

# DESIGN A PREMIUM DIAL FEEL USING MATLAB

MATLAB Expo  
21/05/2019

Romain Garby

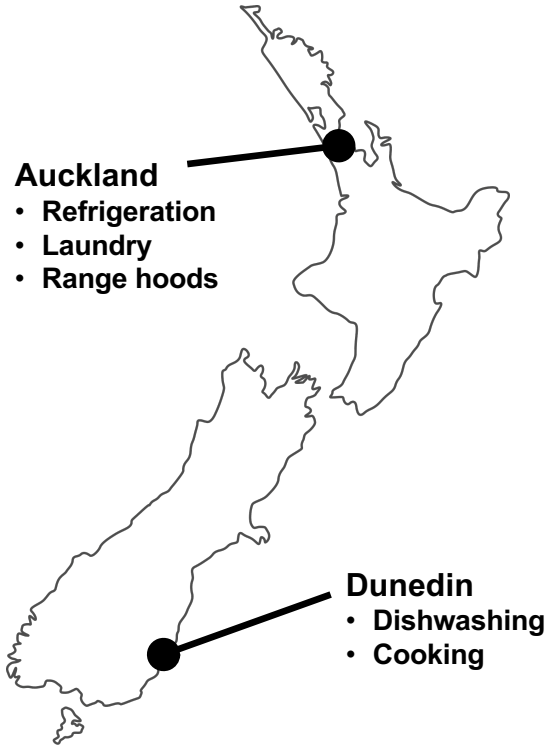
**FISHER & PAYKEL**

# WHO ARE WE: A GLOBAL APPLIANCES COMPANY



- ✓ Founded in 1934 in New Zealand
- ✓ Internationally recognised brand selling in over 50 countries
- ✓ Proven track record of delivering customer-focused product innovation
- ✓ Manufacturing facilities in China, Thailand, Mexico, and Italy
- ✓ 3000 staff worldwide

## FISHER & PAYKEL: NEW ZEALAND DESIGN CENTRES



### Product Development Capability:

- Industrial Design
- Mechanical and Engineering Science Engineers
- Electronics Hardware and Software Engineers
- Reliability, Safety and Compliance
- Wash Scientists and Product Evaluators



**400 Product Development staff across 2 sites**

## INDUSTRY LEADERS IN APPLIANCE TECHNOLOGY

**1985:** Gentle Annie: Brushless DC motor

**1991:** Smart Drive™: Direct Drive Motor

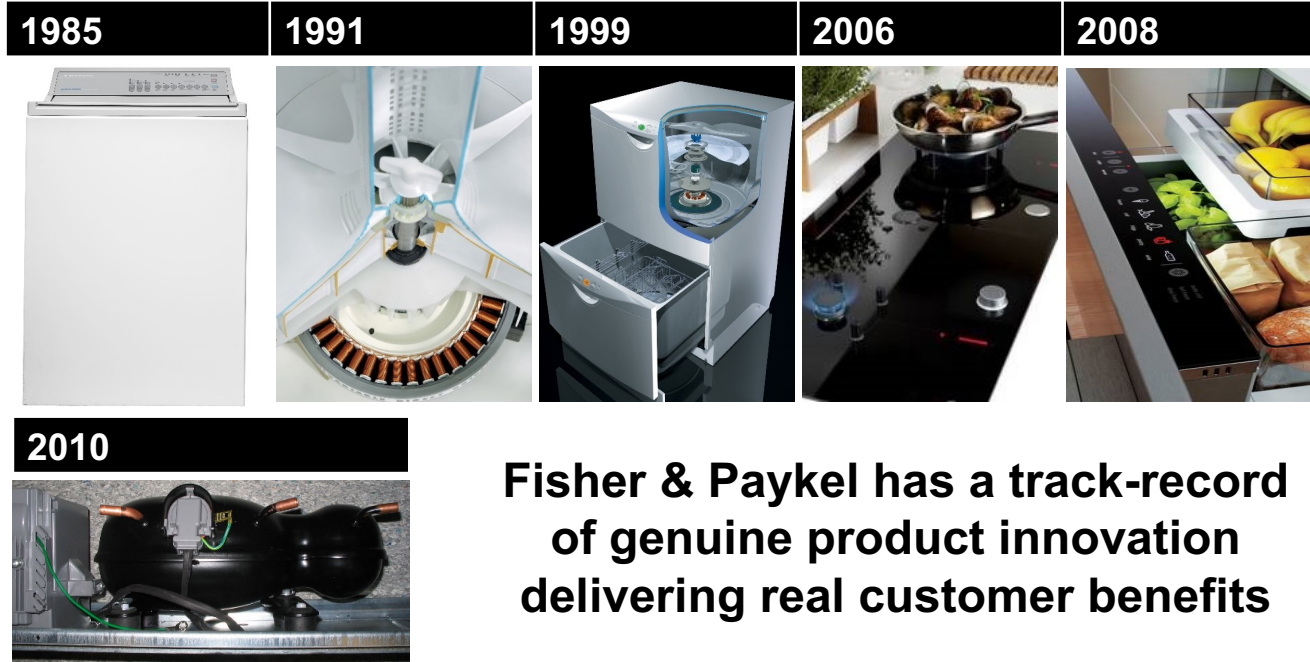
**1997:** Active Smart™: Refrigeration

**1999:** DishDrawer® Dishwasher

**2006:** CookSurface Cooktop

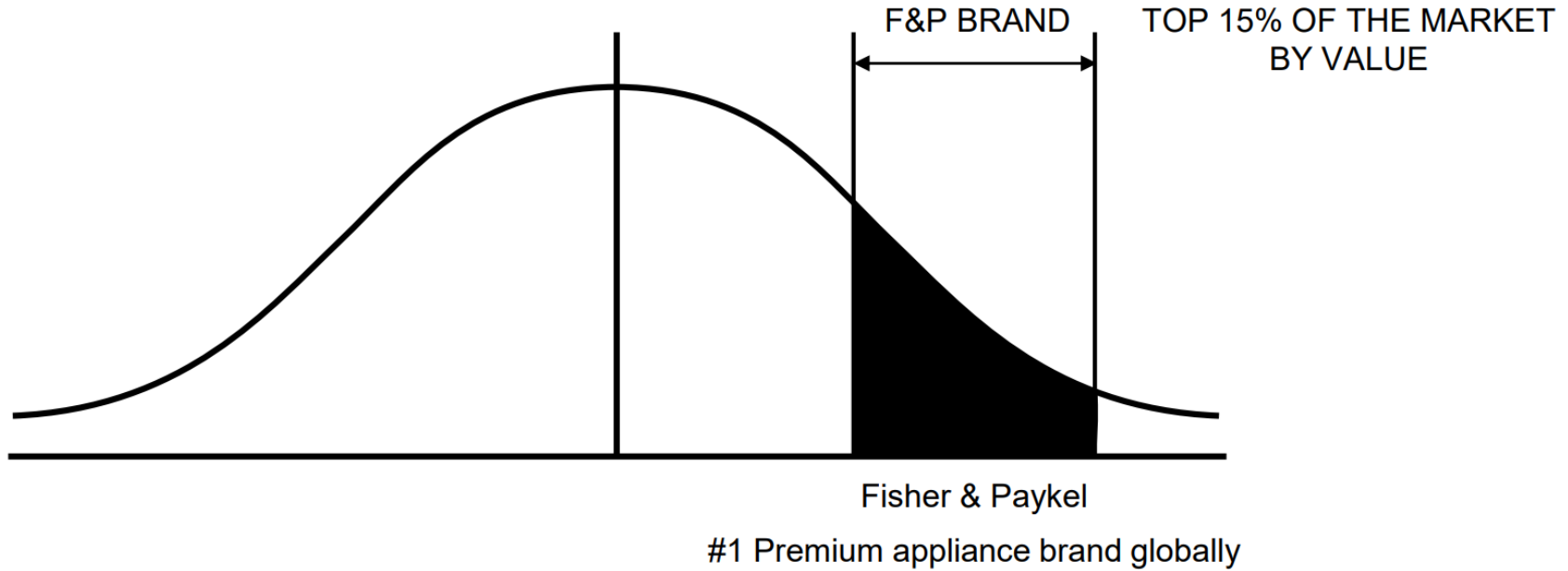
**2008:** CoolDrawer: Refrigeration

**2010:** Linear Compressor



**Fisher & Paykel has a track-record  
of genuine product innovation  
delivering real customer benefits**

# OUR GOAL: TO BE #1 PREMIUM BRAND GLOBALLY



# WHY A CUSTOM DIAL FEEL?

- One of the direct points of contact between a customer and the product
- The way a dial feels can inadvertently convey the *perceived* quality of a product
- We need to translate highly subjective attributes into objective measures

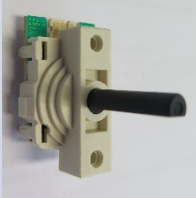



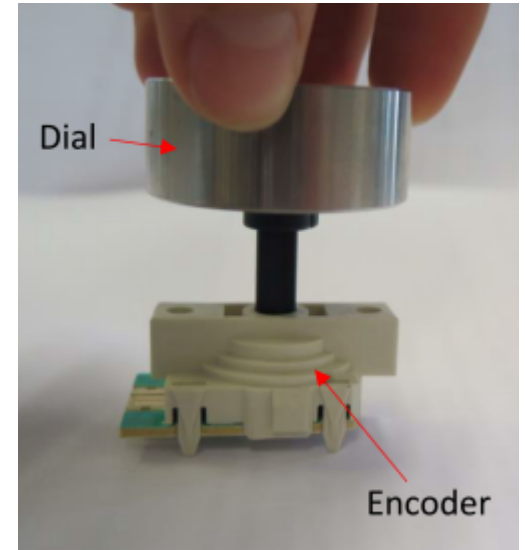
[Knob Feel Youtube Channel](#)

*“The A29 is another home run for Arcam. Lovely feel here, solidly built Knob. Incredibly weighted rotation. Also includes a lovely slight click to the rotation, which does not deter from the smoothness of it. This is one satisfying Knob.”*

# SCOPE

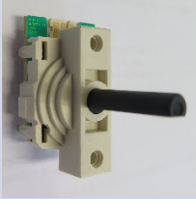

## Definitions:

<p>Encoder</p> 	<p>A rotary encoder (shaft encoder) is an electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code. (wiki)</p>
<p>Dial/Knob</p> 	<p>A plate or disc that can be turned to select a setting on a piece of equipment.</p>

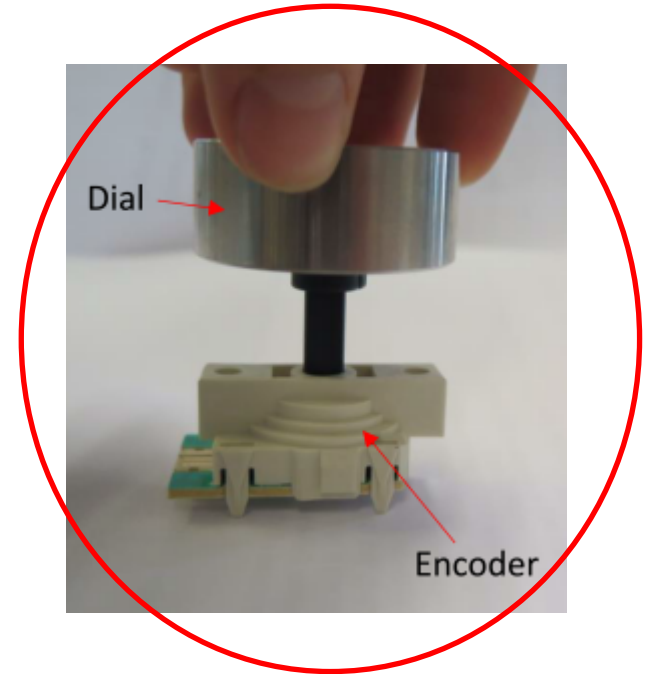


# SCOPE

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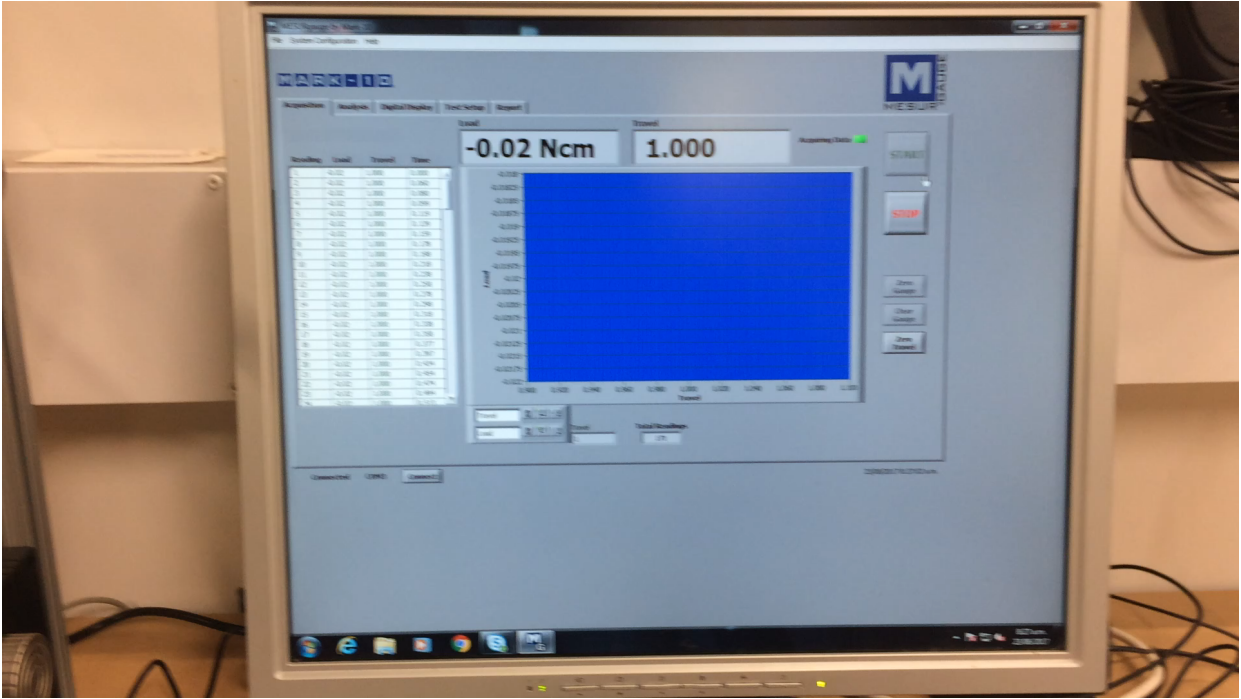
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## DIAL FEEL





