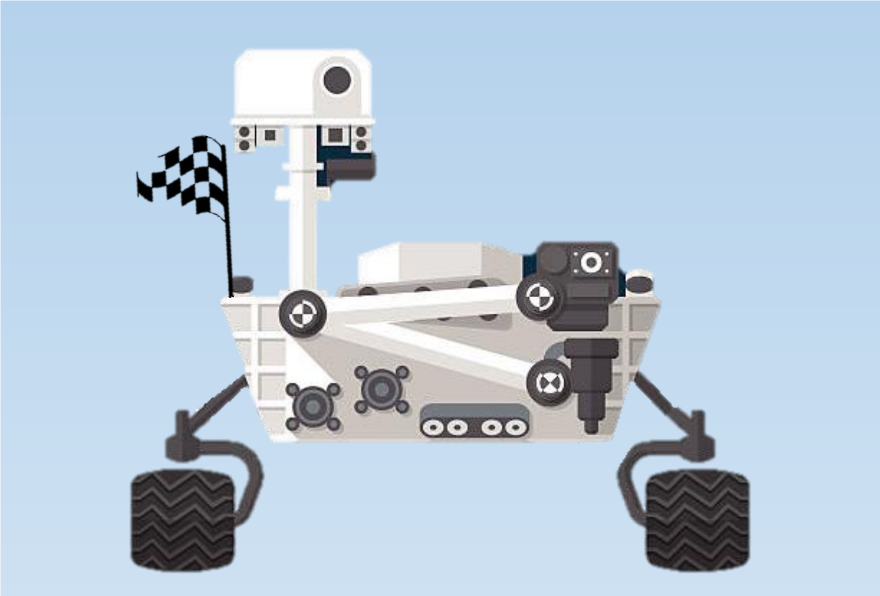
ENGINEERING FOR MANKIND

Contents









Section – A

Goal

Problem Definition

- Parameters
  - ✓ Precise ball collection
  - ✓ Finishing task in 2 trials
  - ✓ Minimizing trial time
  - ✓ Eliminating error

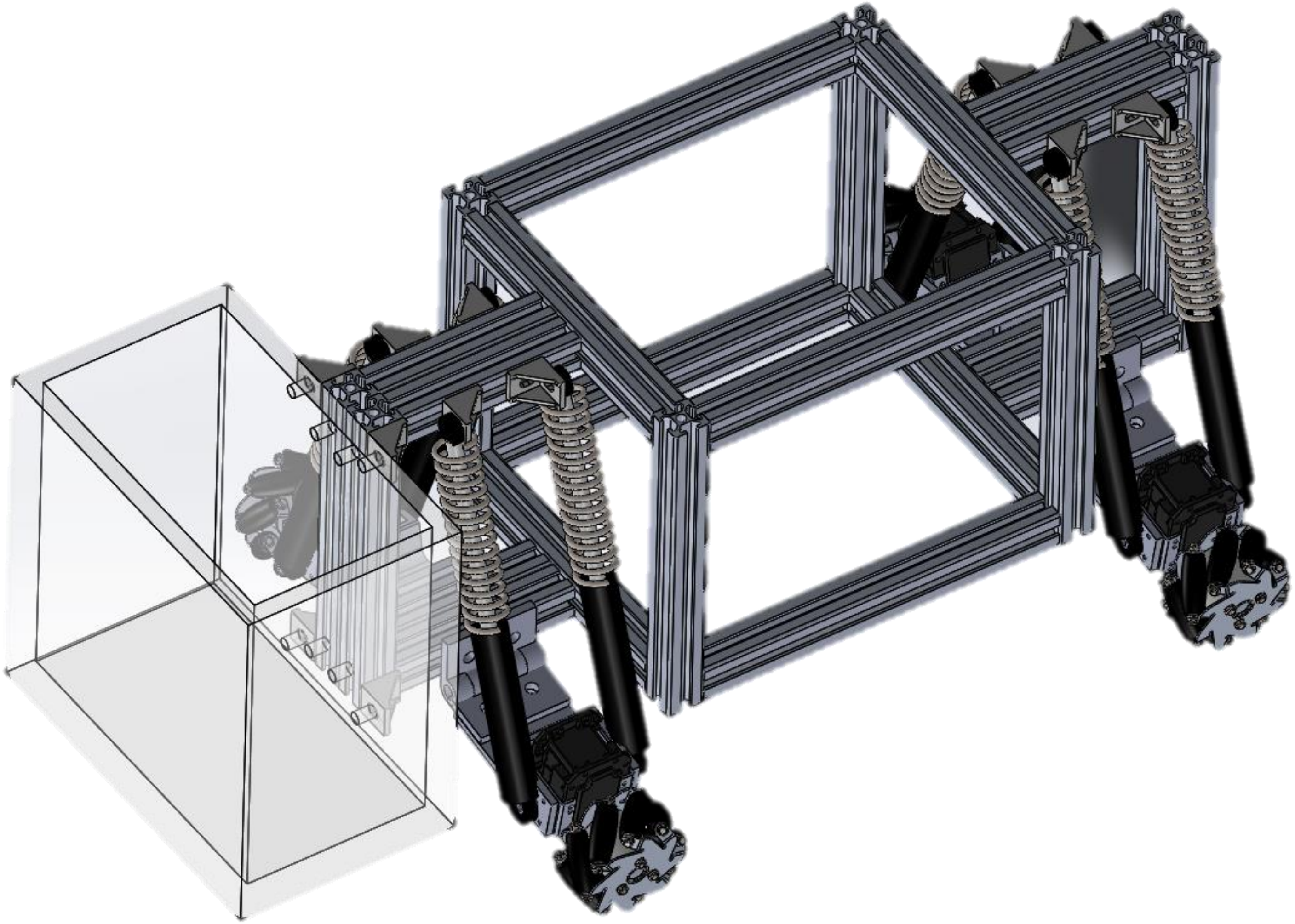
- Cooling System
  - ✓ Active cooling
  - ✓ Fins, fans & heat pipes
  - ✓ Minimize temperature rise

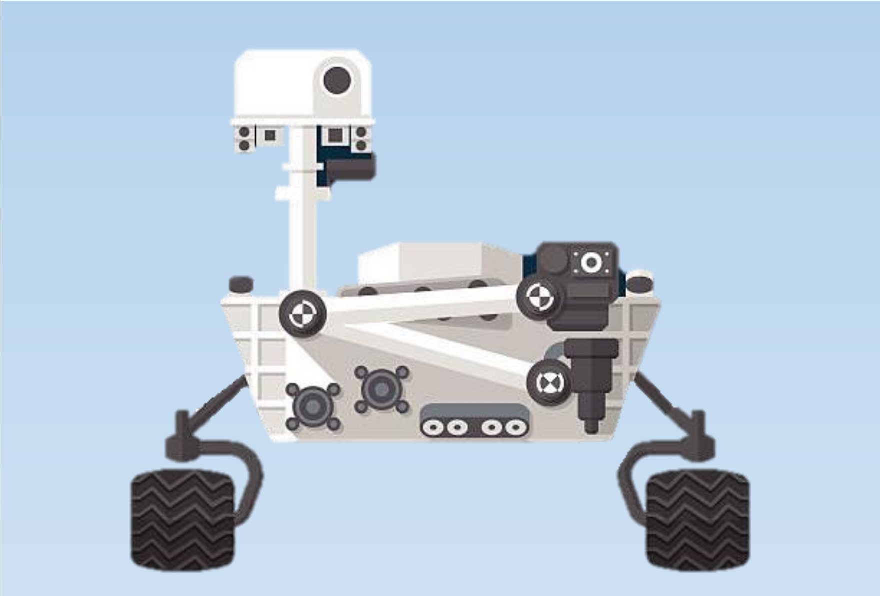
- Creativity
  - ✓ Enhance existing ideas
  - ✓ Look for creative solutions

Challenges

- Parameters
  - Efficient power consumption
  - Intelligent algorithm
  - Effective system design
- Cooling System
  - Efficient power management
  - Feedback through temperature sensor
- Creativity
  - Modify existing ideas
  - Analysis based modelling approach

