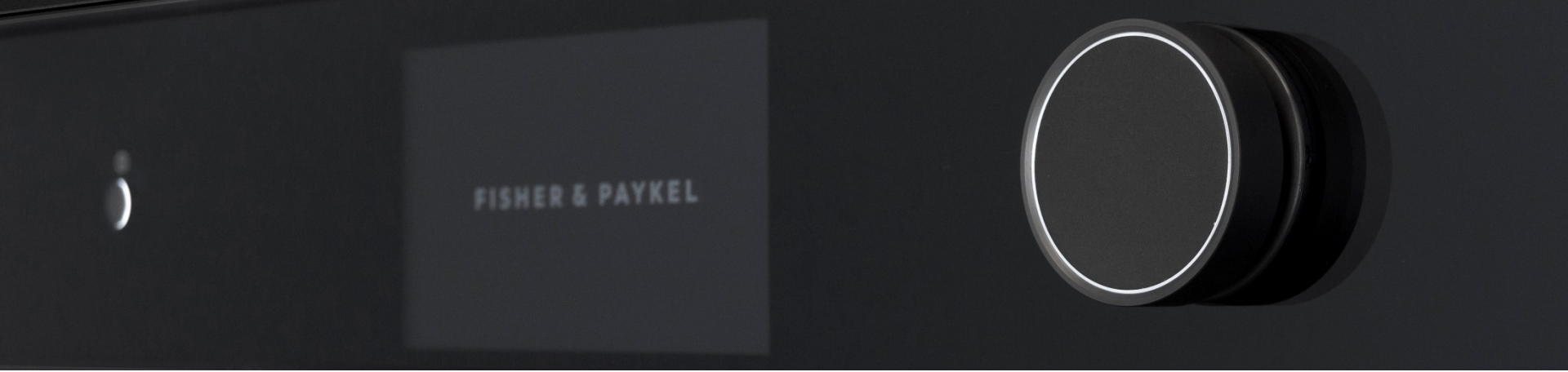


DESIGN A PREMIUM DIAL FEEL USING MATLAB

MATLAB Expo
21/05/2019

Romain Garby

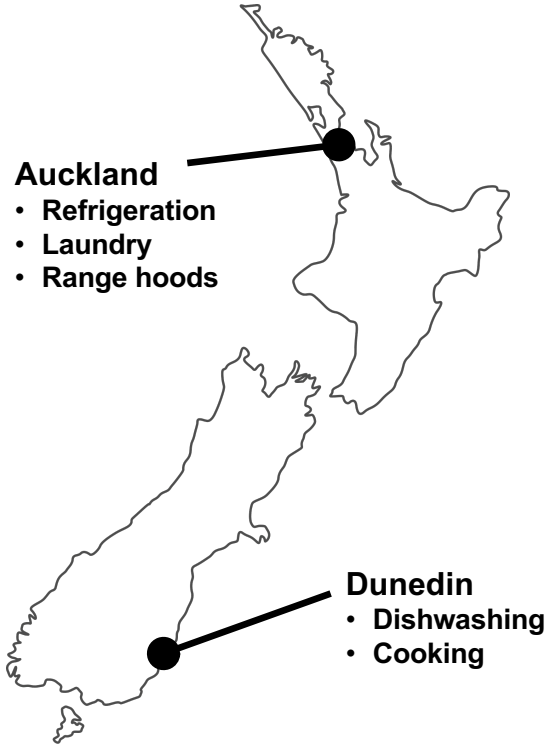
FISHER & PAYKEL

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

FISHER & PAYKEL: NEW ZEALAND DESIGN CENTRES



Product Development Capability:

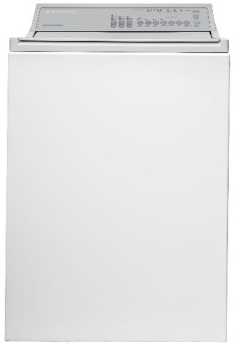
- Industrial Design
- Mechanical and Engineering Science Engineers
- Electronics Hardware and Software Engineers
- Reliability, Safety and Compliance
- Wash Scientists and Product Evaluators

400 Product Development staff across 2 sites

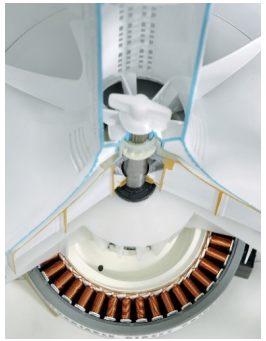
INDUSTRY LEADERS IN APPLIANCE TECHNOLOGY

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

1985



1991

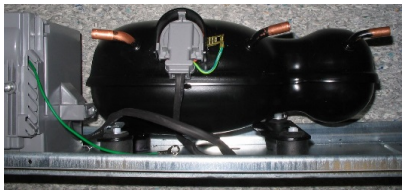


1999

2006

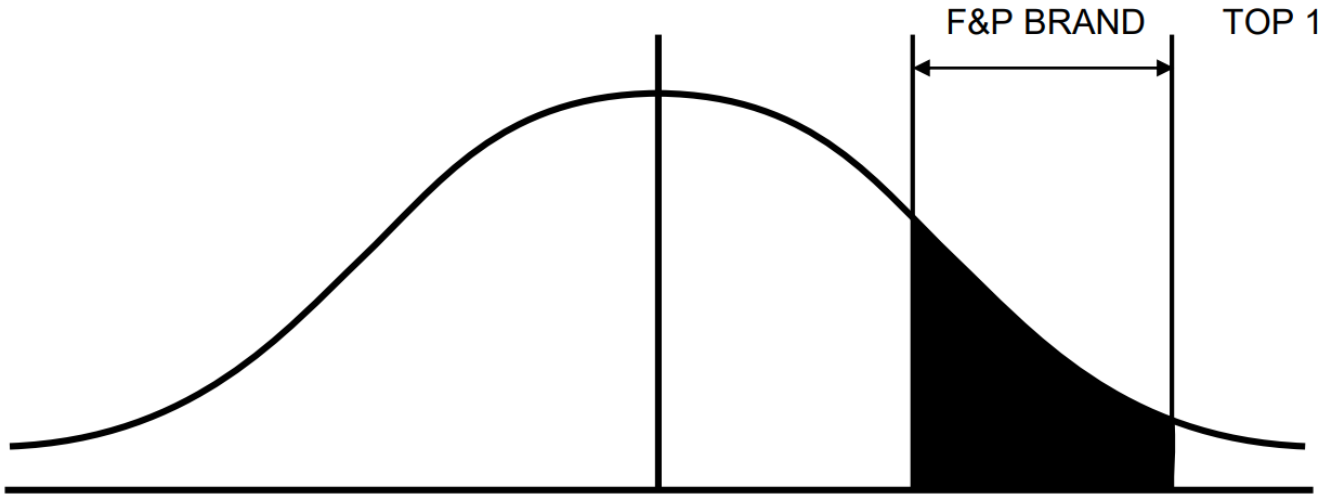
2008

2010



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?