# FIRST MEASUREMENTS: TORQUE VS ROTATION



# GOALS OF THE PROJECT

At the end of this project we will:

- be able to measure & quantify what a 'premium' dial feels like
- understand the variables within a dial that influence its feel
- understand the parameters we are likely to vary for future dial designs

How to get there:

- benchmark against selected purchased encoders for dial feel
- acquire the reusable knowledge available to go straight to detailed design of a dial, for future projects

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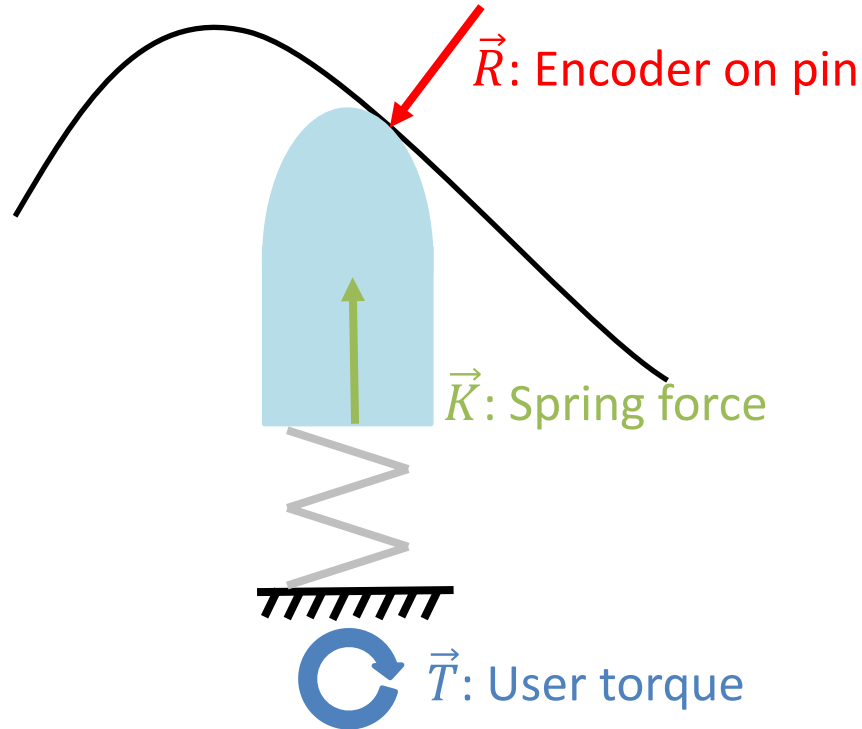
How to

- ben
- acquire the reusable knowledge available to go straight to detailed design of a dial, for future projects

**MODELLING CAN HELP**

# PROOF OF CONCEPT

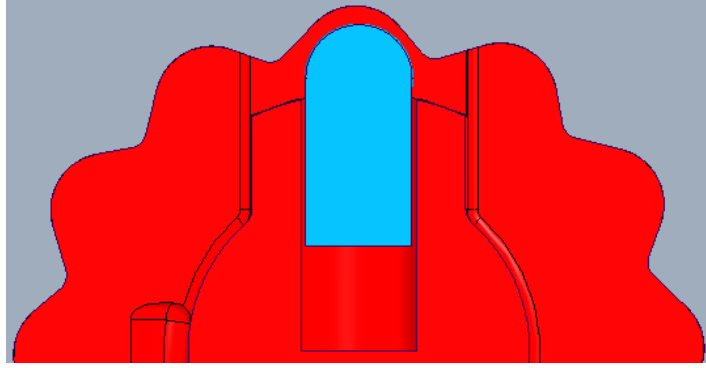
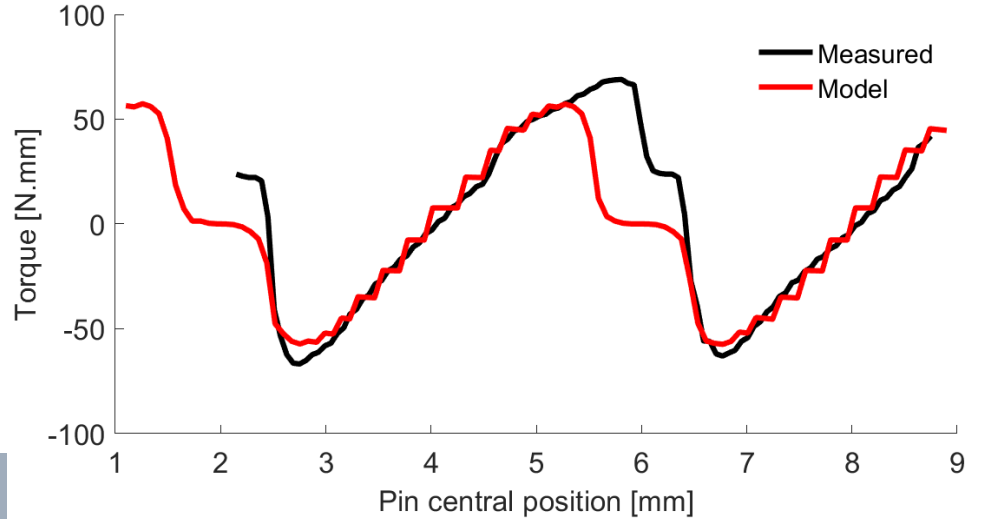
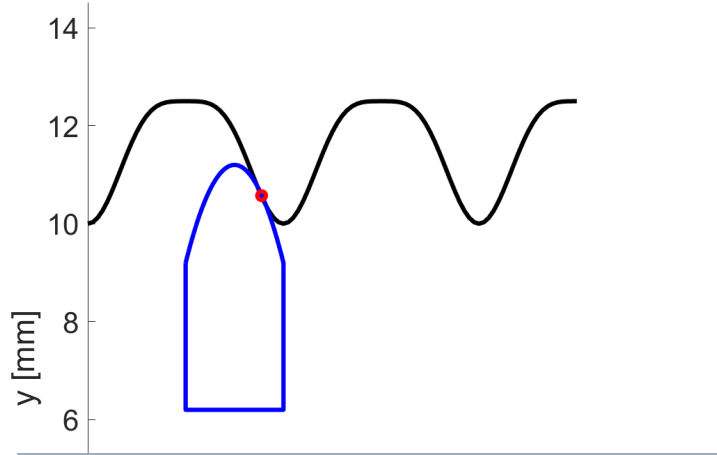
# STEADY-STATE STRENGTH BUDGET



## Parameters:

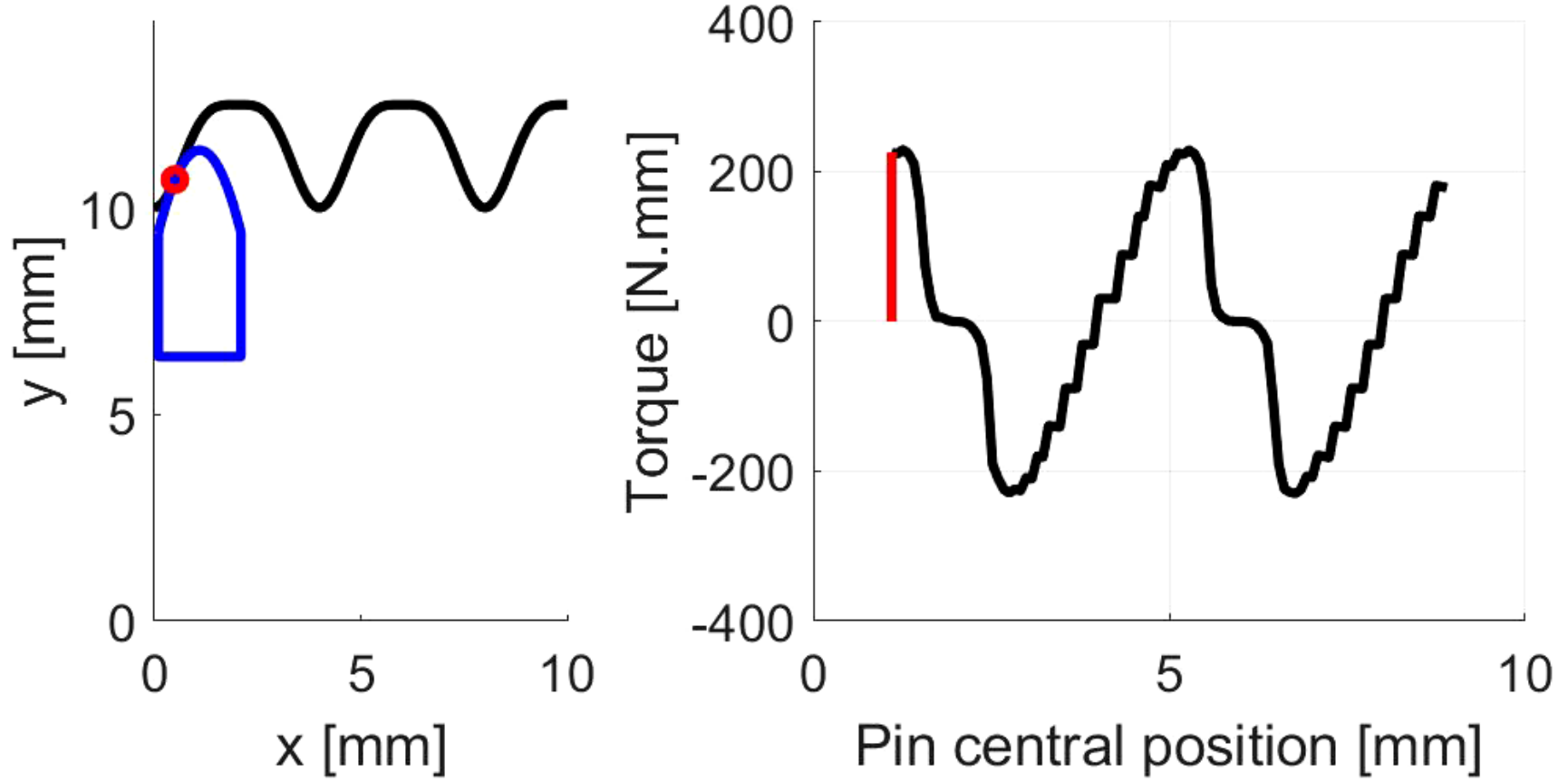
- Size and shape of the encoder
- Size and shape of the pin
- Spring force and free length