Proposed Vehicle Design



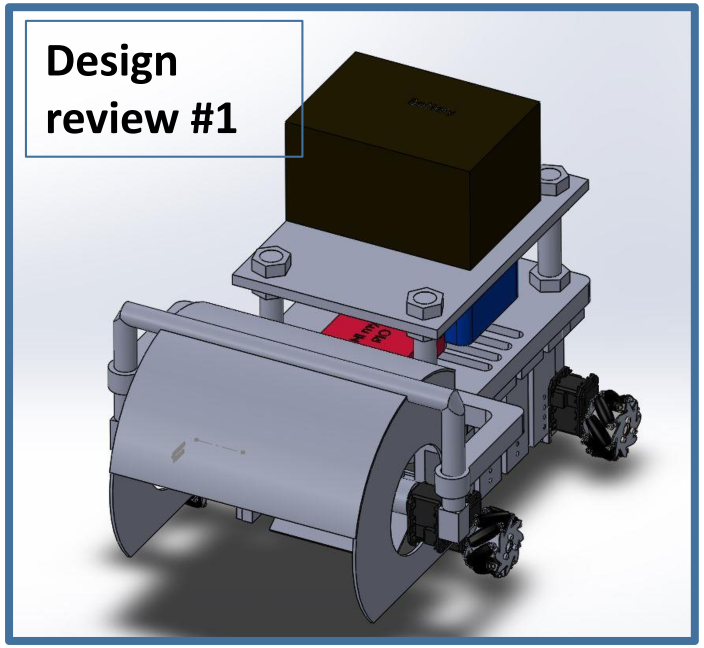


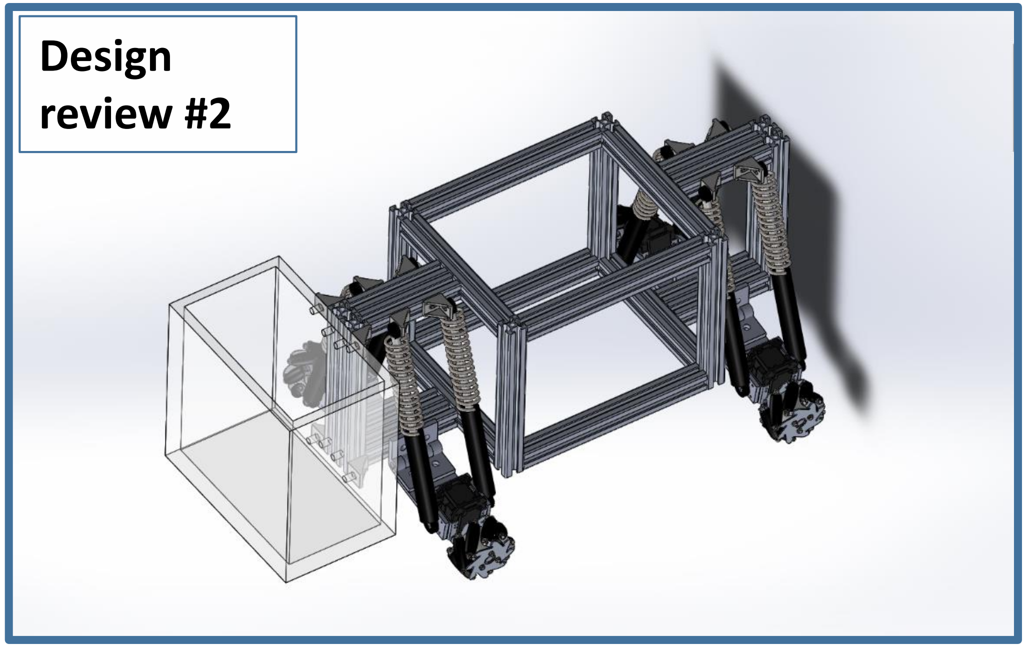
Section – B

Subsystems

Design & Manufacturing

Main Body → Gripper & Storage → Suspension → Cooling System





X High center of gravity -> Lower center of gravity (Improved stability)

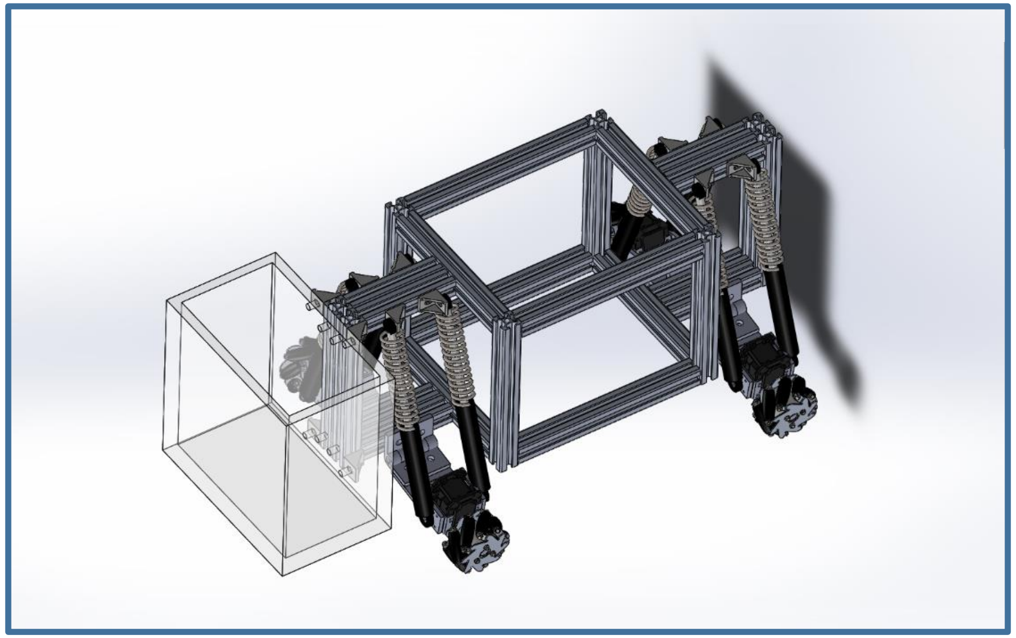
X No suspension -> Active suspension (Reduced Vibration)

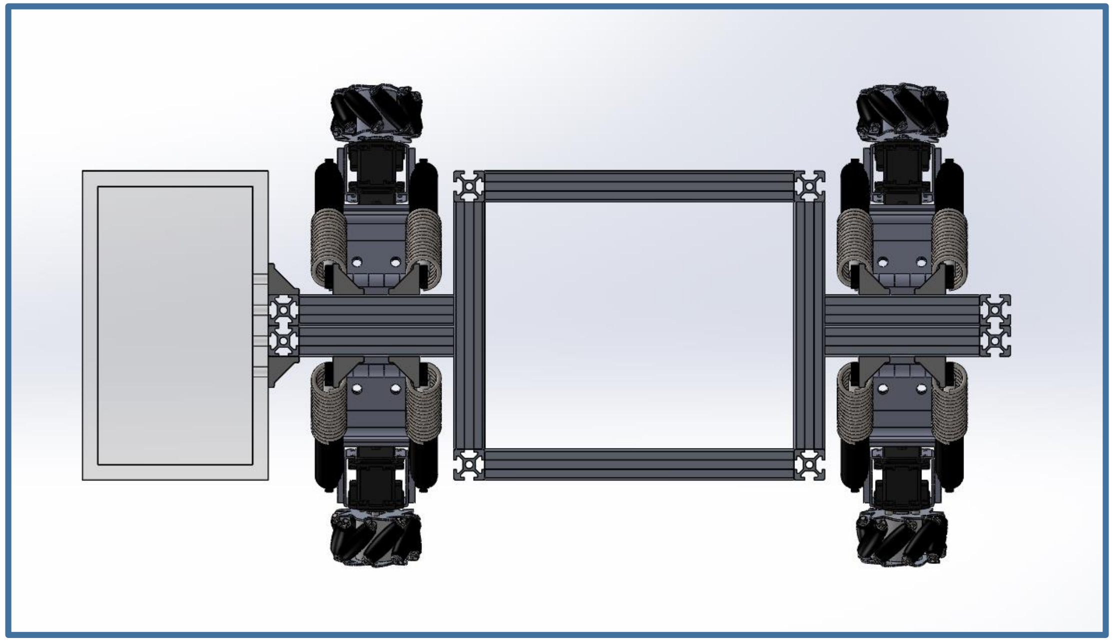
X Limited space -> Dedicated storage space

Design & Manufacturing

Main Body | Gripper & Storage | Suspension | Cooling system

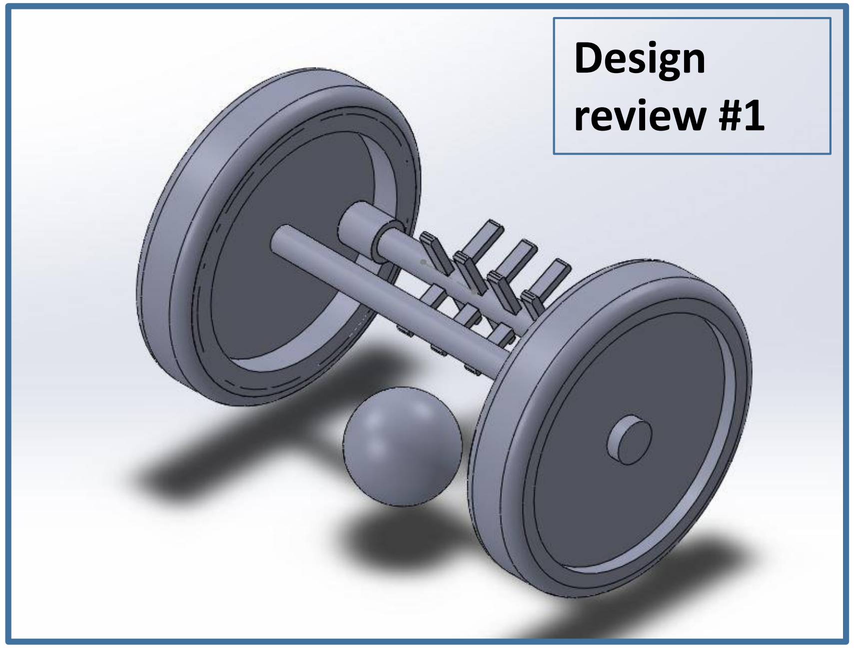
Solidworks Model

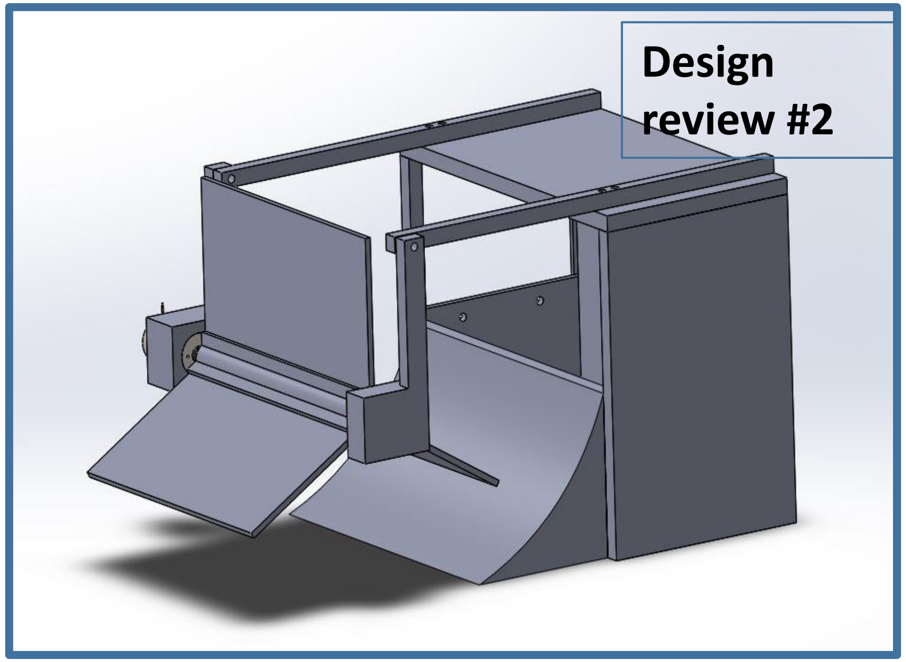




Design & Manufacturing

Main Body → **Gripper & Storage** → Suspension → Cooling system





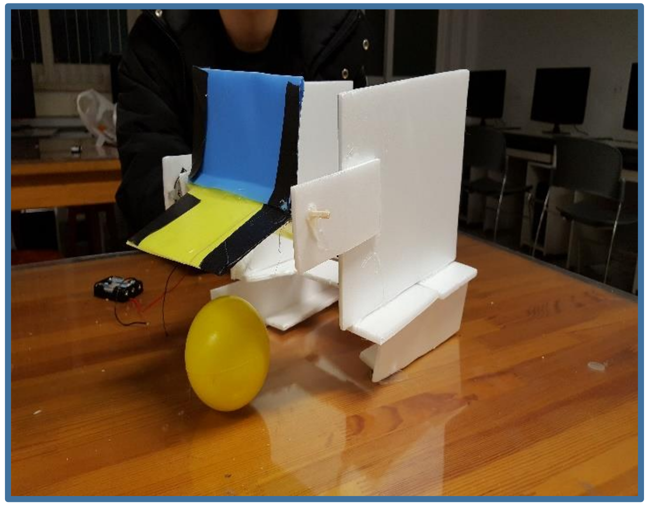
X Connected to wheel -> Dedicated motor (Wheels are independent)