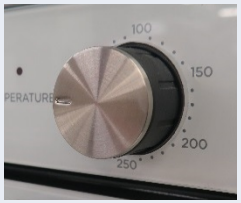
- One of the direct points of contact between a customer and the product
- The way a dial feels can inadvertently convey the *perceived* quality of a product
- We need to translate highly subjective attributes into objective measures

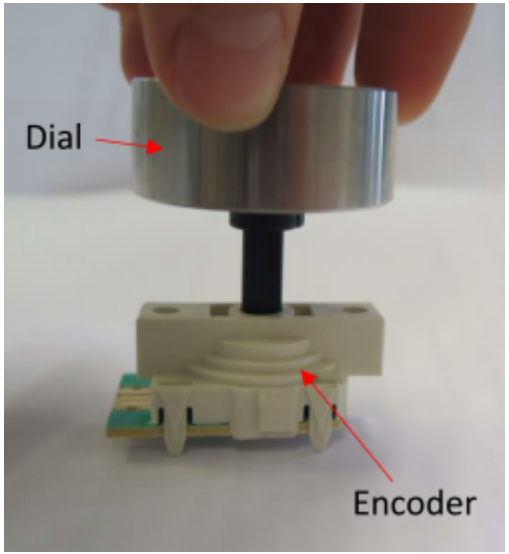
Knob Feel Youtube Channel

"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

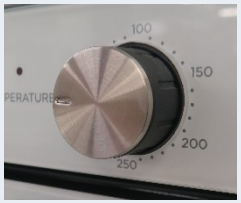
Definitions:

Encoder 	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)
Dial/Knob 	A plate or disc that can be turned to select a setting on a piece of equipment.

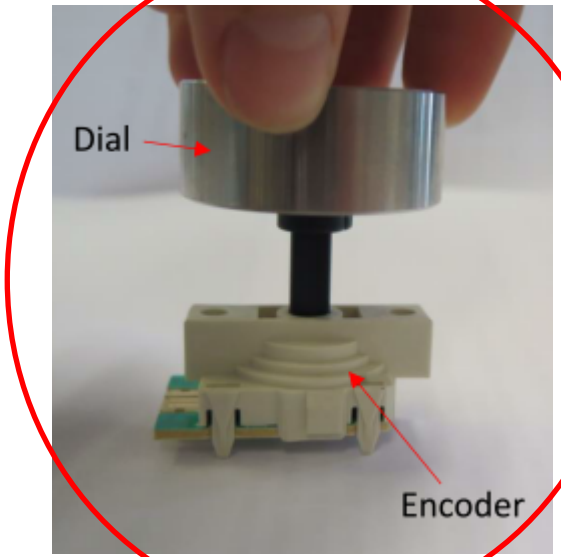


SCOPE

Definitions:

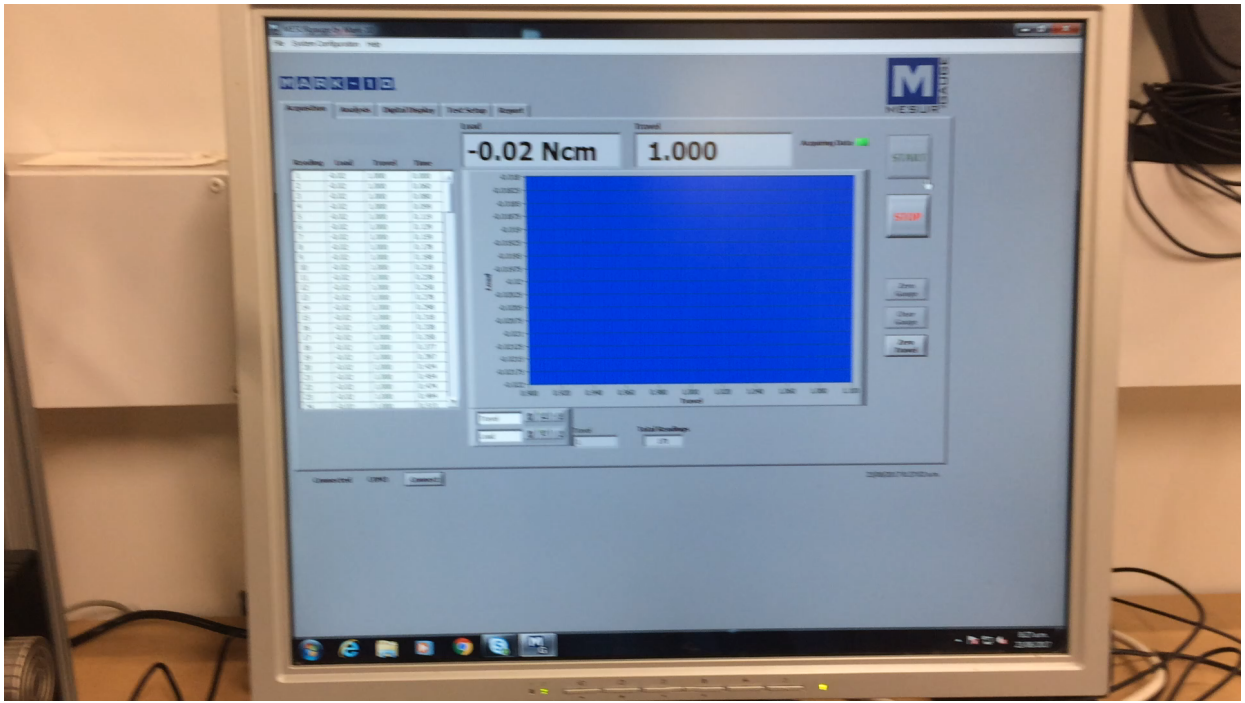
Encoder 	A rotary encoder (shaft encoder) is an electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code. (wiki)
Dial/Knob 	A plate or disc that can be turned to select a setting on a piece of equipment.