# VALIDATION ON EVEREL ENCODER



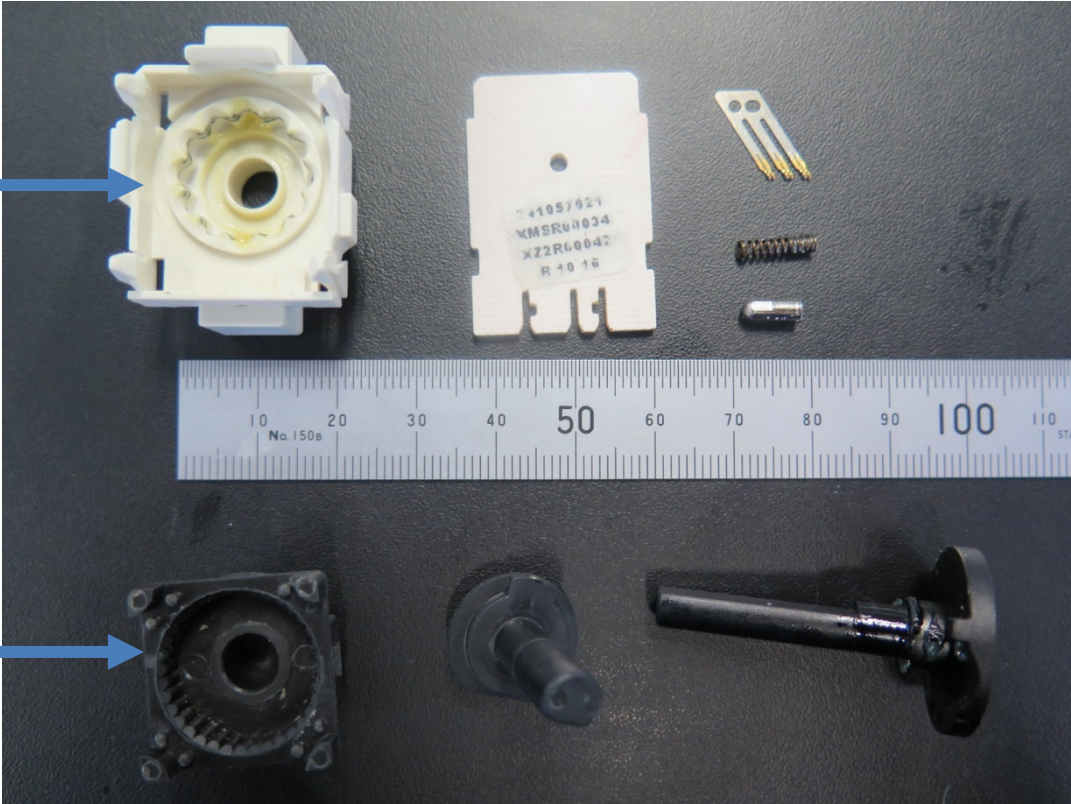
SHAPE OF ENCODER IS AN ESTIMATION AND CAN BE IMPROVED BY IMPORTING CAD MODEL

# CLOSE LOOK ON STEPS



# REAL ENCODER SHAPE

Everel



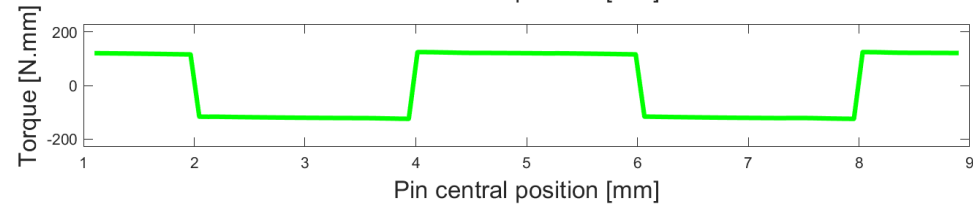
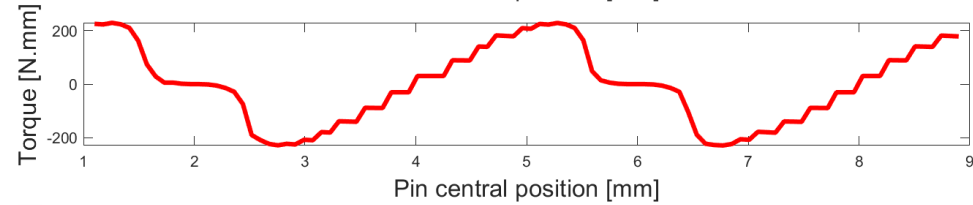
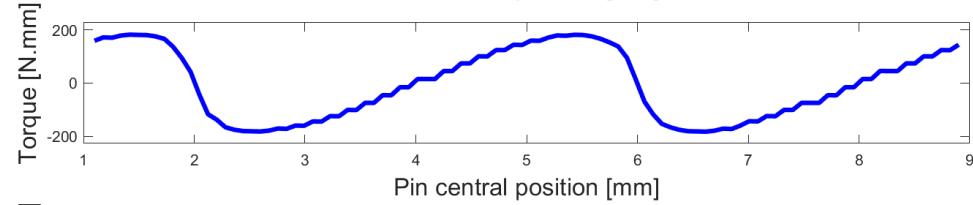
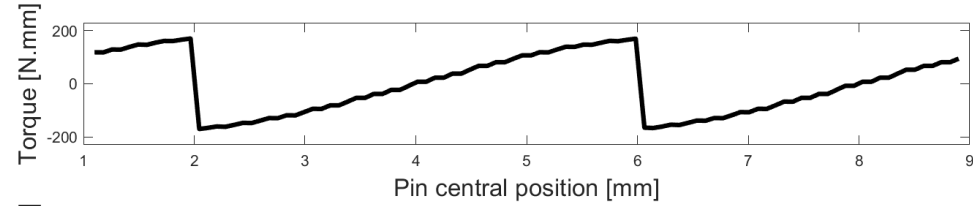
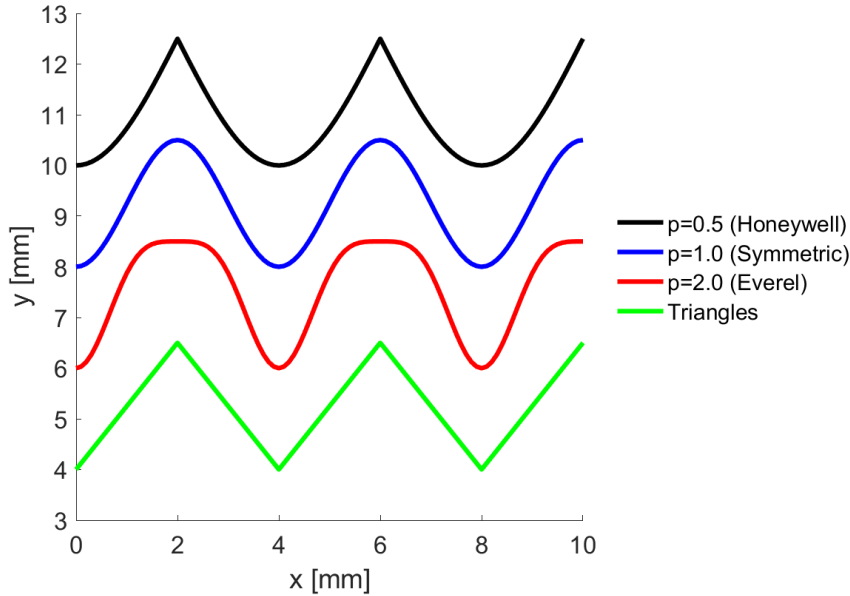
Honeywell



# SHAPE OF ENCODER

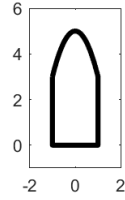
Sinusoidal shape defined as:

$$y = \frac{\theta}{2} - D \left[ \left( \frac{1 + \cos\left(\frac{x}{g}2\pi\right)}{2} \right)^p - 1 \right]$$

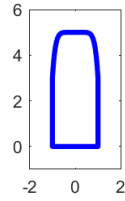


# SHAPE OF PIN

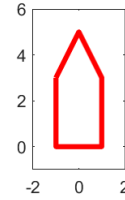
- Encoder: symmetric sinus
- Pin: Sinusoidal shape:  
 $y = Ax^p$   
All pin have the same height



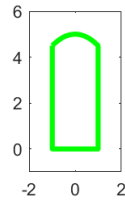
— p=2, A=2.0



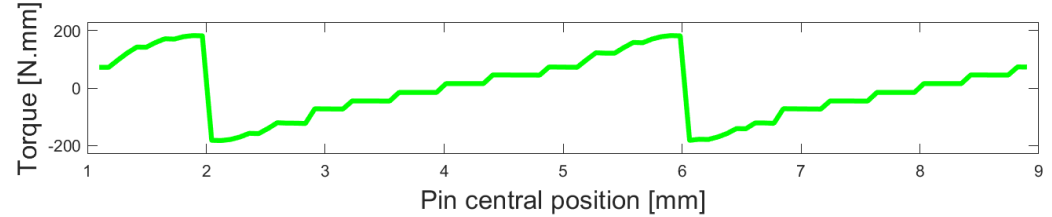
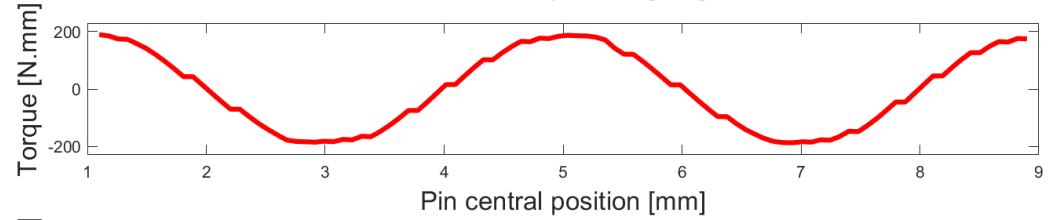
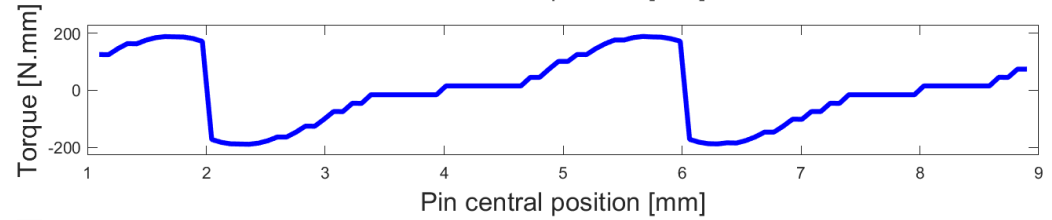
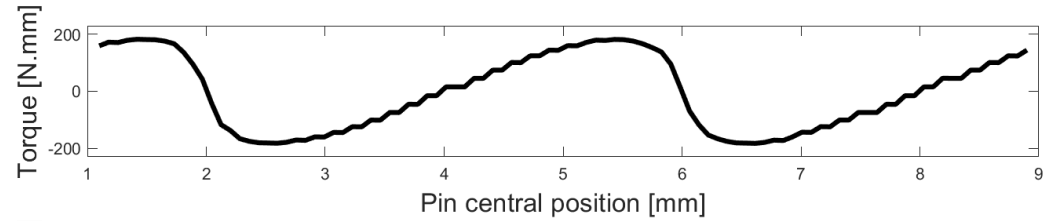
— p=8, A=2.0



— Tri, A=2.0

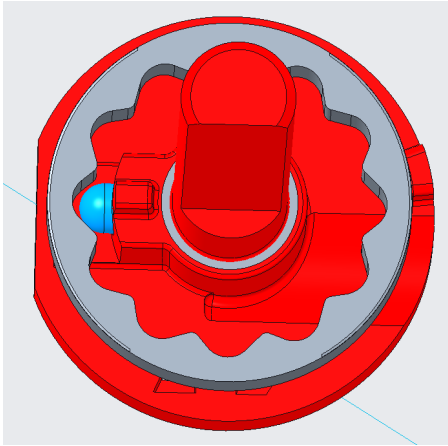


— p=2, A=0.5

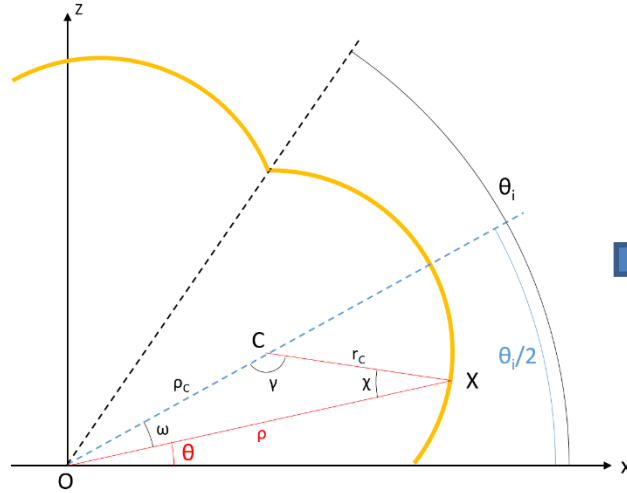


# CYLINDRICAL 3D MODEL

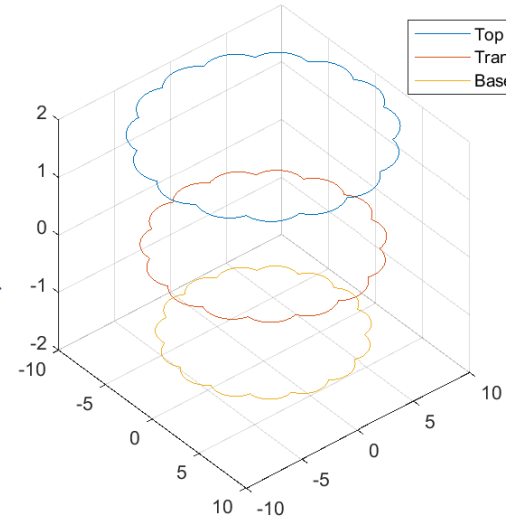
# CYLINDRICAL 3D MODEL



CAD model



2D section

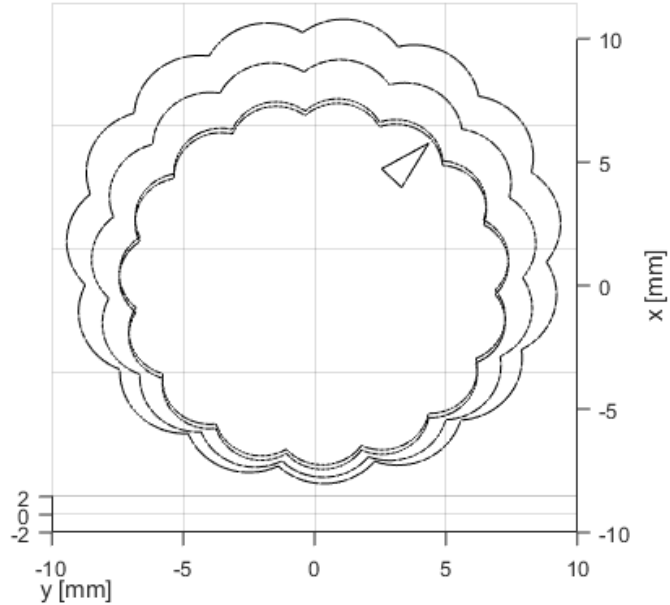


3D Reconstitution

# WORKFLOW

For each angle of dial:

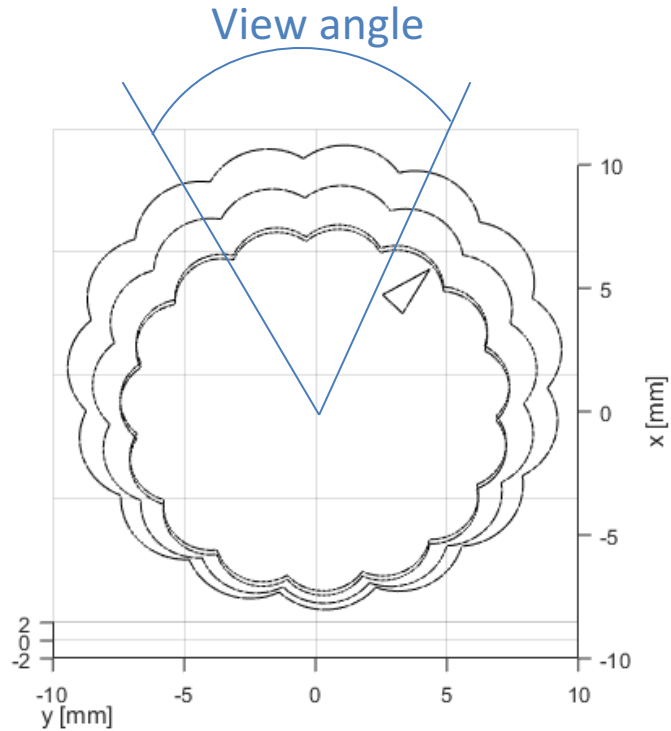
- Rotate 2D sections



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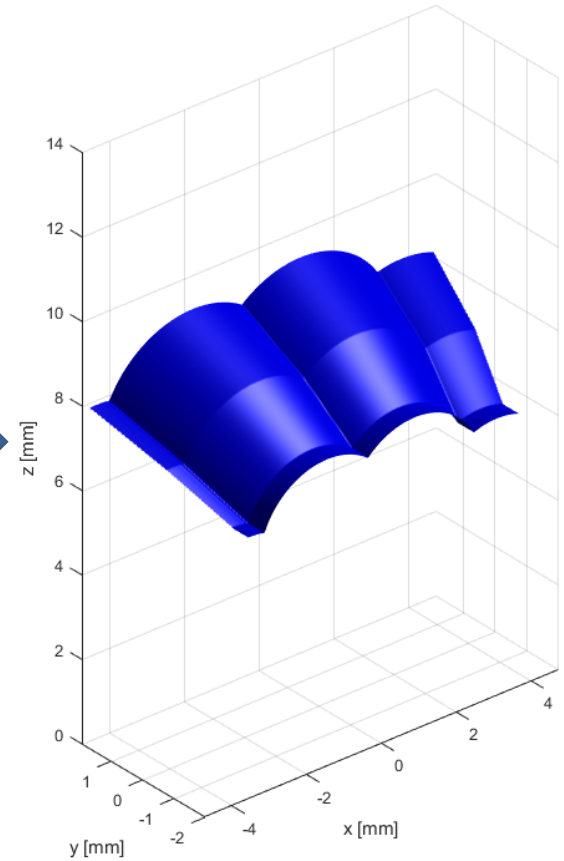
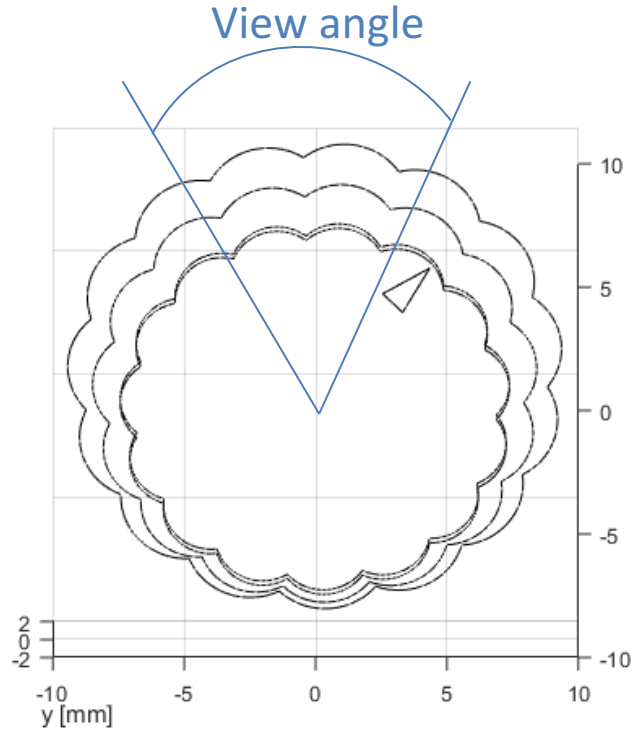
- Rotate 2D sections
- ↓
- Create 3D surface



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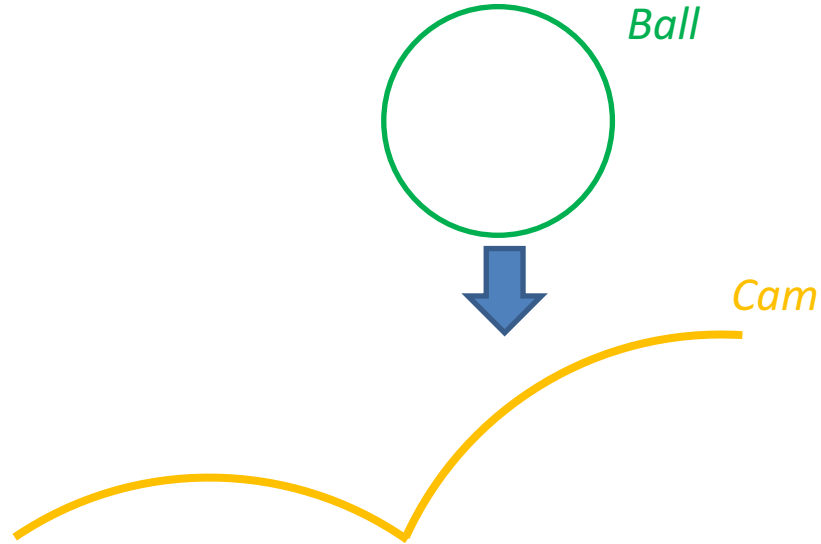
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- ↓
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# WORKFLOW

For each angle of dial:

- Rotate 2D sections
- ↓
- Create 3D surface
- ↓
- Iteratively lower the ball until contact  
Get spring tension