X Whole robot moves -> Only gripper actuator moves (Independent)

X Control is difficult -> Simple control (Power on/off control)

Main Body | **Gripper & Storage** | Suspension | Cooling system

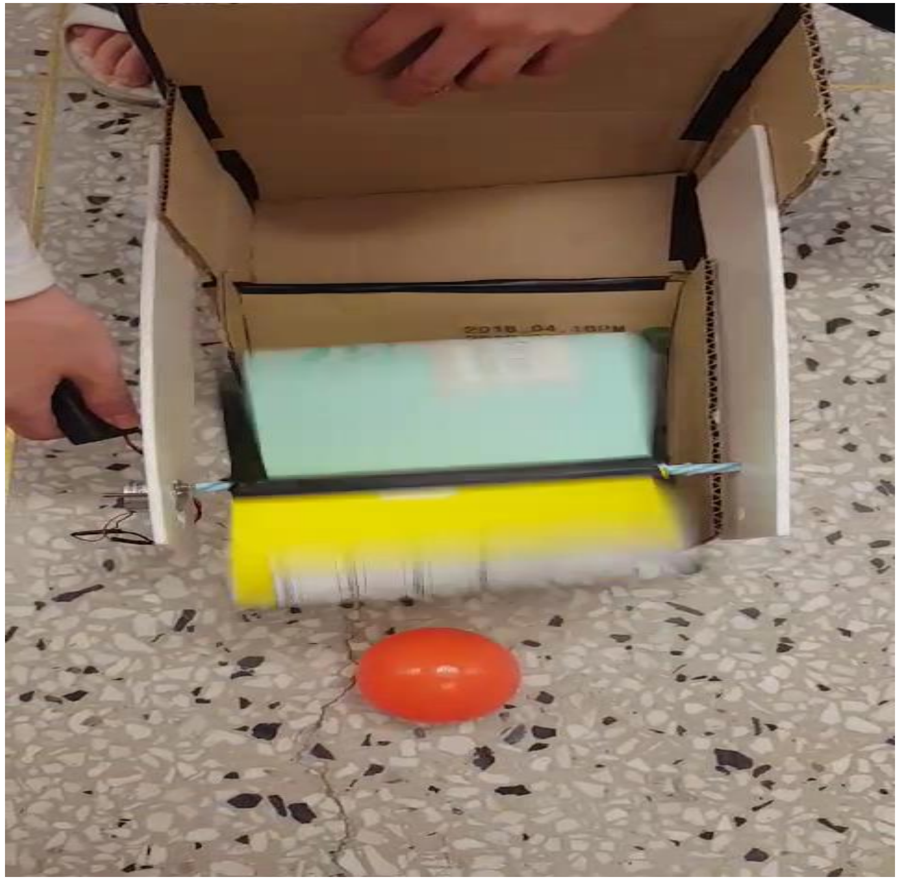
Deciding blade type



- ✓ Low power (~5V)
- ✓ Ball and storage are close
- X High blade axis
- X Ball gets low torque for climbing up the storage

- ✓ Modified prototype of blade

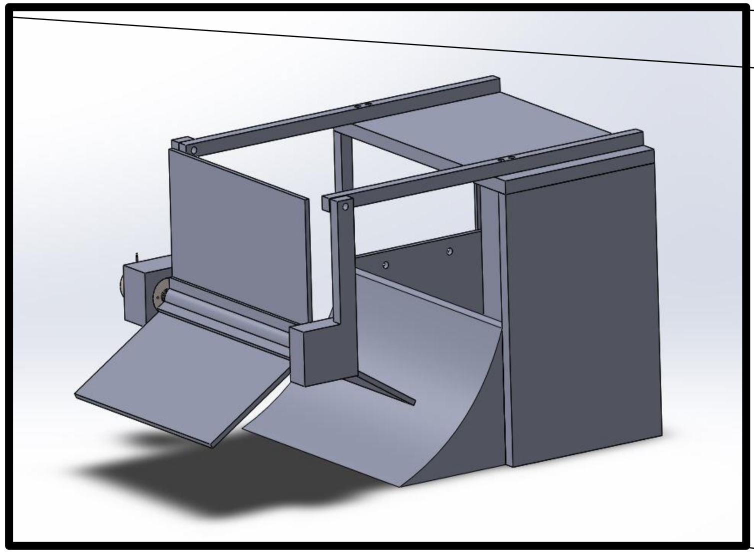
Main Body | Gripper & Storage | Suspension | Cooling system

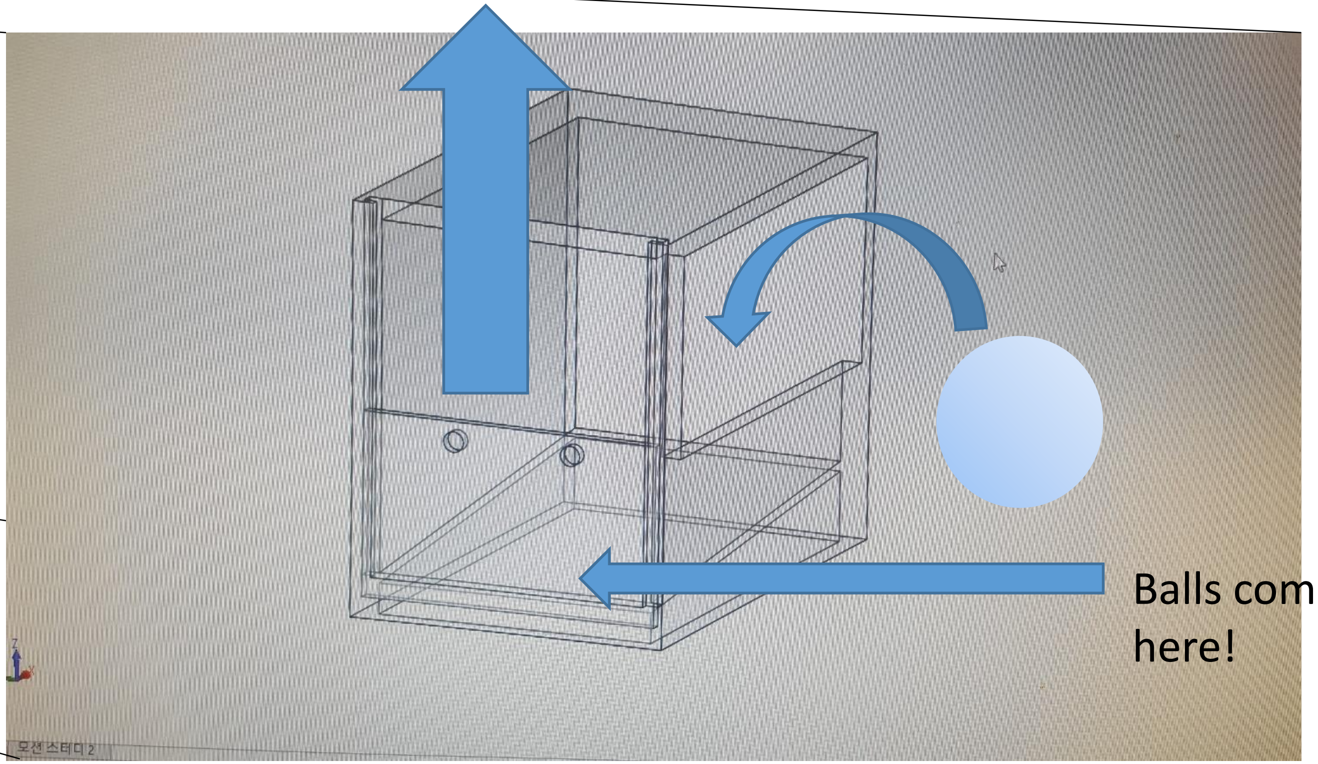


- Advantages
- ✓ Successful: successful test of mechanism
- ✓ Wide reach: reduces the need for exact location
- ✓ Simple control: actuation by activating the motor
- ✓ Energy efficient: less power requirement
- ✓ Light-weight: light weight structure of the gripper

Design & Manufacturing

Main Body | Gripper & Storage | Suspension | Cooling system





Balls come out at here!