DIAL FEEL



FISHER & PAYKEL

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

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

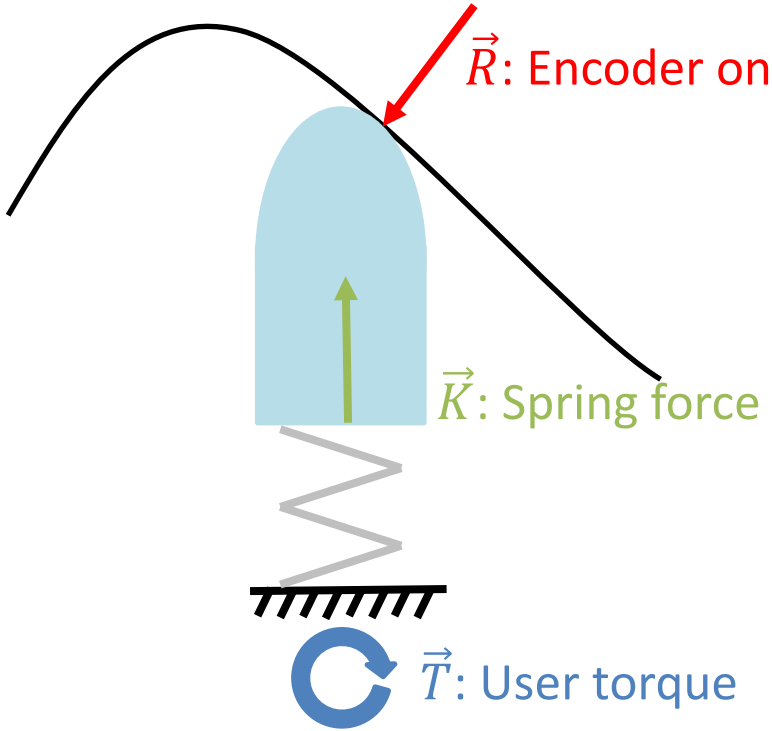
How to

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

MODELLING CAN HELP

PROOF OF CONCEPT

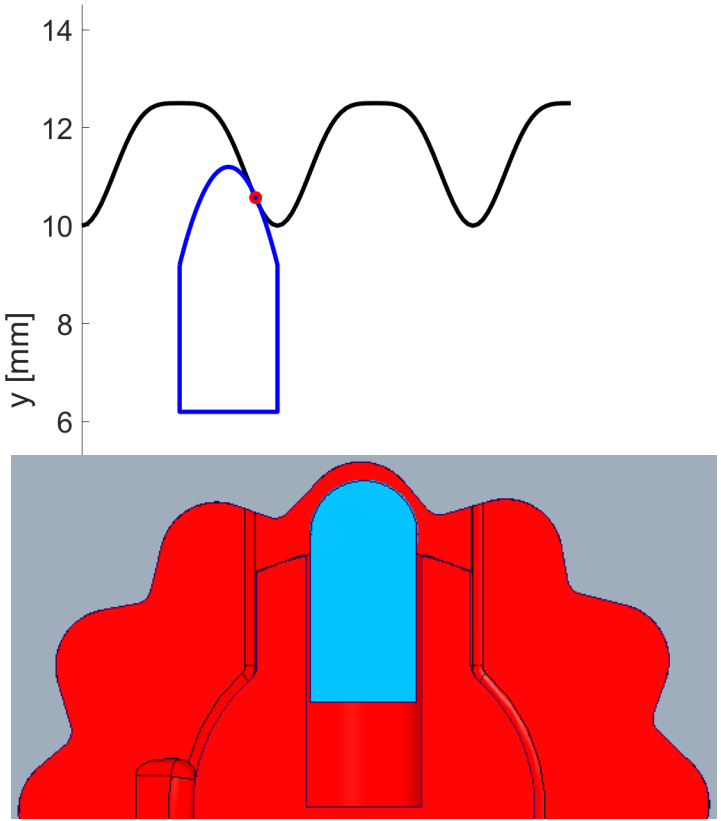
STEADY-STATE STRENGH BUDGET

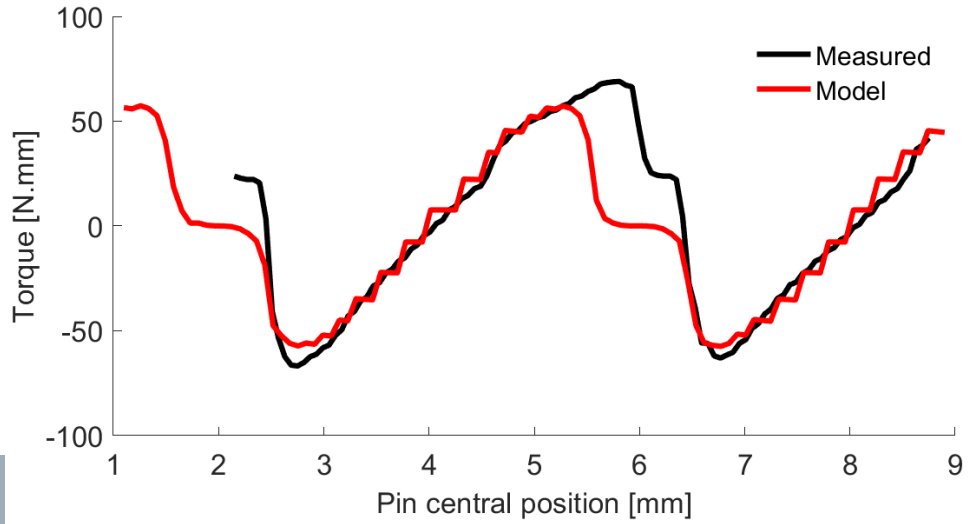


Parameters:

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

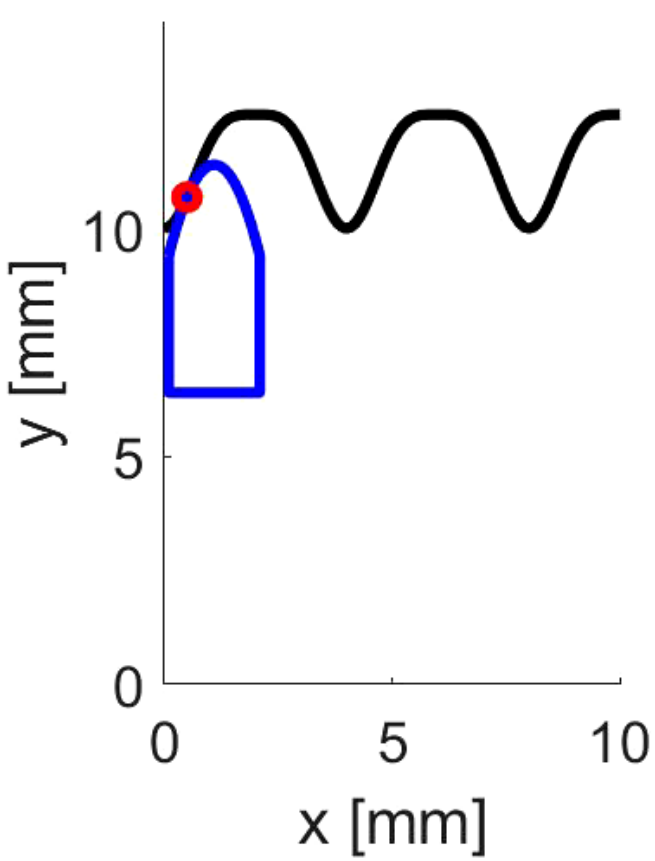
VALIDATION ON EVEREL ENCODER

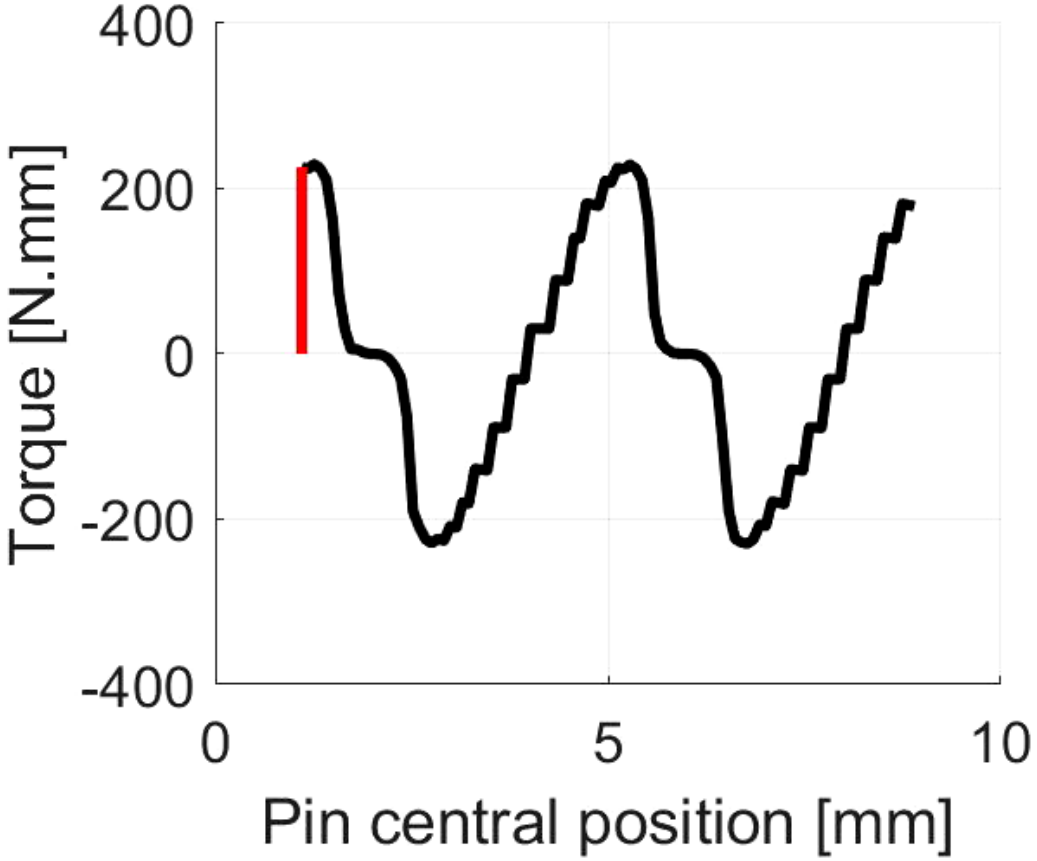




SHAPE OF ENCODER IS AN ESTIMATION AND CAN BE IMPROVED BY IMPORTING CAD MODEL