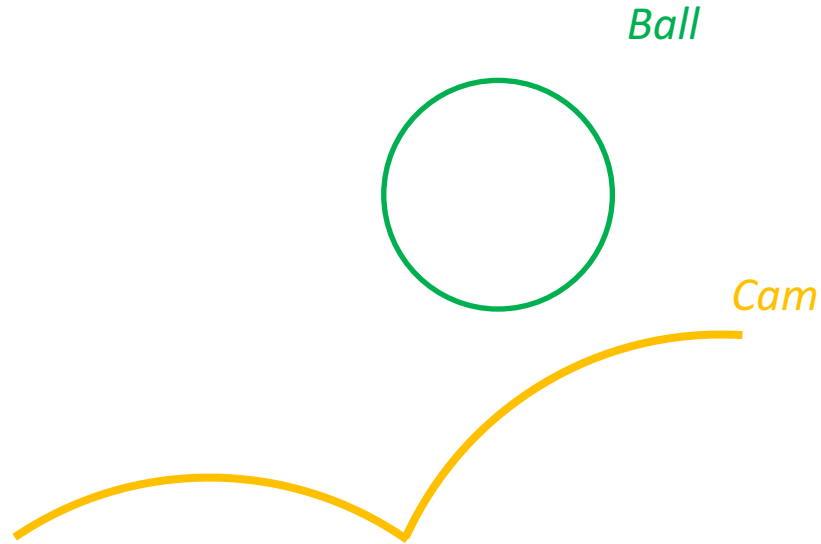




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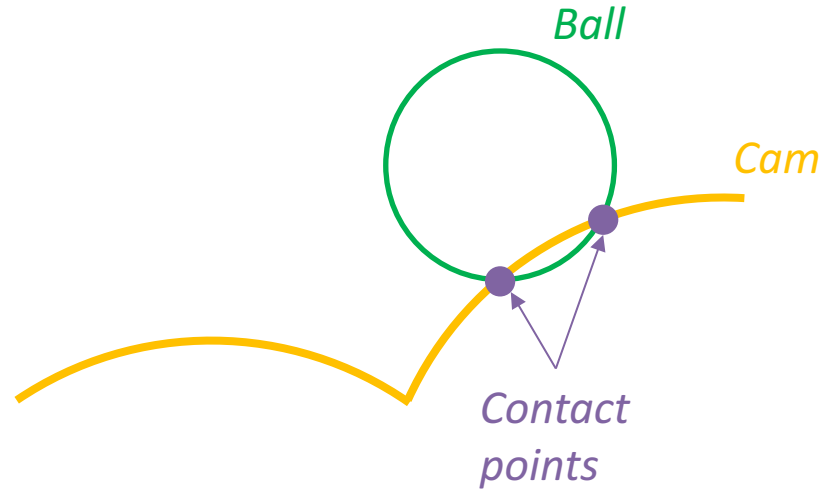
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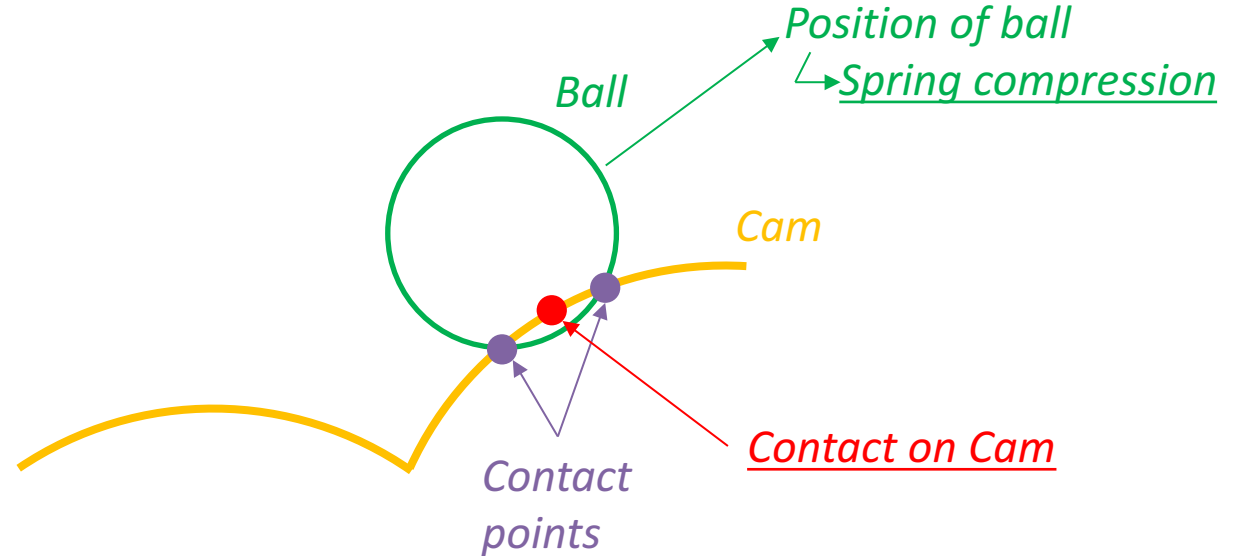
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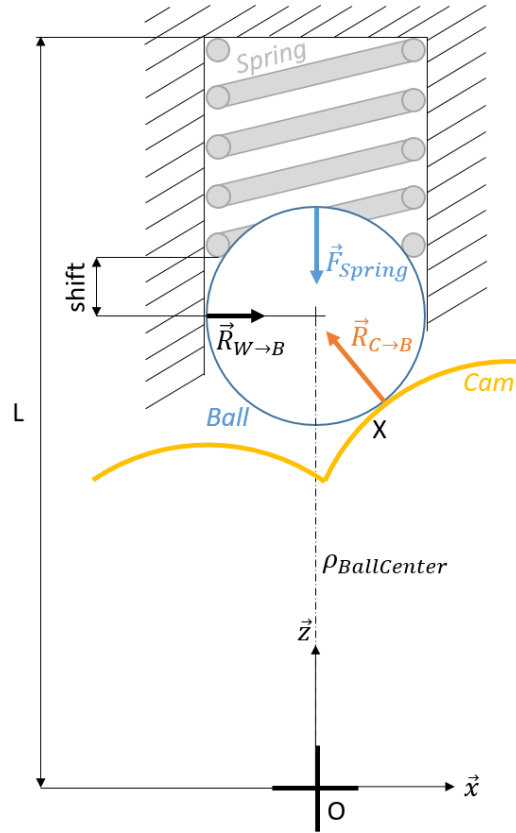
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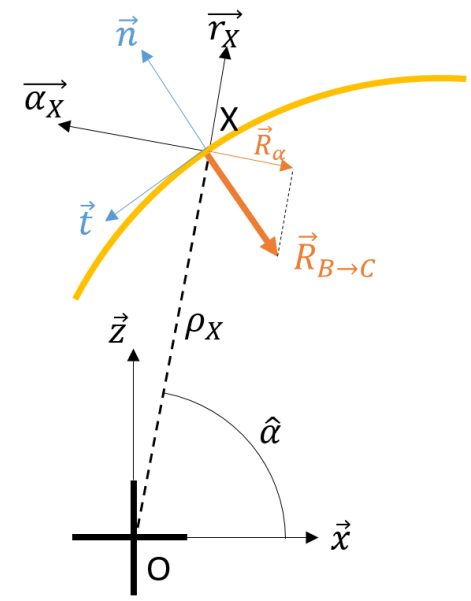
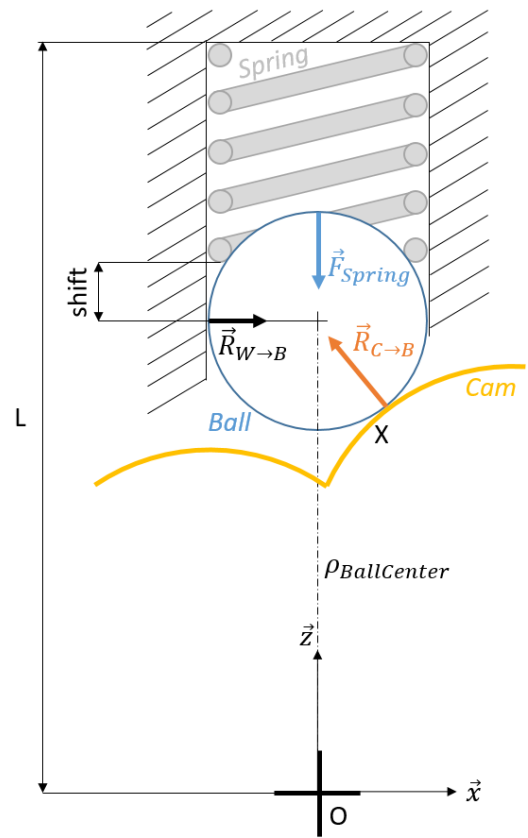
- Rotate 2D sections
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- Create 3D surface
- ↓
- Iteratively lower the ball until contact  
Get spring tension
- ↓
- Find contact point
- ↓
- Calculate projection and then torque



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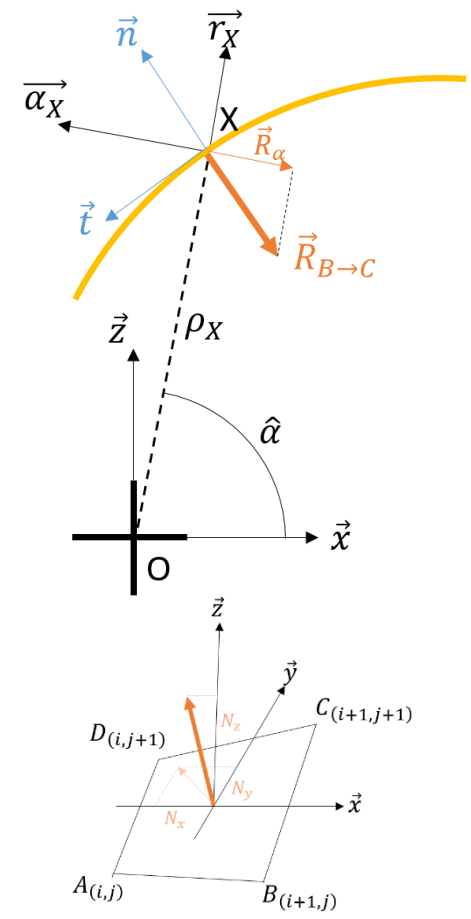
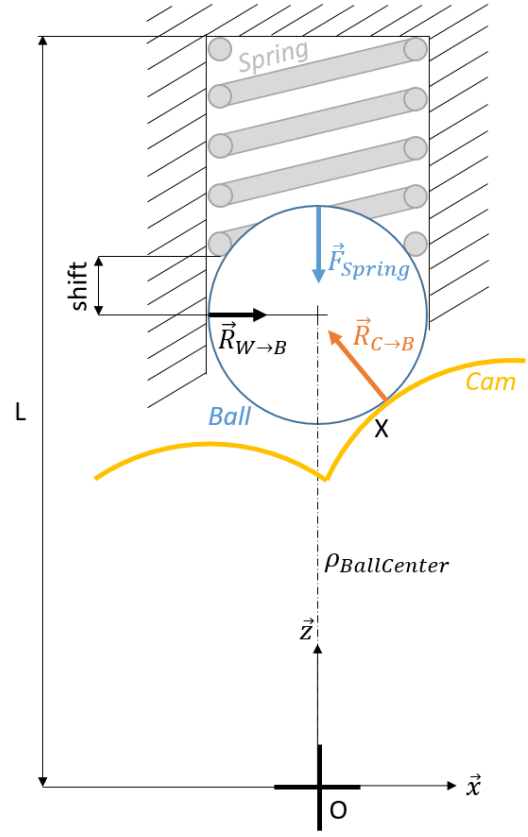
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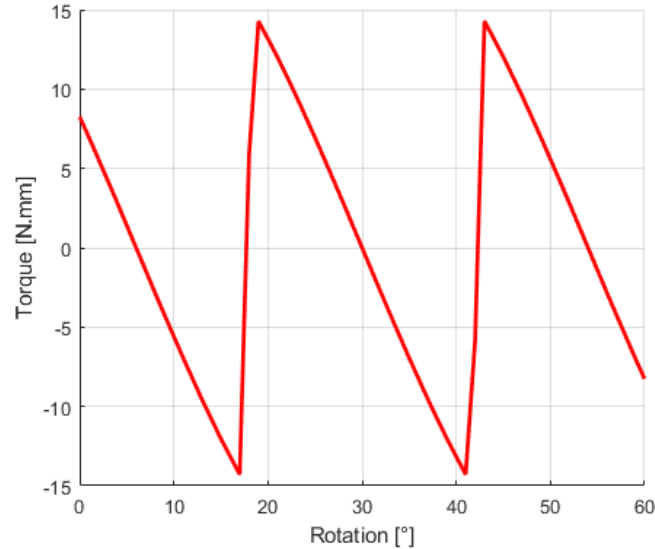
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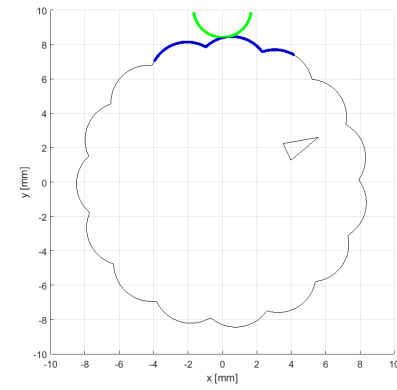
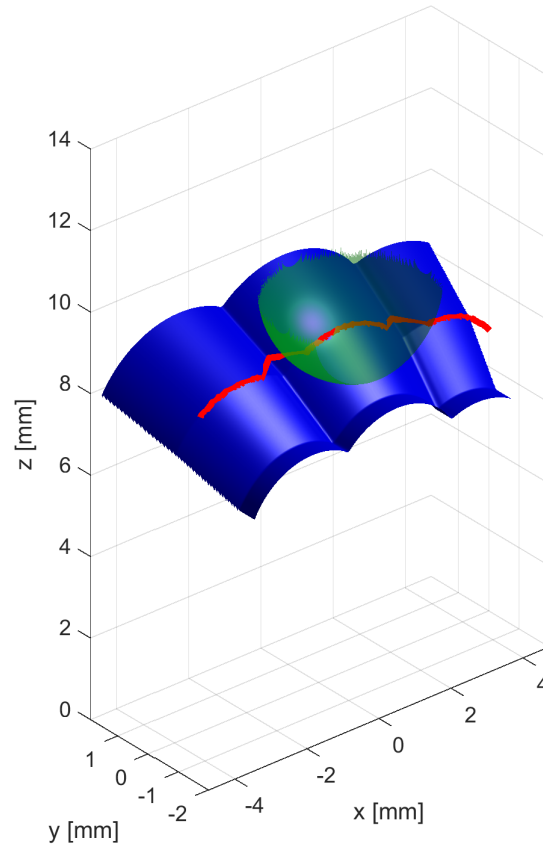
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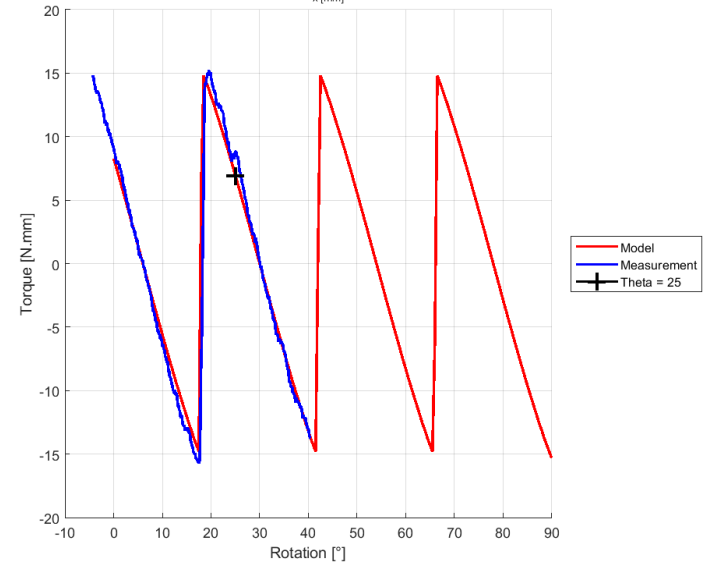
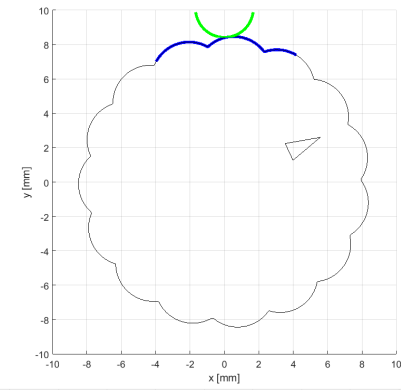
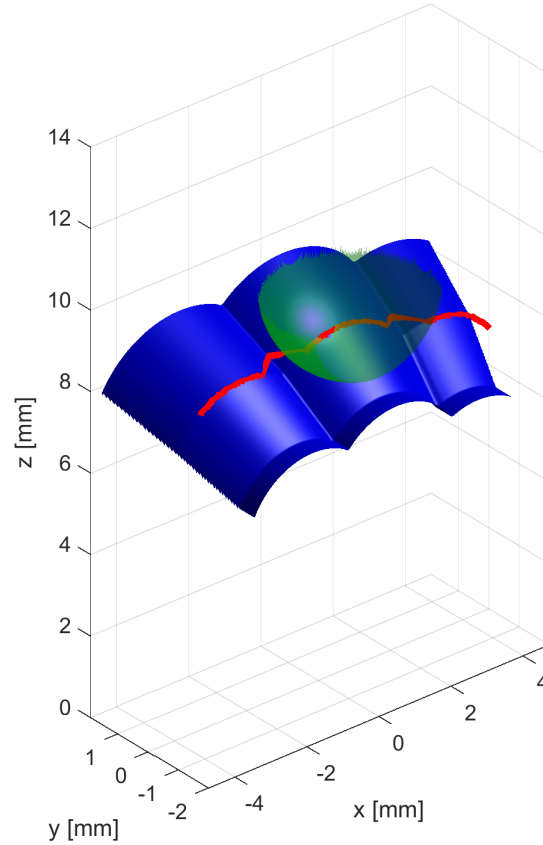