Design & Manufacturing

Main Body → Gripper & Storage → **Suspension** → Cooling system

X Motor connected to profile -> Macpherson strut (Less vibration)

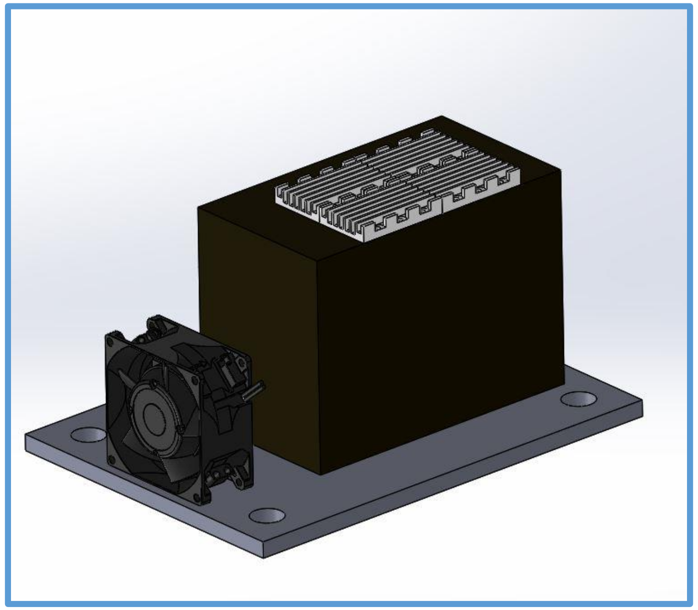
X Base excitation -> Minimize vibration (Small transmissibility)

X Might cause aberration -> Better camera performance (Detection)

Design & Manufacturing

Main Body → Gripper & Storage → Suspension → **Cooling System**

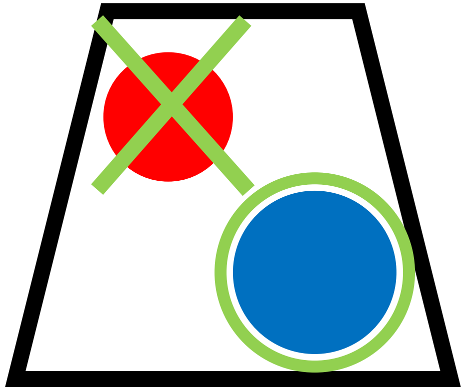
CPU Fan



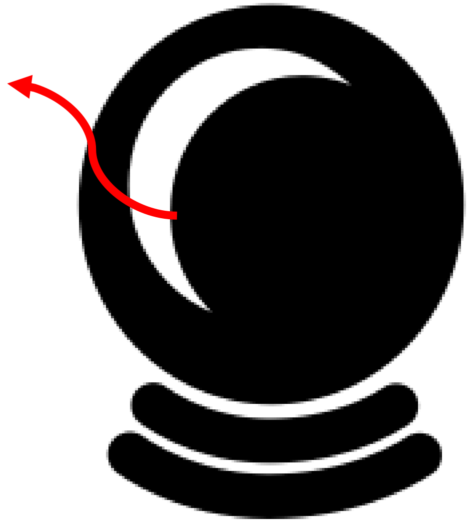
- ✓ Cools the body and controls temperature rise
- ✓ Our main body is open on the outside to facilitate het transfer
- ✓ We intend to add a fan to aid convective heat transfer

Vision & Detection

Problem Definition | **Solution** | **Normalization**



Saturation region



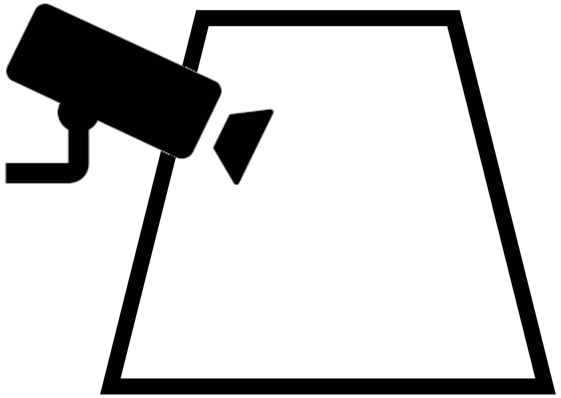
Under varying light condition, There's instability in detecting certain colored ball

Implementing any modification codes can extend operation time

Due to saturation, detecting At close range is hard (saturation region is detected as another ball)

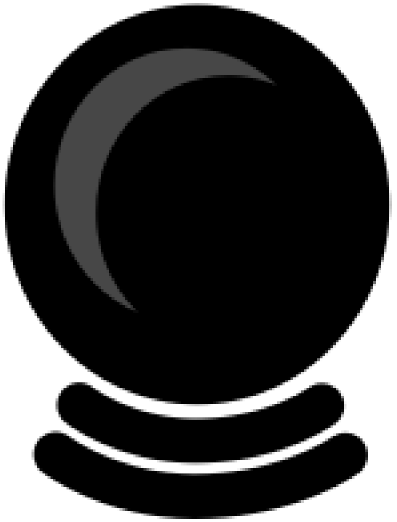
Vision & Detection

Problem Definition → **Possible Solution** → Normalization



Normalize white balance before start detection

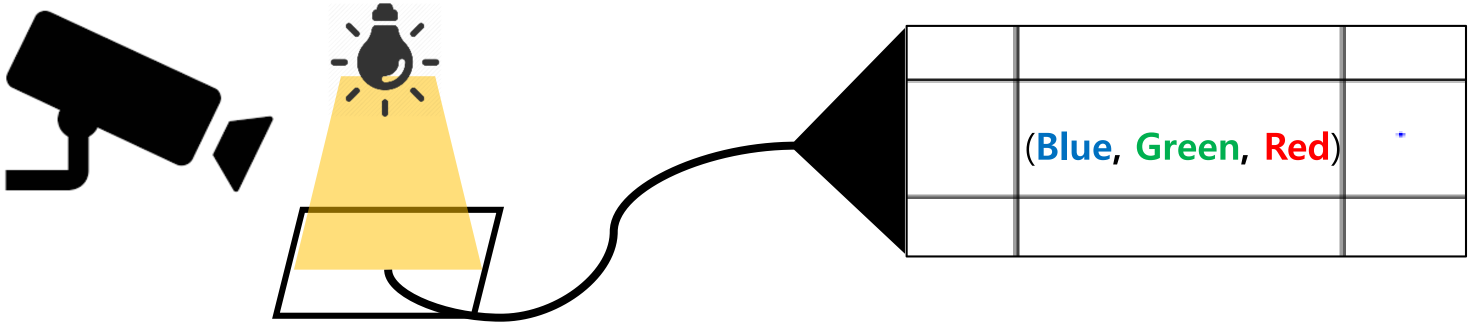
Implement modification directly on image.
Not pixel by pixel



After detecting contour, implement code that fill in the contour and remove saturation region

Vision & Detection

Problem Definition → Solution → **Normalization**



Take picture of white paper under certain light condition

Take pixel value of white paper and set the values as normalizing factor

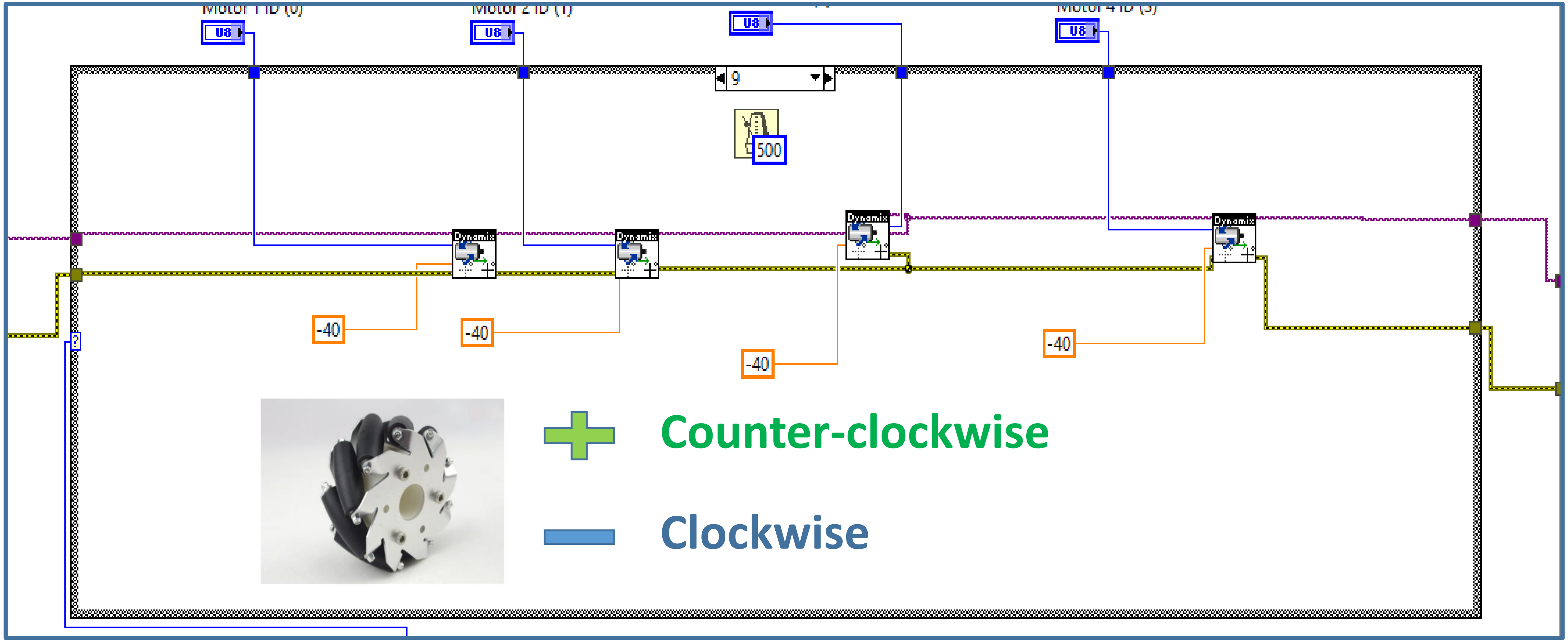
```
//Normalizing algorithm//

Get Norm_Blue, Norm_Green,
Norm_Red values

If ( Input_K < Norm_K (K =
Red, Green, Blue) ) {
        Mat Outputimg_K
        = Mat Inputimg_K *
NormK
}
Else {
         Mat Outputimg_K =
        (255,255,255)* Mat
Inputimg_K
}
```