CLOSE LOOK ON STEPS

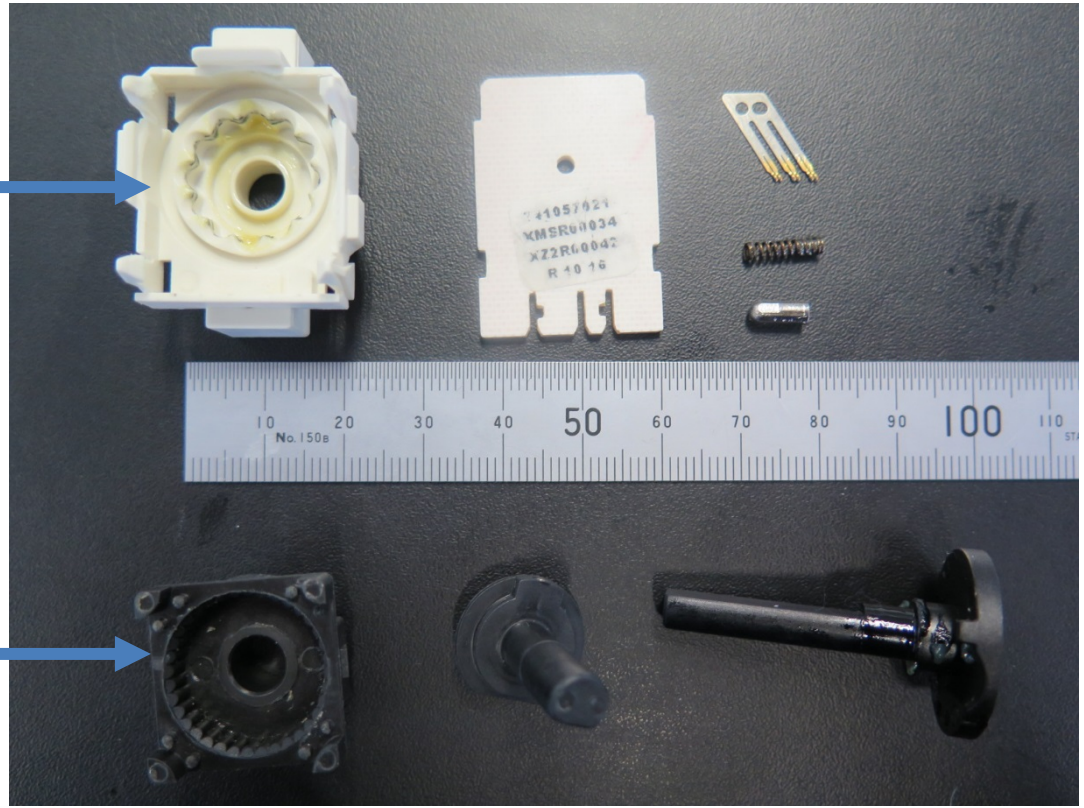




REAL ENCODER SHAPE

Everel

Honeywell

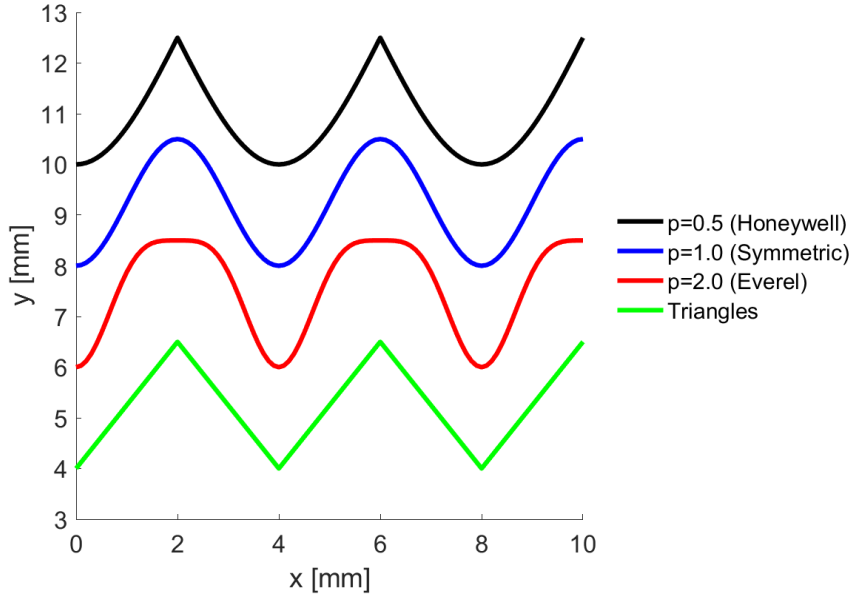


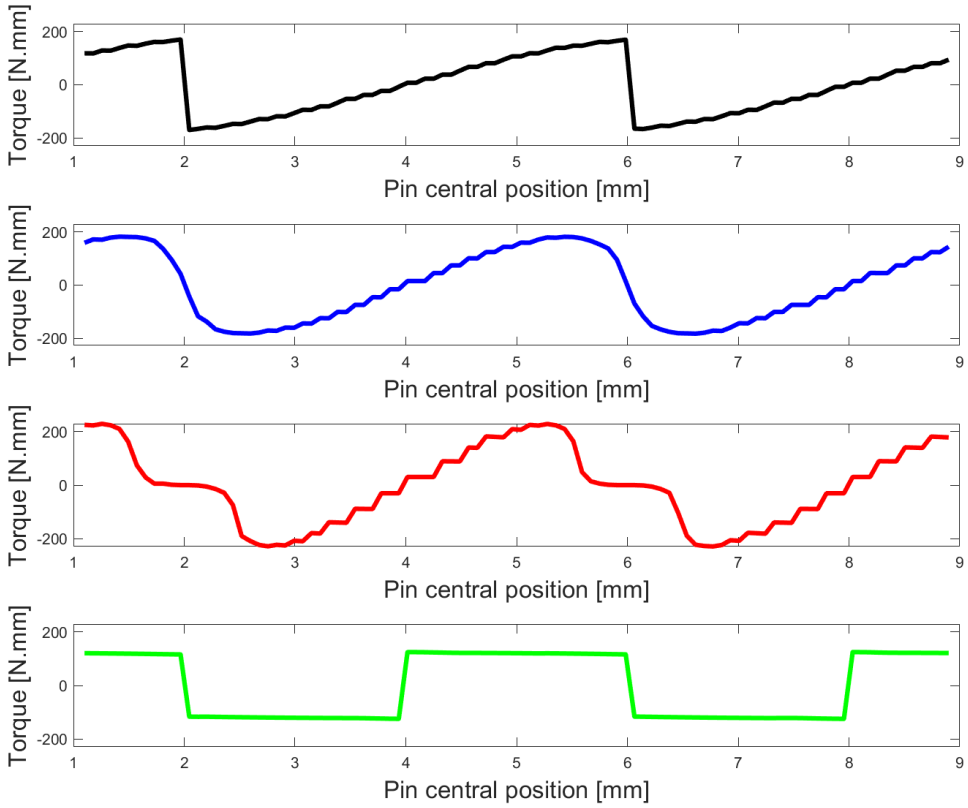
FISHER & PAYKEL

SHAPE OF ENCODER

Sinusoidal shape defined as:

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



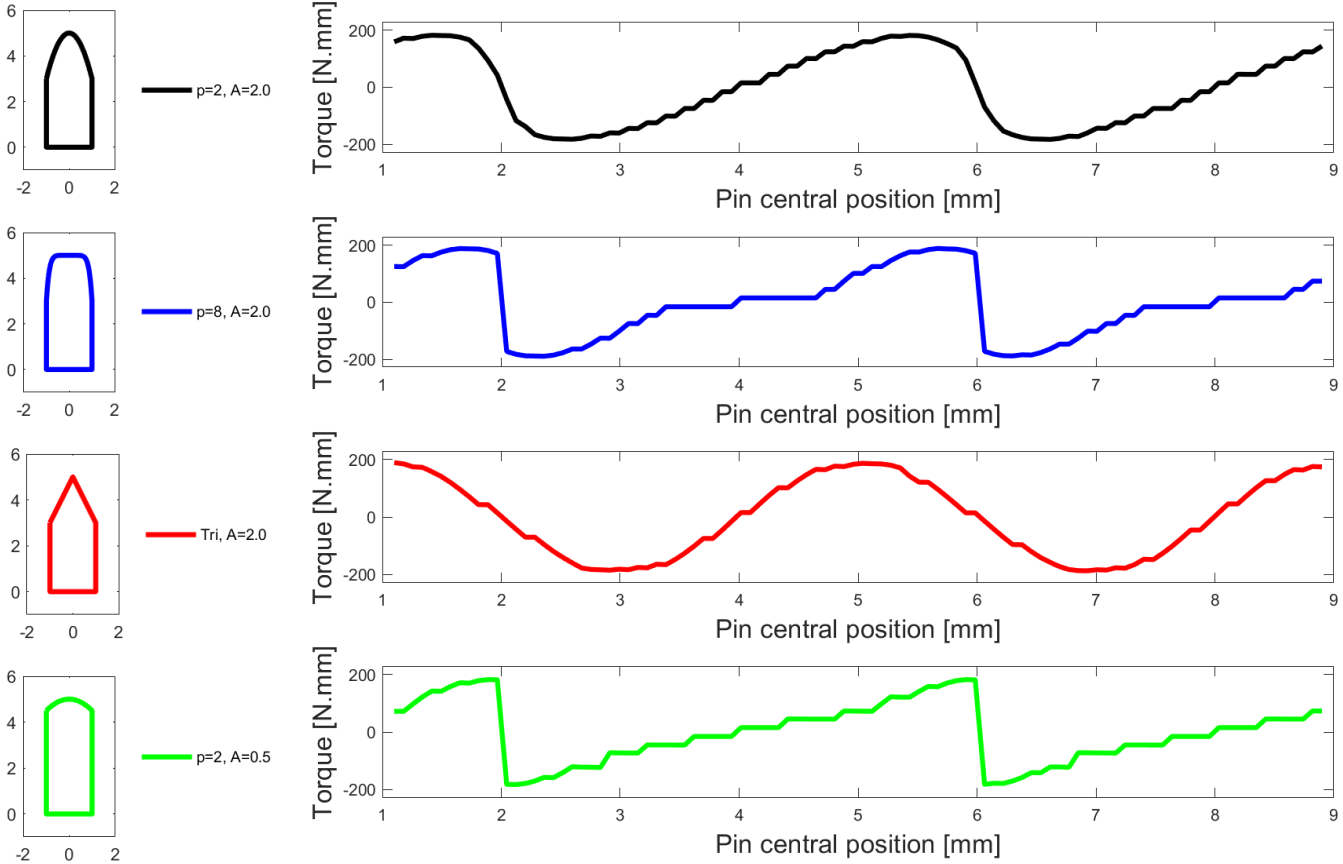


SHAPE OF PIN

- Encoder: symmetric sinus
- Pin: Sinusoidal shape:

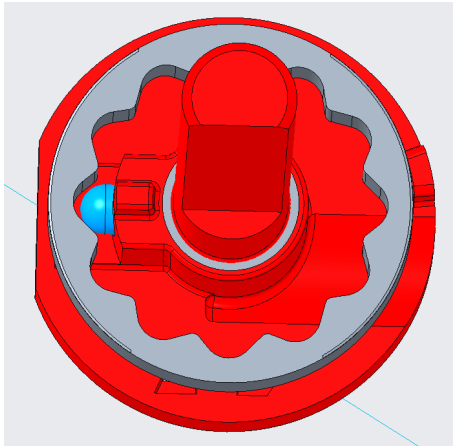
  $y = Ax^p$

  All pin have the same height

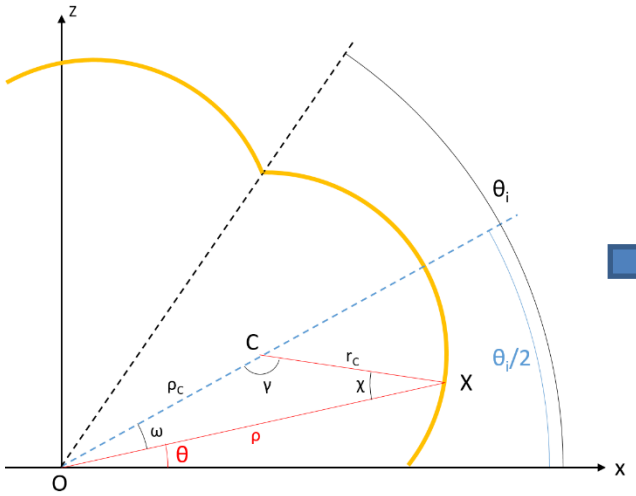


CYLINDRICAL 3D MODEL

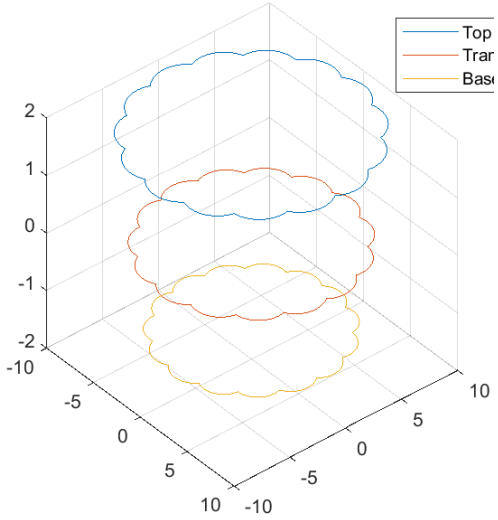
CYLINDRICAL 3D MODEL



CAD model



2D section



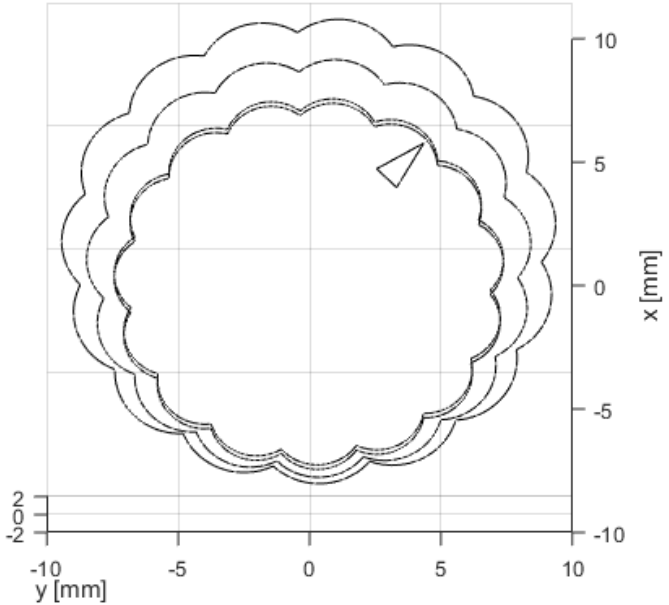
3D Reconstitution

FISHER & PAYKEL

WORKFLOW

For each angle of dial:

- Rotate 2D sections

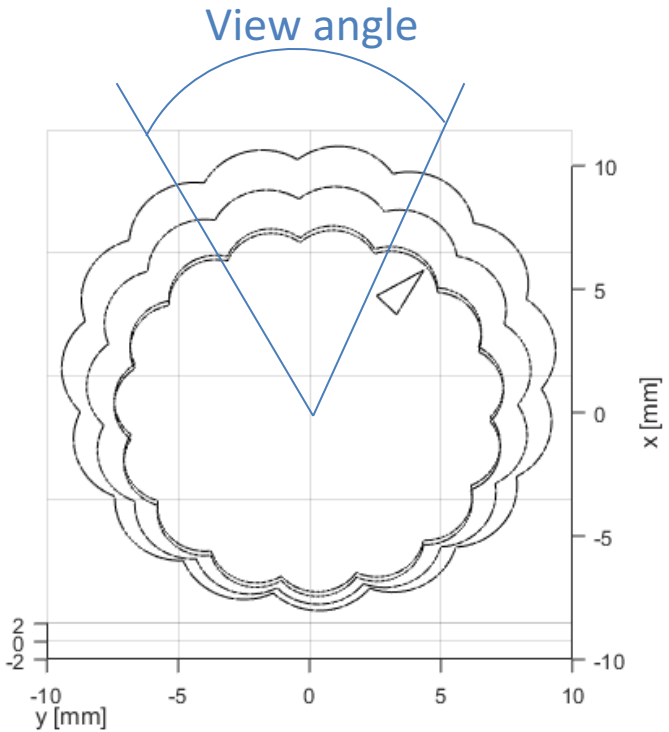


FISHER & PAYKEL

WORKFLOW

For each angle of dial:

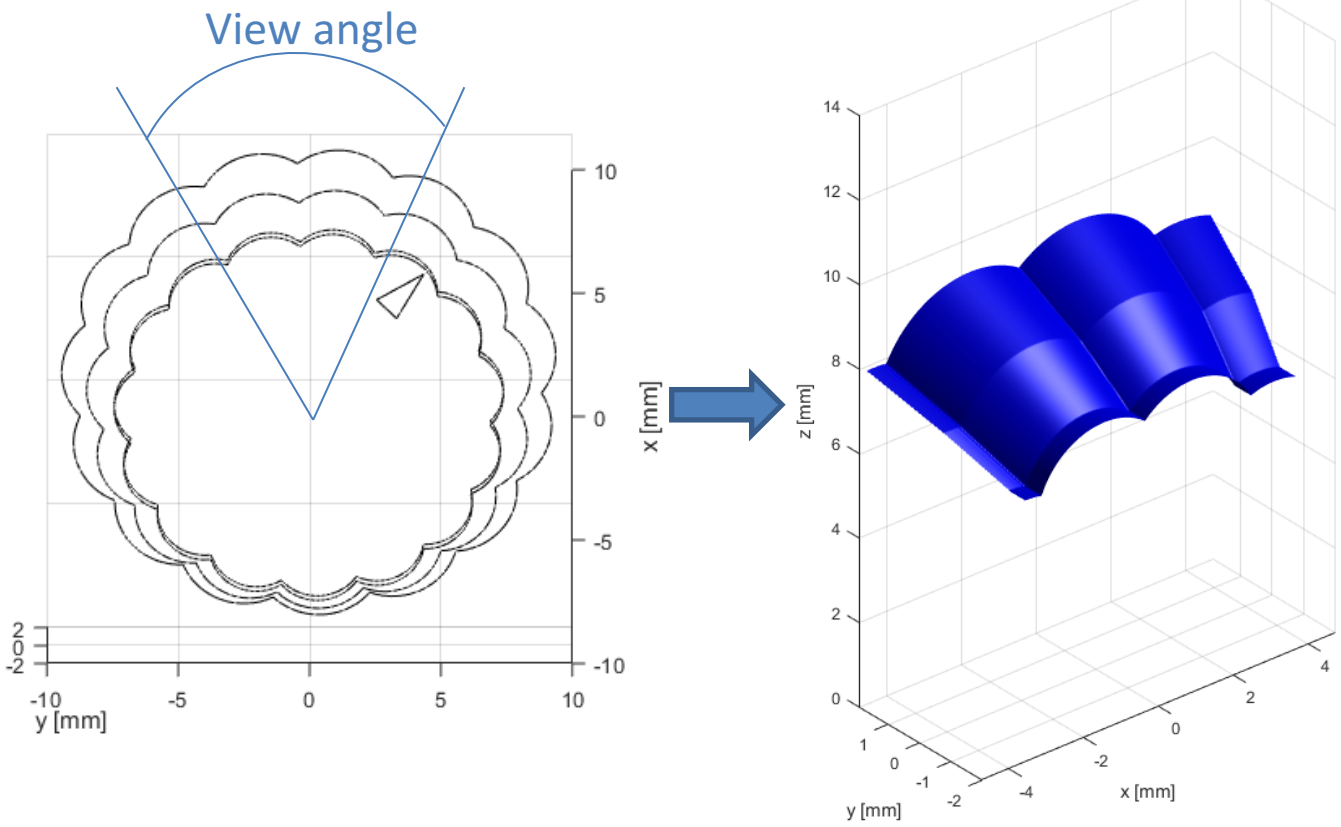
- Rotate 2D sections
- Create 3D surface