# VALIDATION





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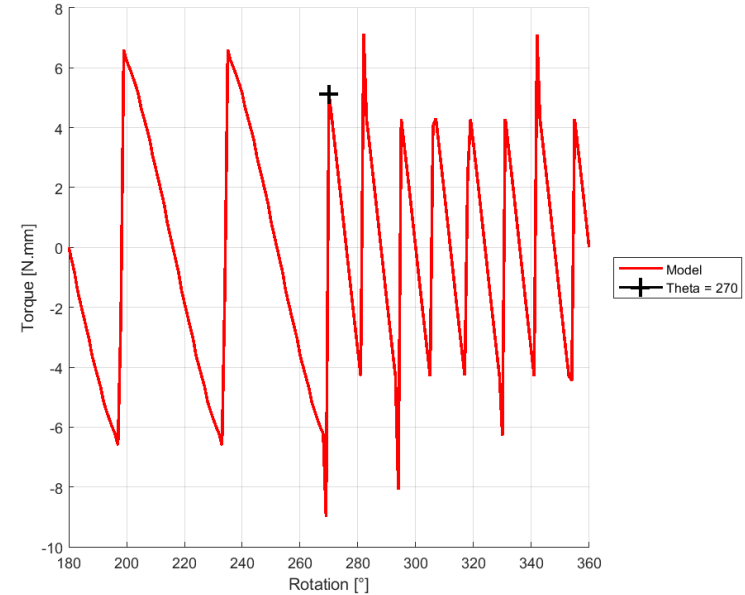
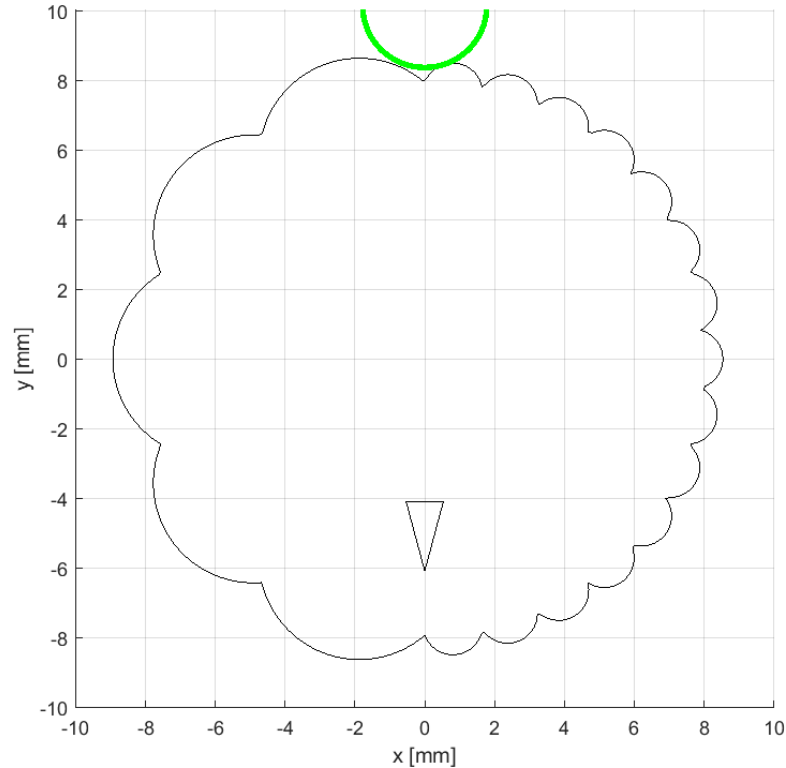


# PARAMETRIC STUDY

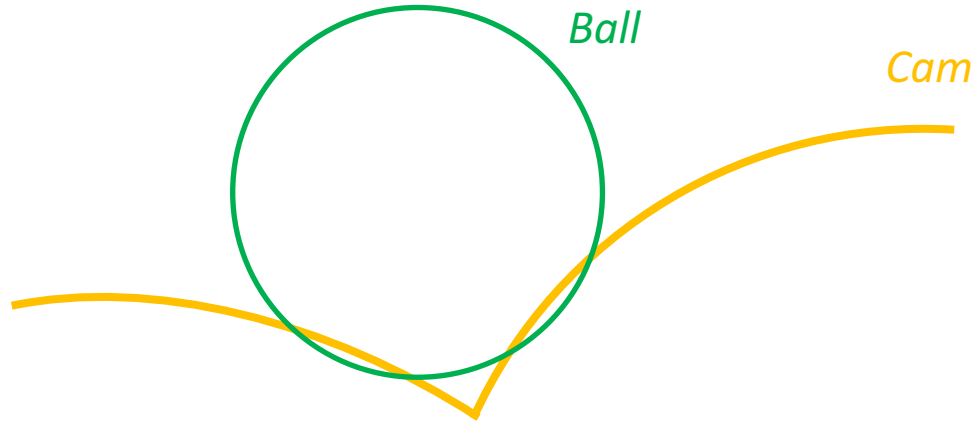
- Push curve
- Spring ratio
- Ball radius
- Ball shape
- Cam shape
- ...

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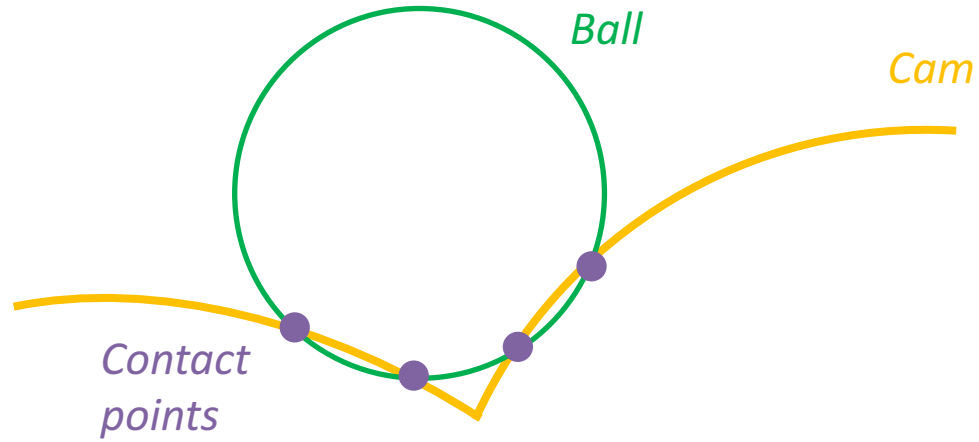
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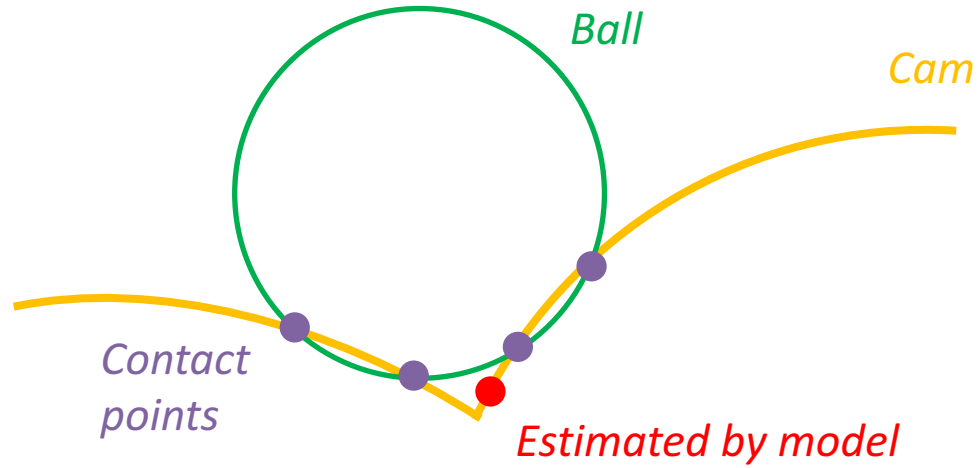
# ROOM FOR HIGHER FIDELITY MODELLING



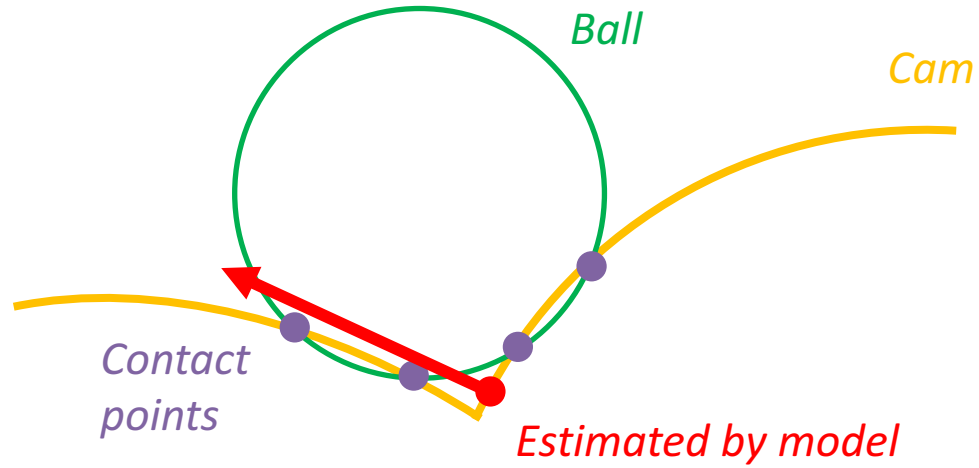
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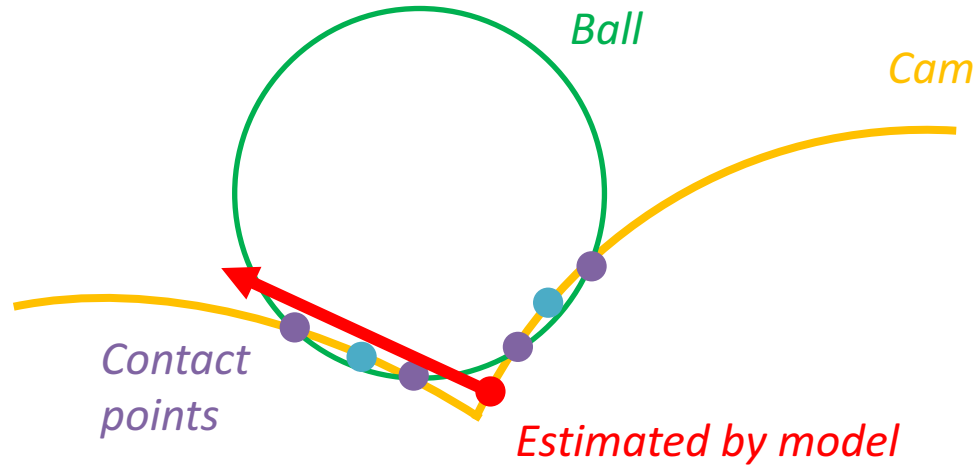
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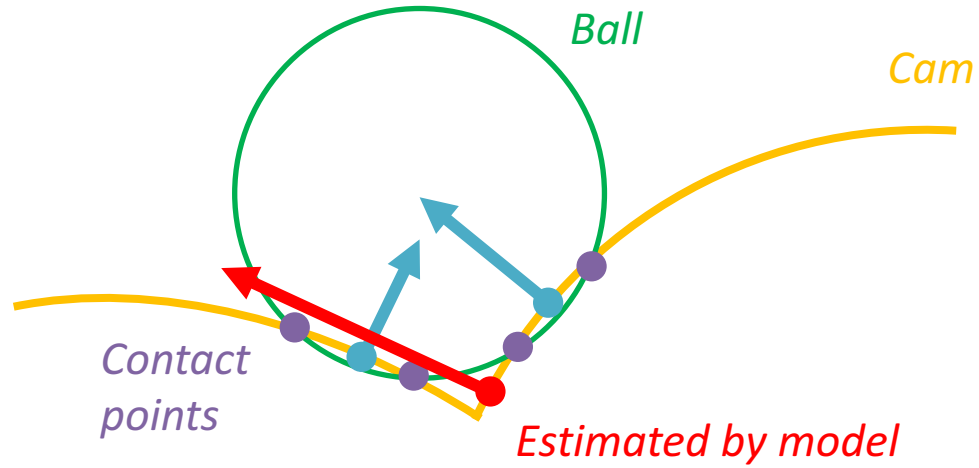