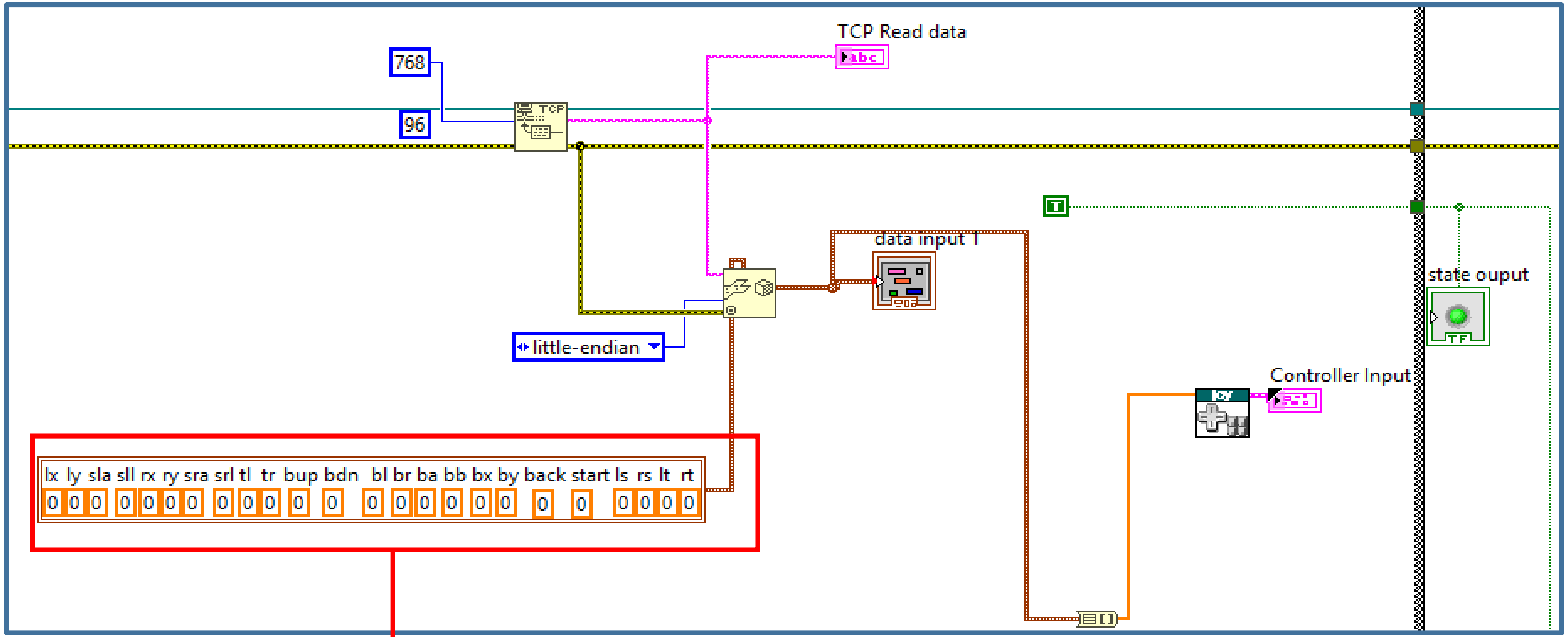
Actuation: LabVIEW

Motor control | Xbox control | Final code



Actuation: LabVIEW

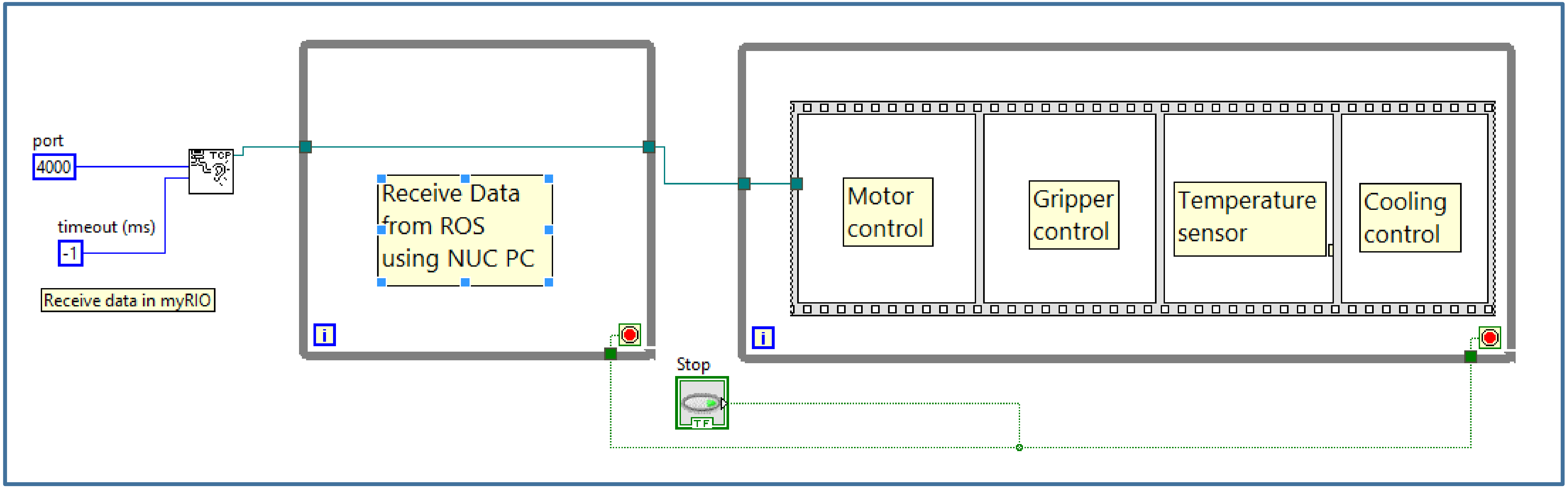
Motor control → **Xbox control** → **Final code**



ROS receives Xbox controller key press data and sends it to LabVIEW in this format

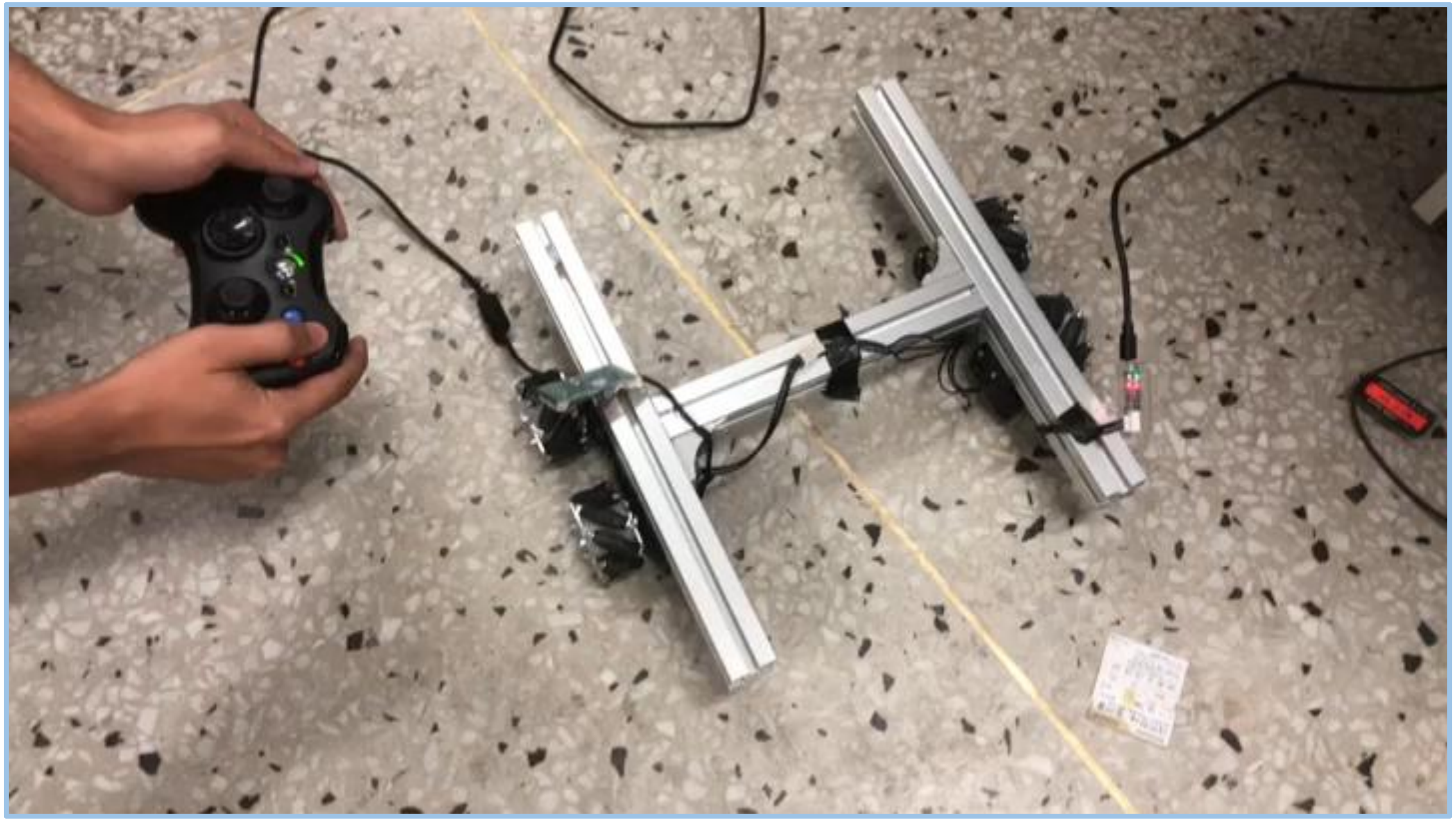
Actuation: LabVIEW

Motor control | Xbox control | **Final code**



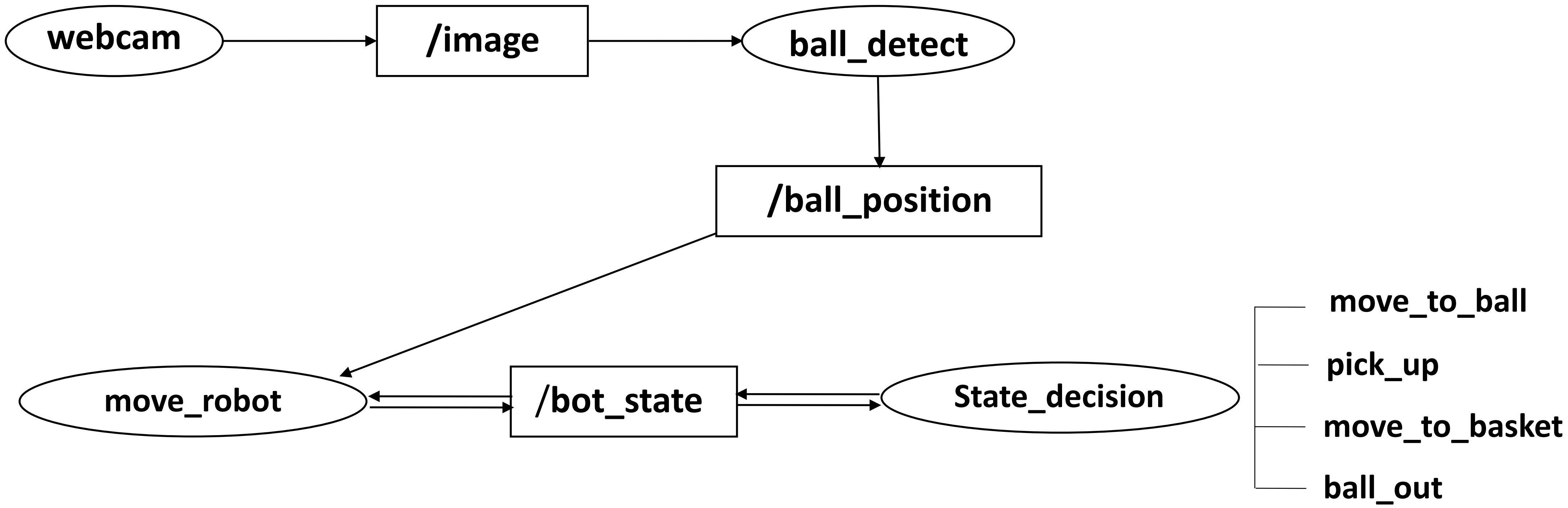
ROS & Integration

Xbox control | Diagram | Tracking | Mapping



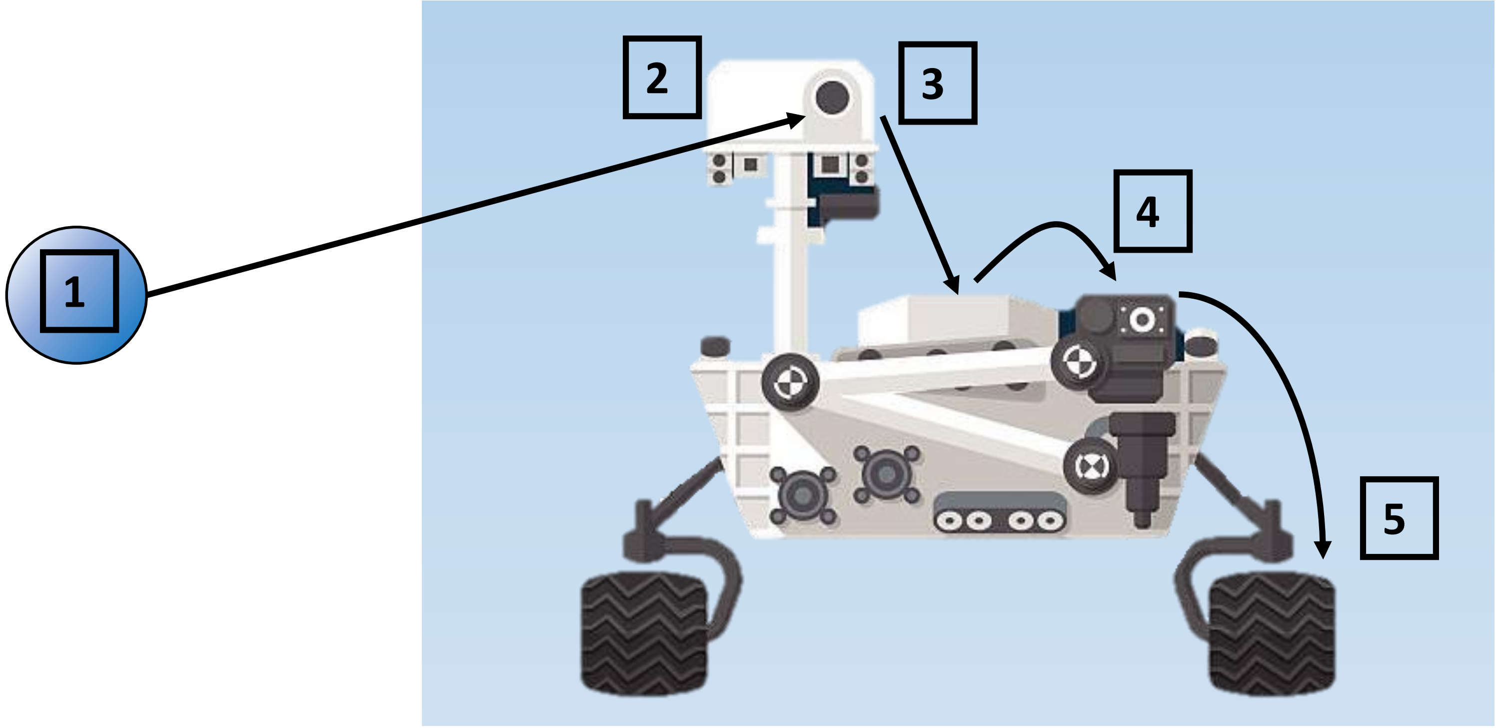
ROS & Integration

Xbox control → **Diagram** → Tracking → Mapping



ROS & Integration

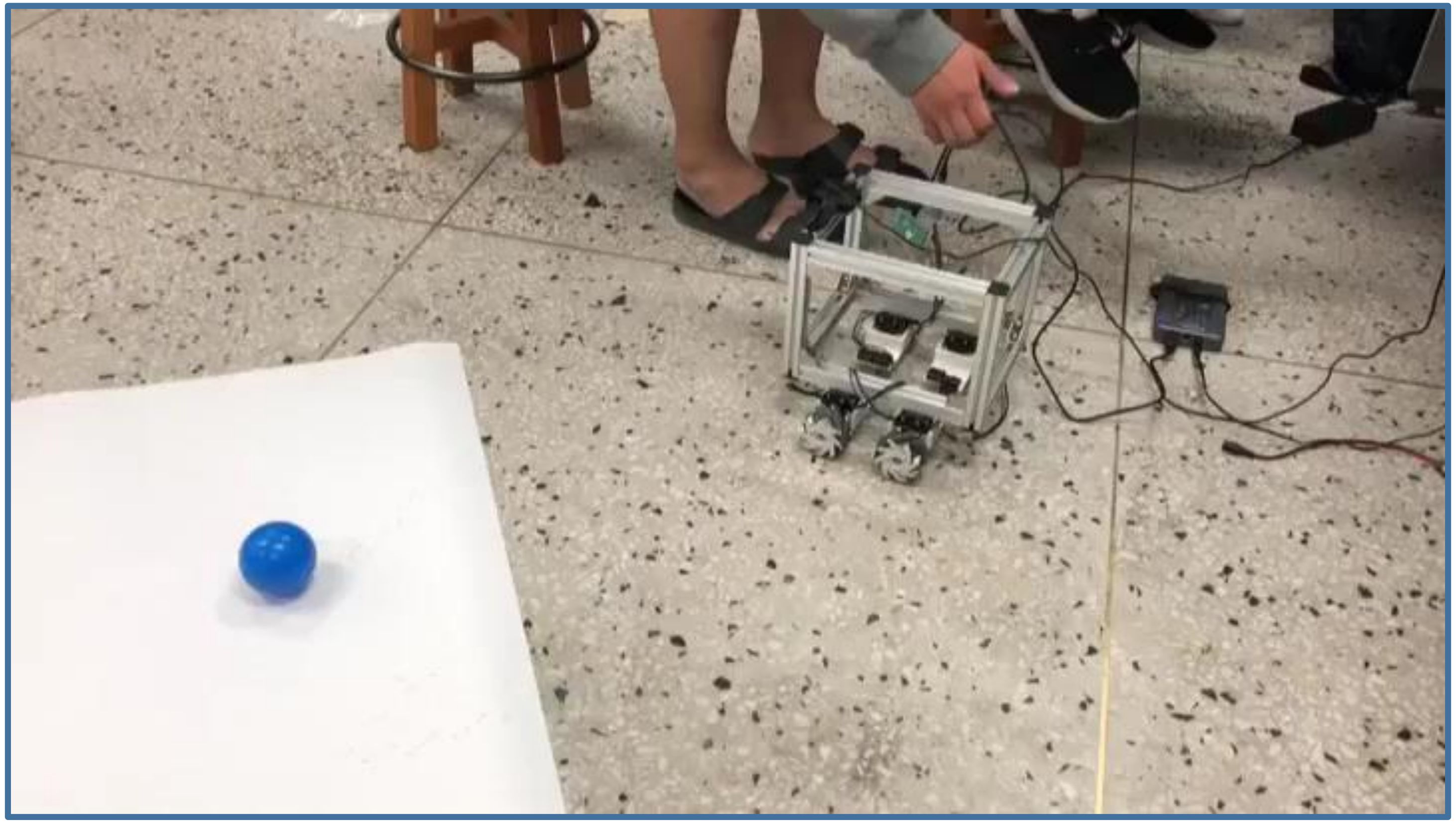
Xbox control → **Diagram** → Tracking → Mapping



1. Blue ball at a distance
2. Webcam detects blue ball
3. Webcam sends data to ROS
4. ROS calculates distance and sends to myRIO
5. myRIO actuates the motors

ROS & Integration

Xbox control → Diagram → Tracking → Mapping



ROS & Integration

Xbox control → **Diagram** → **Tracking** → **Mapping**

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	0	0	0	0
3	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	**2**

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7
4	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	6	6	6	6
3	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	5	5	5
2	0	0	0	0	0	0	0	0	0	0	7	6	5	4	4	4
1	0	0	0	0	0	0	0	0	0	0	7	6	5	4	3	3
0	0	0	0	0	0	0	0	0	0	0	7	6	5	4	3	**2**

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	**18**	17	16	15	14	13	12	11	10	9	9	9	9	9	9	9
6	17	17	16	15	14	13	12	11	10	9	8	8	8	8	8	8
5	17	16	16	15	14	13	12	11	10	9	8	7	7	7	7	7
4	17	16	15	15	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	6	6	6	6
3	17	16	15	14	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	5	5	5
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1	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	3
0	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	**2**