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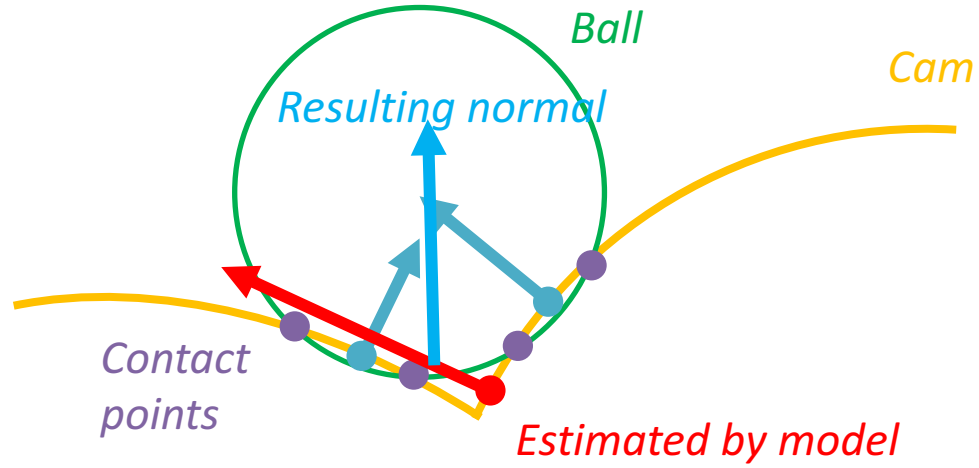




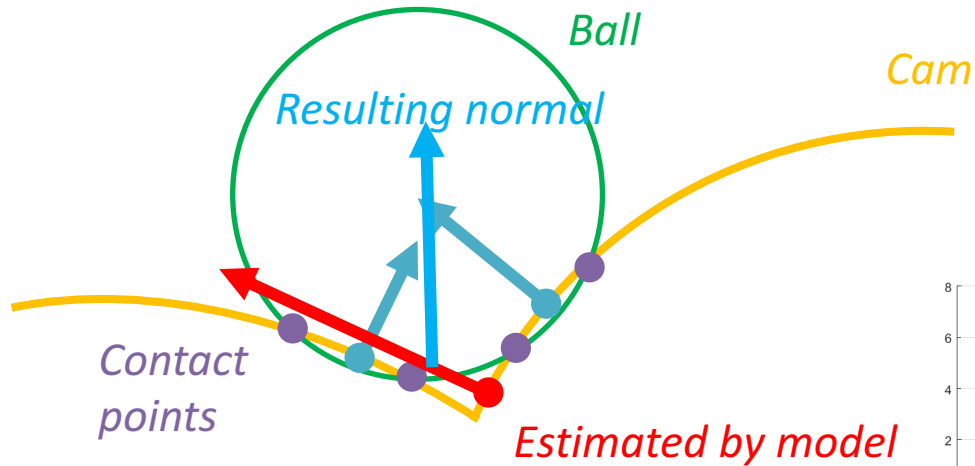
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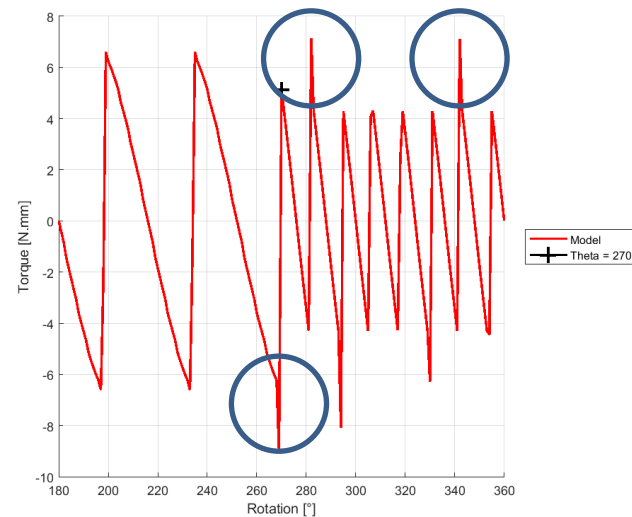
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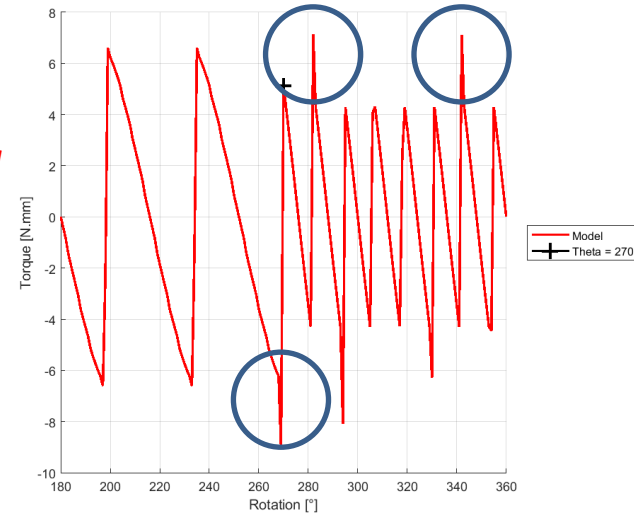
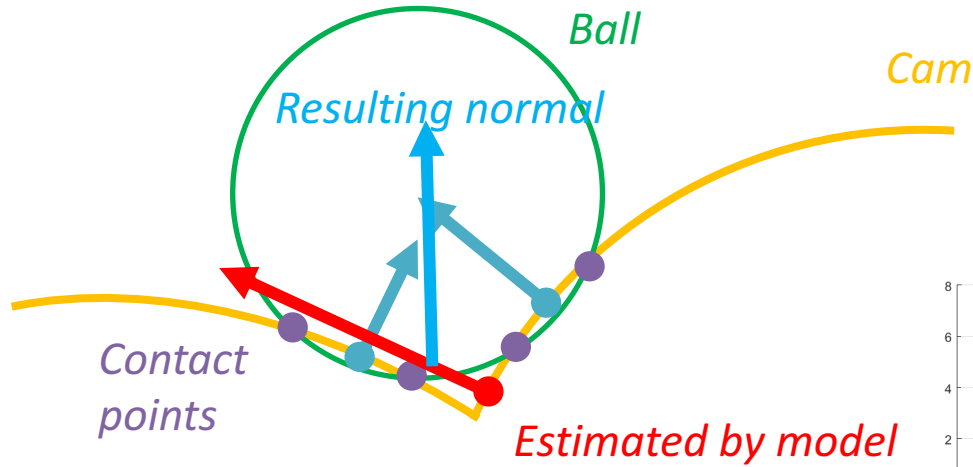
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Over estimation of torque at some locations



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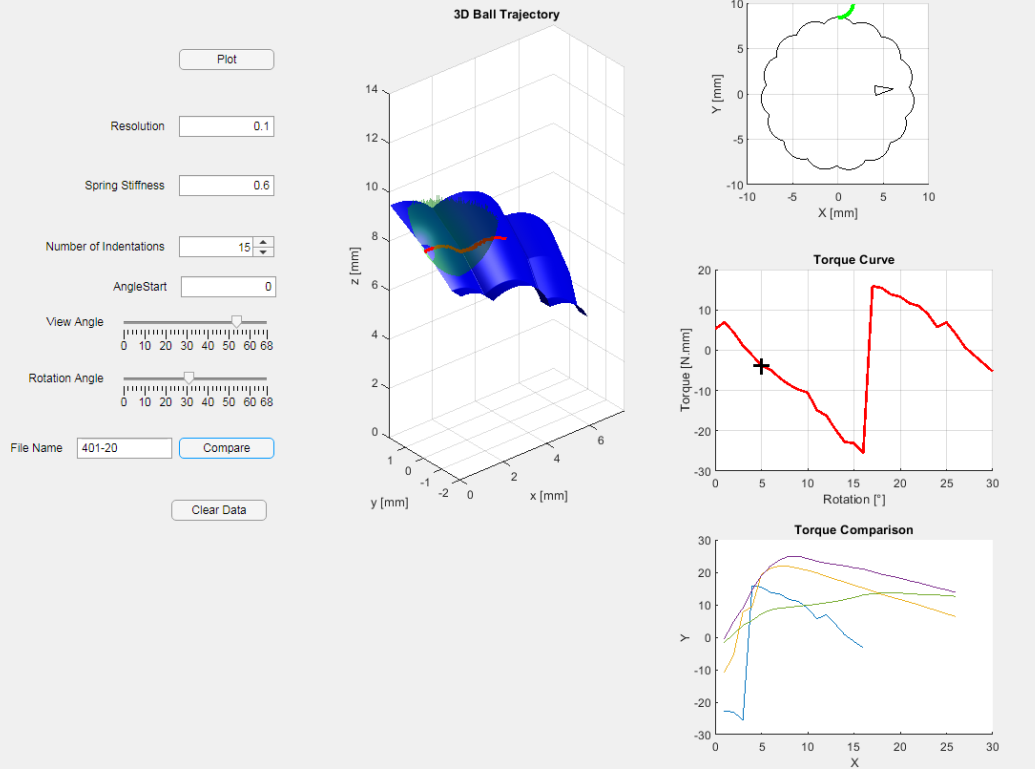


Over estimation of torque at some locations

**Good enough to take decision  
without building prototypes**

# MATLAB APP DESIGNER

## Dial Feel Analysis



# WHAT DID WE GAIN?

Classical Way:

With Matlab:

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Prototyping ! (A lot)

With Matlab:

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- \$300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

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Rotational curve profile : 5 prototypes

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Spring ratio : 3 prototypes

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- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : ~~4~~<sup>1</sup> prototypes

Rotational cur~~0~~<sup>1</sup> profile : ~~5~~ prototypes

Ball radius : ~~3~~ prototypes

Spring ratio : 3 prototypes

## With Matlab:

3 weeks to choose a modelling strategy

1 week to code the model

Few minutes to get a result

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## With Matlab:

3 weeks to choose a modelling strategy

1 week to code the model

Few minutes to get a result

- Modelling started way too late for this project
  - Initial learning curve was steep
- Need to be reused and improve

# TO GO FURTHER

Steady-state model:

- Make it easier to use by anybody
- Work on how to import a cam geometry from CAD