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	**18**	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	9	9	9	9	9	9
6	17	[illegible]	16	15	14	13	12	11	10	9	[illegible]	8	8	8	8	8
5	17	16	[illegible]	15	14	13	12	11	10	9	8	[illegible]	7	7	7	7
4	17	16	15	[illegible]	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	[illegible]	6	6	6
3	17	16	15	[illegible]	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	[illegible]	5	5
2	17	16	15	14	[illegible]	12	11	10	9	8	7	6	5	4	[illegible]	4
1	17	16	15	14	13	[illegible]	11	10	9	8	7	6	5	4	3	[illegible]
0	17	16	15	14	13	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	**2**

Integration

OpenCV

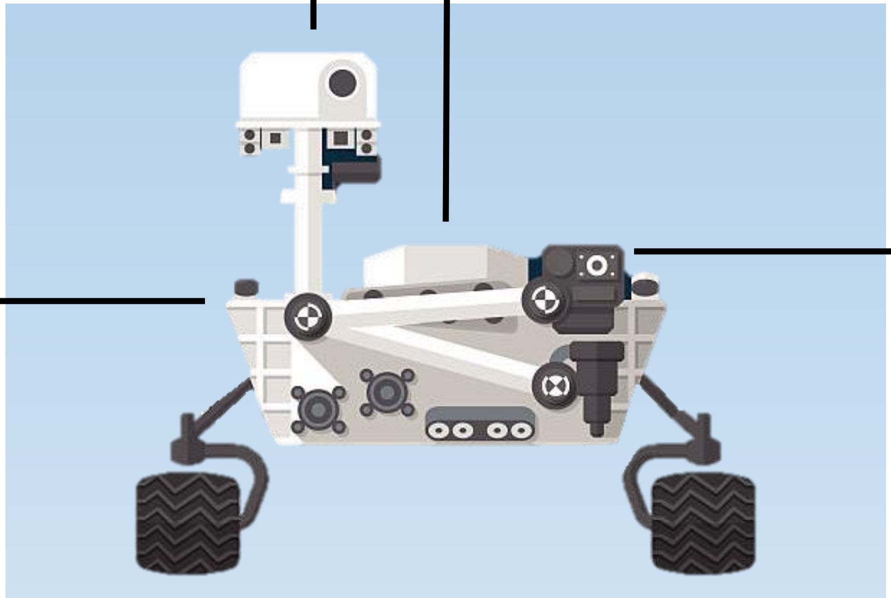
DATA Transfer

ROS

- Identifies blue ball
- Calculates distance
- Sends data to ROS

Instruction

- Determines direction
- Commands myRIO
- Continuous calculation

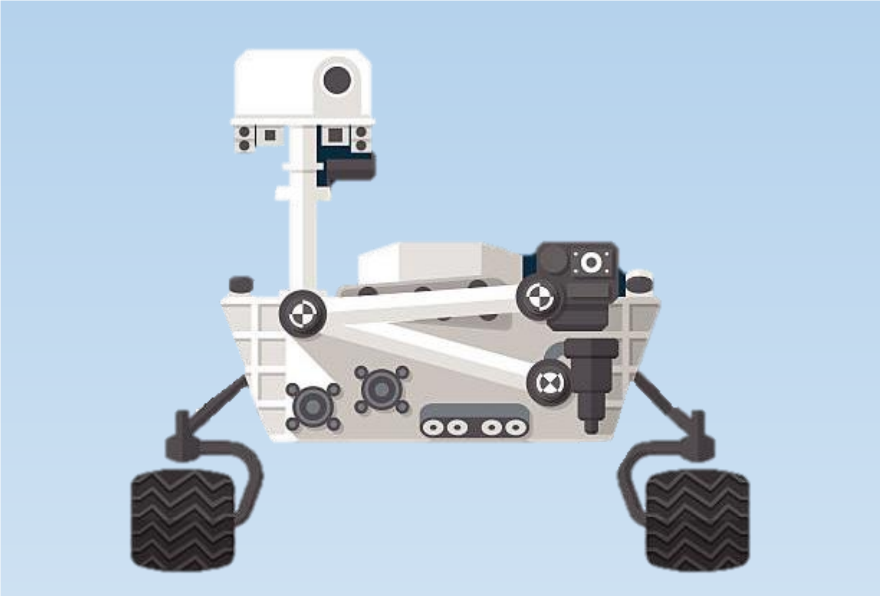


SolidWorks

- Design the structure
- 3D print parts

NATIONAL INSTRUMENTS LabVIEW

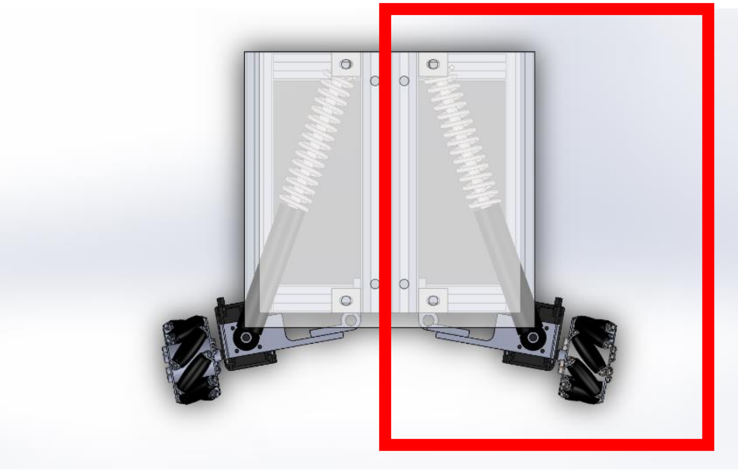
- Actuates wheels
- Actuates gripper
- Measures temperature

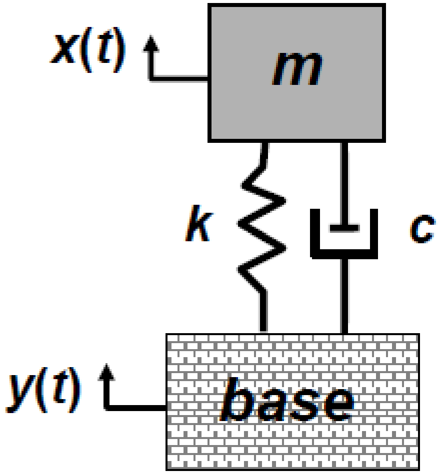


Section – C

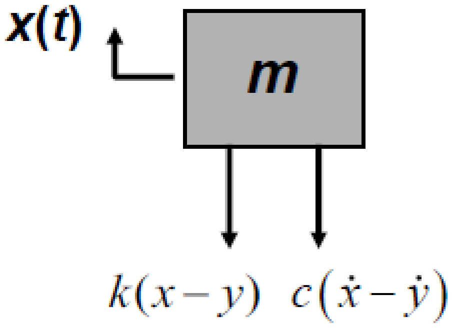
Analysis

Vibration: Suspension Model





Free Body Diagram

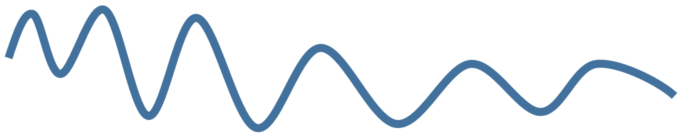


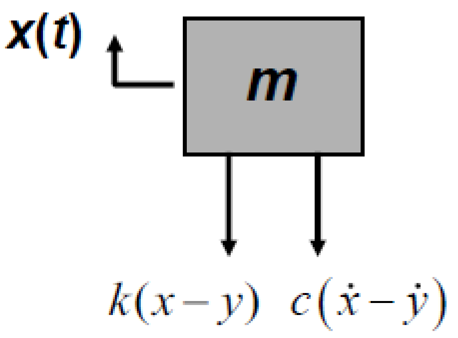
$$y(t) = Y \sin \omega t \longrightarrow$$

Smooth road

Rough road

Road noise dominant





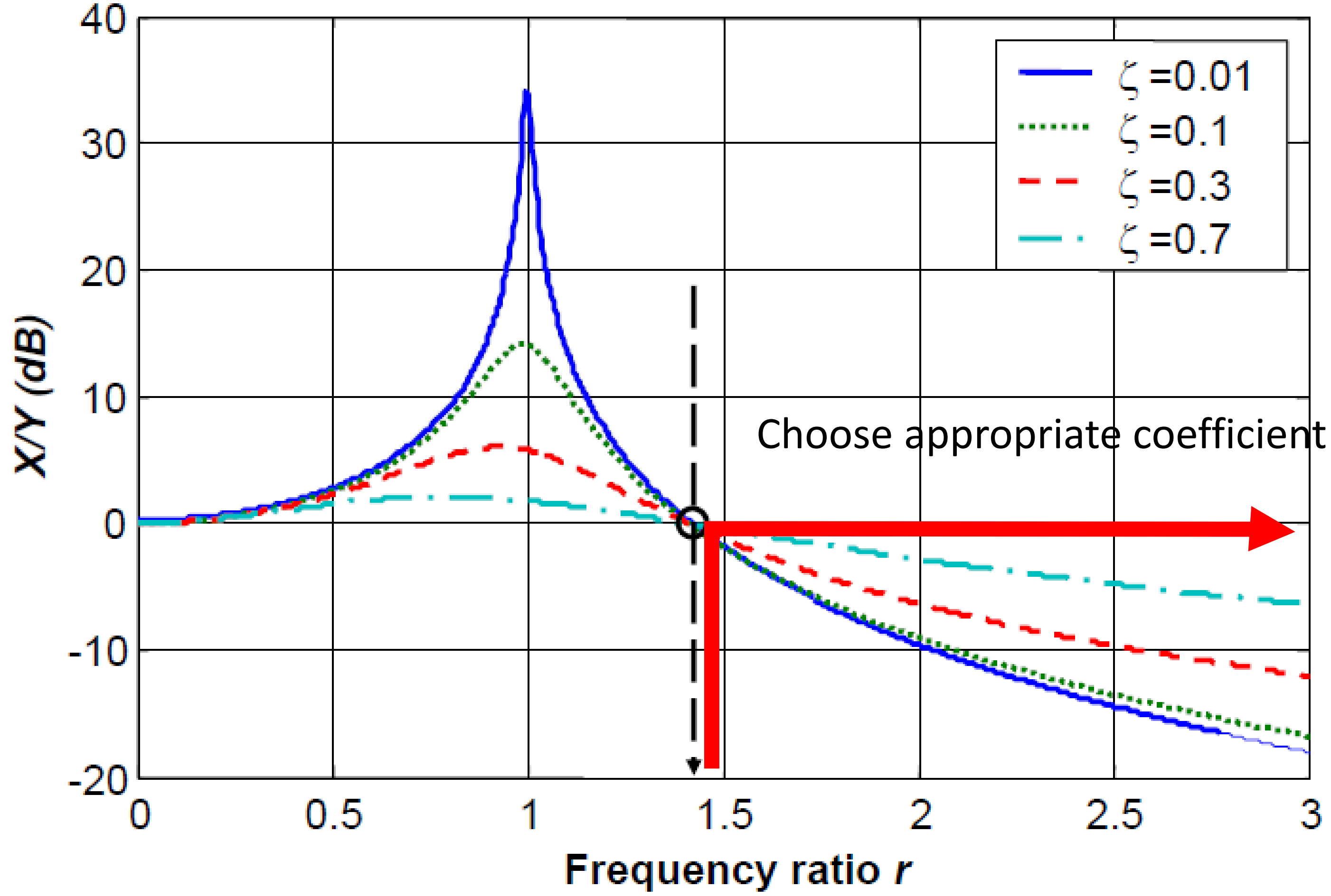
Newton Equation

$$m\ddot{x}+c\dot{x}+kx=c\dot{y}+ky$$

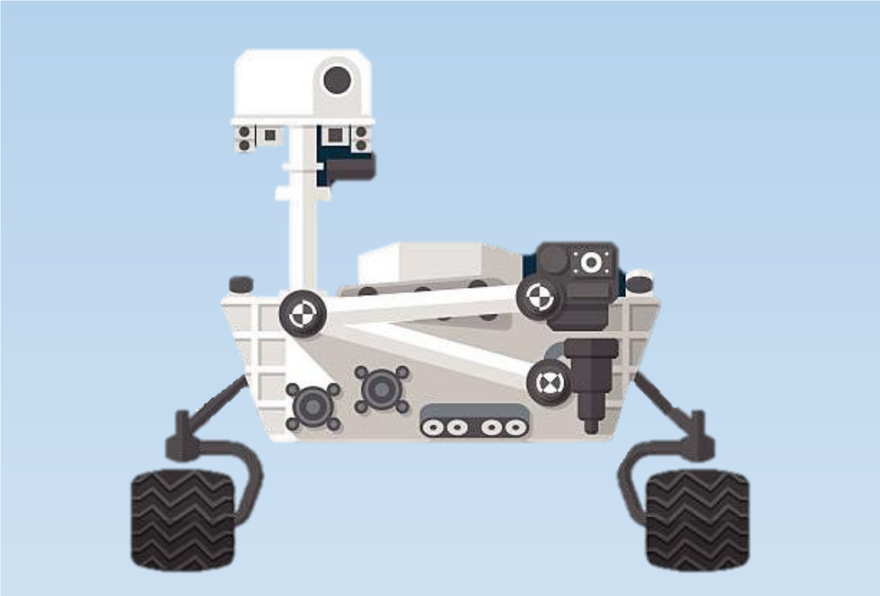
Laplace Transform

$$\left|\frac{X}{Y}(r)\right|=\sqrt{\frac{1+(2\zeta r)^2}{(1-r^2)^2+(2\zeta r)^2}}$$

$$r=\frac{\omega}{\omega_n}$$



For Smooth road -> $\omega_n = \frac{v}{r}$



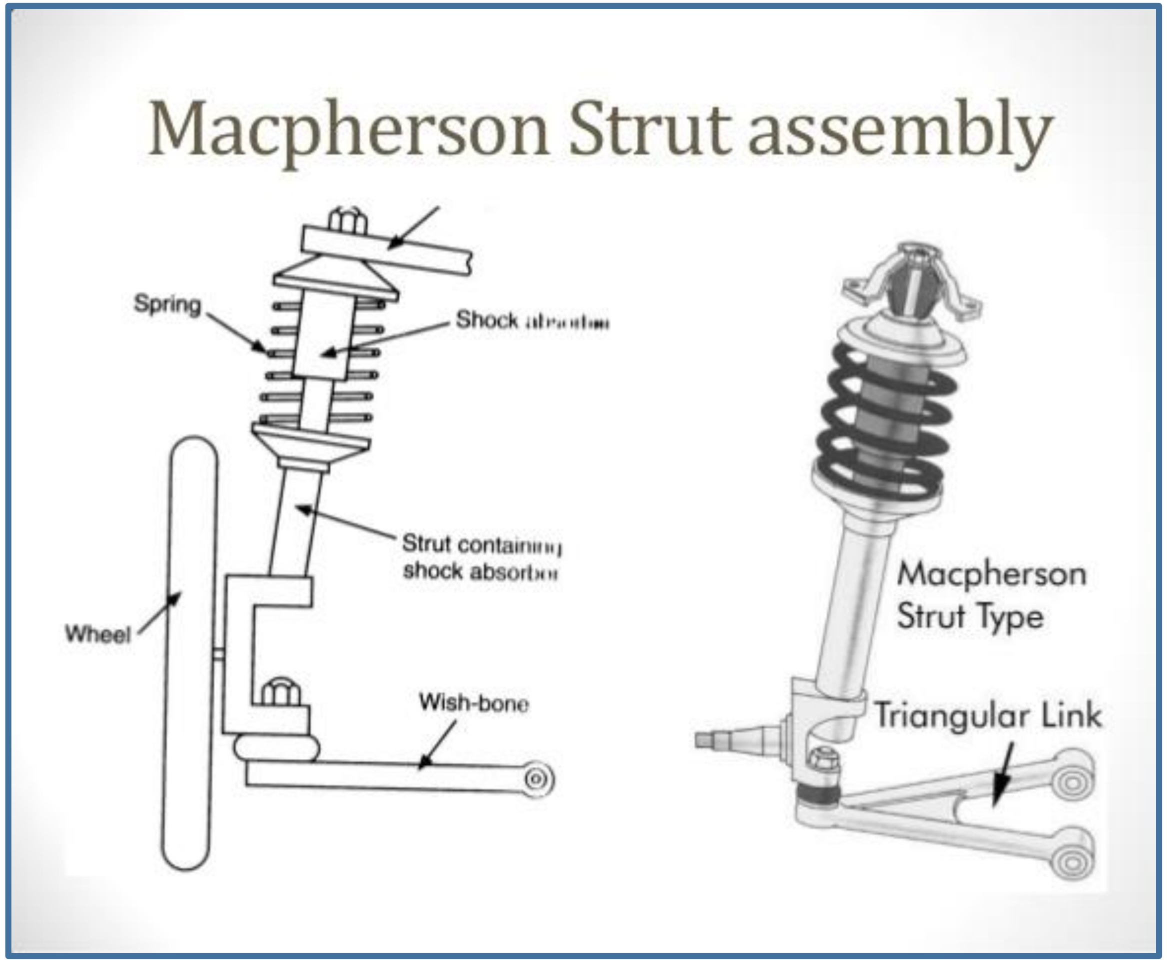
Thanks for listening

Questions or comments are welcome

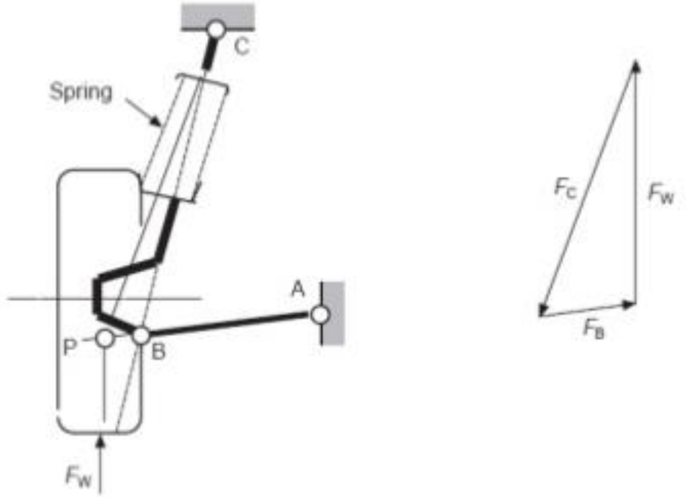
Appendix

- ✓ Integration of Vision+ROS+LabVIEW (by 3rd week of May)
- ✓ Minimize temperature rise with **cooling system (**by 3rd week of May)
- ✓ Efficient algorithm for collecting and returning blue balls (by 2nd week of May)
- ✓ Minimize vibration using proper **suspensions** by 2nd week of May)
- ✓ Perform test runs and minimize ball collection time (by 4th week of May)

Appendix



Vertical loading- Macpherson



Force analysis of a MacPherson strut, (a) Wheel loading, (b) Forces acting on the strut

Figure from Smith,2002

Appendix

	SPRING SPEC.				PJT. NAME : Suspension Spring DOC. NO. : DATE :
SPRING TYPE : Compression Coil Spring					
MATERIAL : SUS316					
Modulus of transverse elasticity (G)	7000		Number of active coils (Ne)	23	
Wire diameter (d)	0.5	mm	Free length(L)	100	mm
Center diameter (D_m)	15	mm	Displacement(l)	60	mm
Total number of active coils (Nt)	25		Tensile stress(σ)	53	kg/mm^2
External diameter			Spring Pitch		
$OD = d + D_m$	15.50	mm	$p = \frac{L}{N_e + 1}$	4.17	mm
Internal diameter			Maximum compression height		
$ID = D_m - d$	14.50	mm	$L_{min} = d \times N_t$	12.50	mm
Torsion stress			Spring length		
$\tau = \sigma \times 0.33$	17.49	kg/mm^2	$ML = \pi \times D_m \times N_t$	1178.10	mm
Initial tension					
$P_0 = \frac{\pi \times d^3 \times \tau}{8 \times D_m}$	0.06	kg			
Load					
$P = l \times K$	414.2512	kg			
Spring constant					
$K = \frac{G \times d^4}{8 \times (OD - d)^3 \times N_e}$	6.904187	N/m			