# TO GO FURTHER

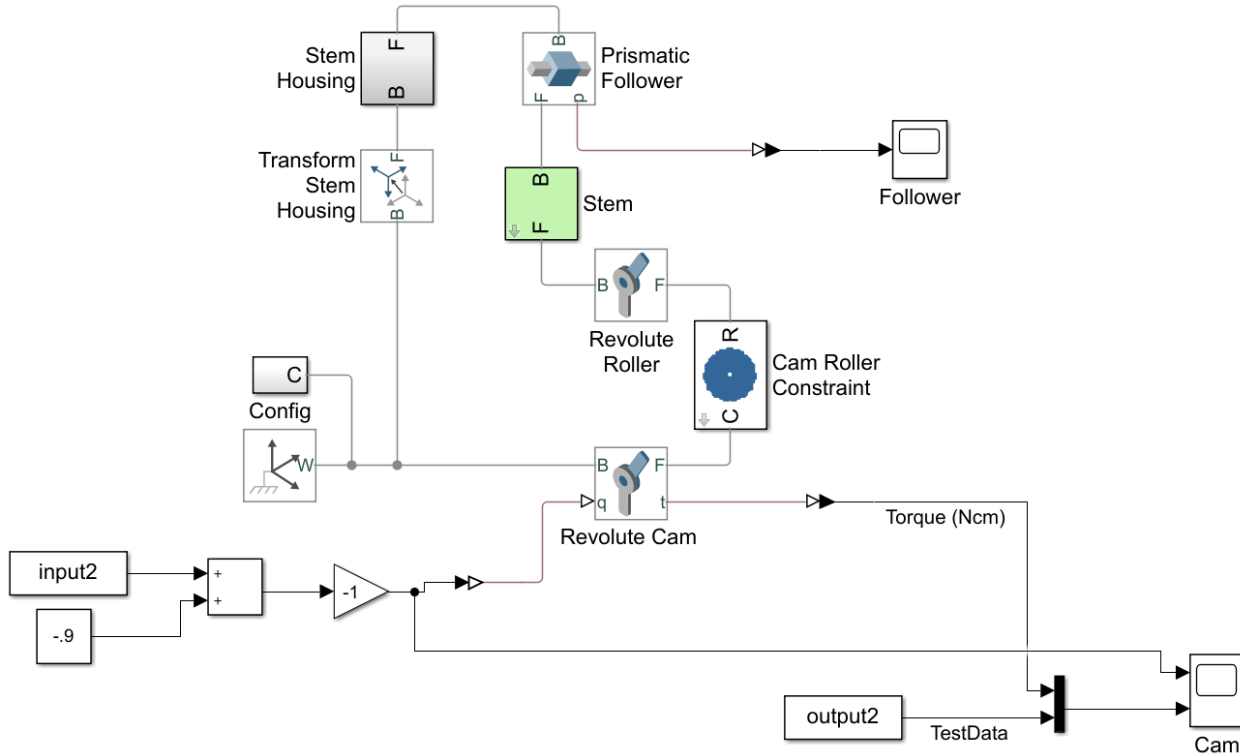
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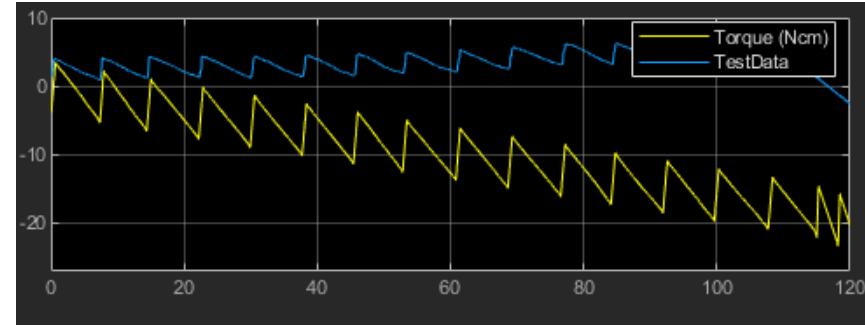
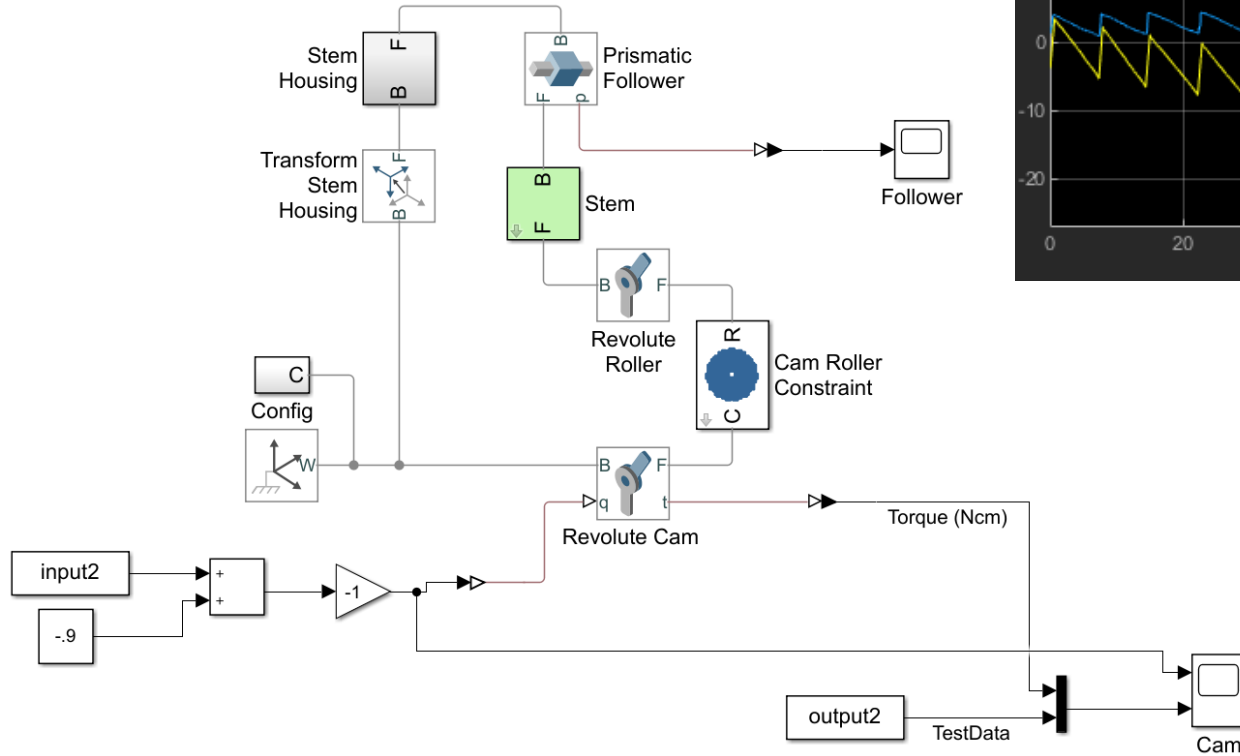
Dynamic model (Simscape):

- Investigate what we can learn

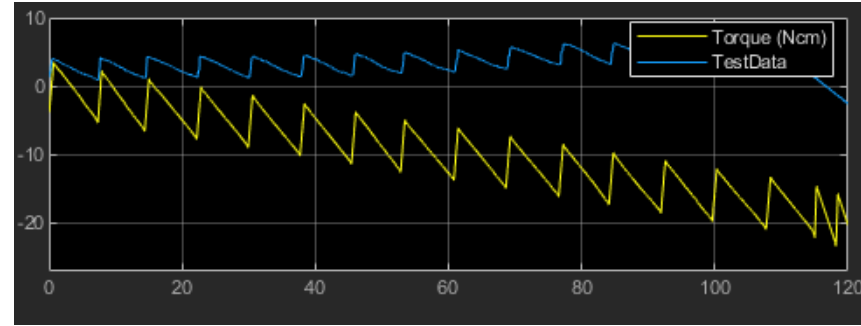
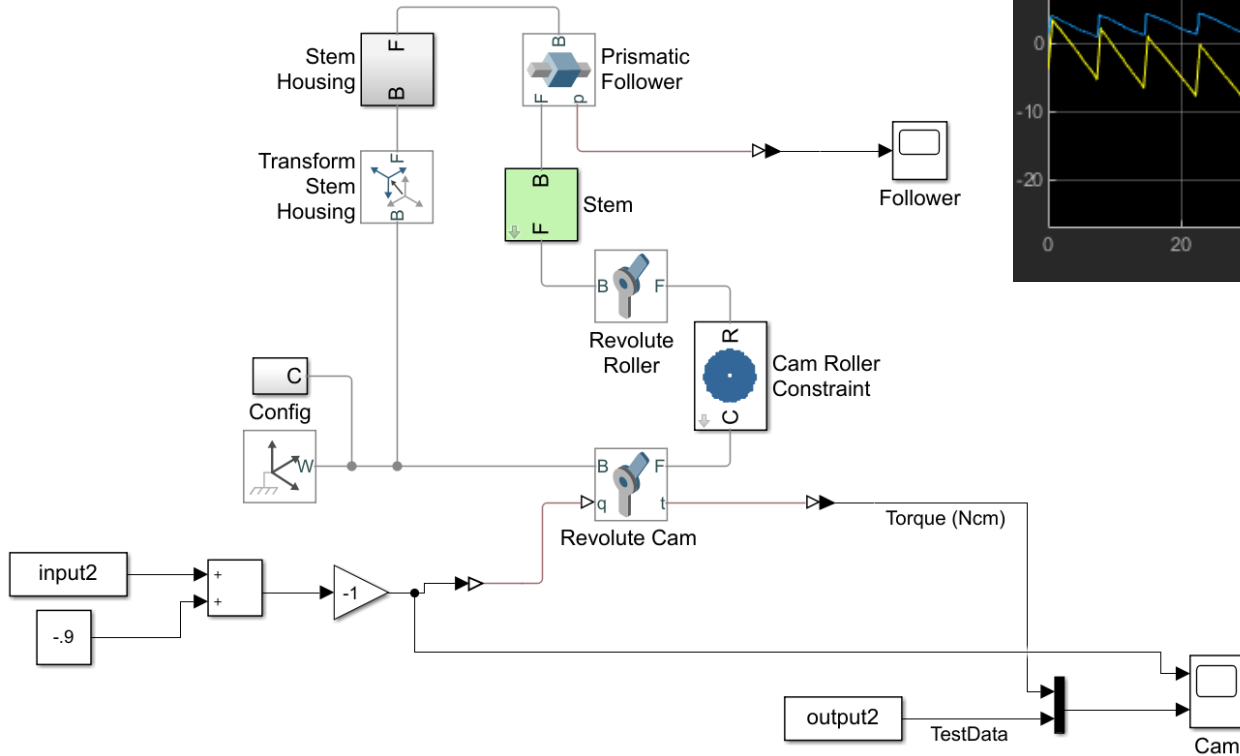
# A DYNAMIC MODEL?



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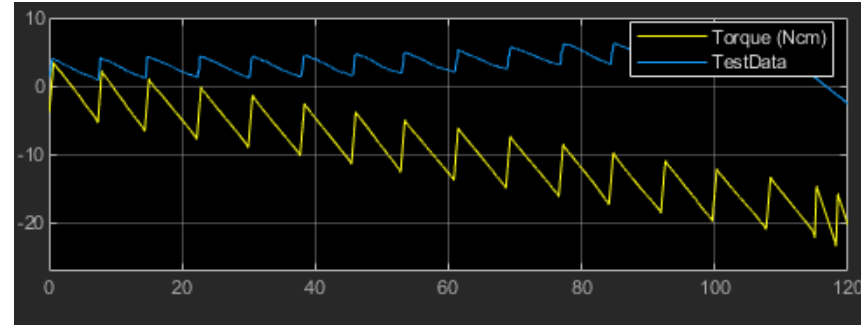
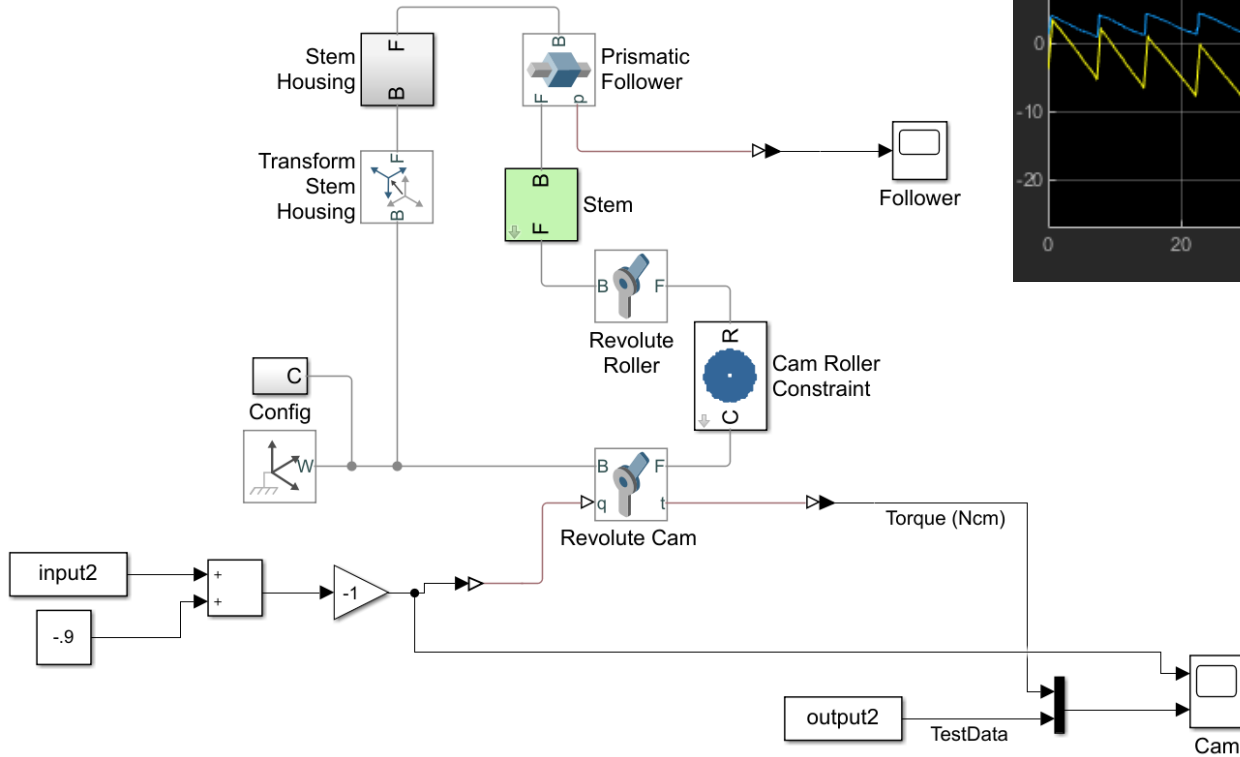
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## Expected benefits:

- Dynamic:
  - how the ball jumps and miss indents
  - how it reacts to acceleration

# A DYNAMIC MODEL?



## Expected benefits:

- Dynamic:
  - how the ball jumps and miss indents
  - how it reacts to acceleration
- Friction
  - Impact of material/lubricant

# TO GO FURTHER

Steady-state model:

- Make it easier to use by anybody
- Work on how to import a cam geometry from CAD

Dynamic model (Simscape):

- Investigate what we can learn

**Define what a premium feel is:**



# OTHER POTENTIAL PROJECTS USING MATLAB AT FISHER & PAYKEL DUNEDIN

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Dish performance  
assessment with **image  
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Design a self/soft-closing self-  
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Model based design  
and product logic

# THANK YOU