WORKFLOW

For each angle of dial:

- Rotate 2D sections
- Create 3D surface

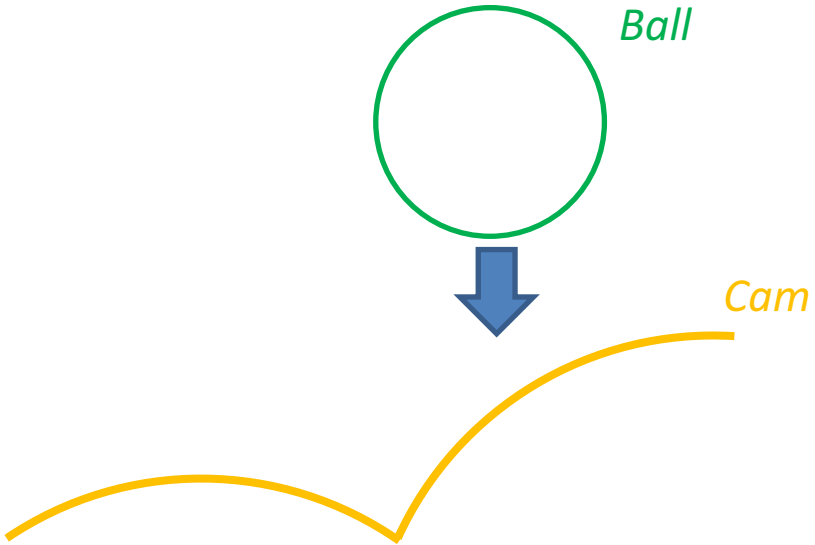


FISHER & PAYKEL

WORKFLOW

For each angle of dial:

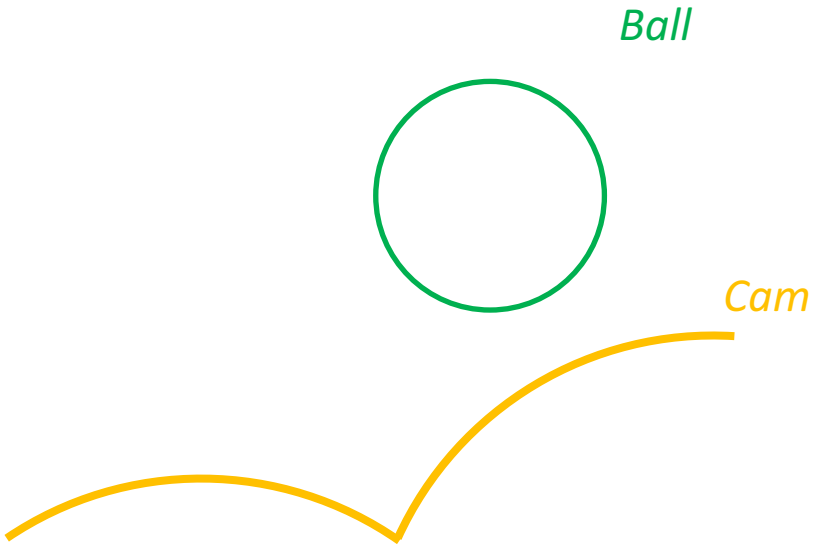
- Rotate 2D sections
- Create 3D surface
- Iteratively lower the ball until contact
  Get spring tension



WORKFLOW

For each angle of dial:

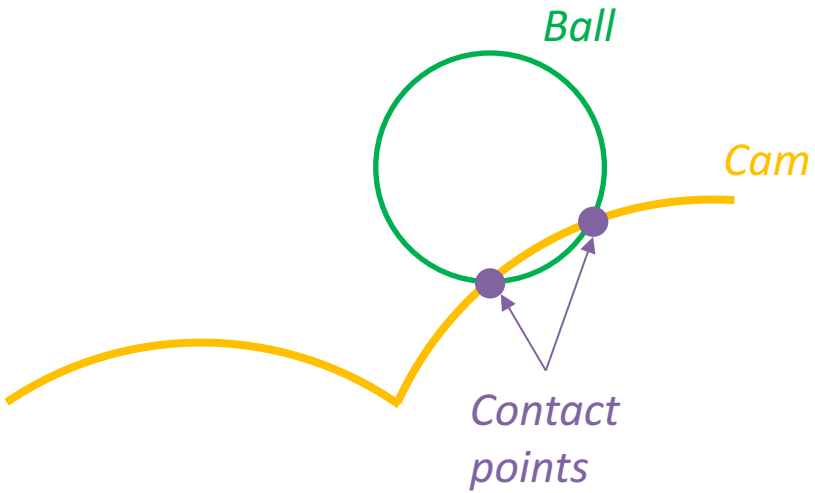
- Rotate 2D sections
- Create 3D surface
- Iteratively lower the ball until contact
  Get spring tension



WORKFLOW

For each angle of dial:

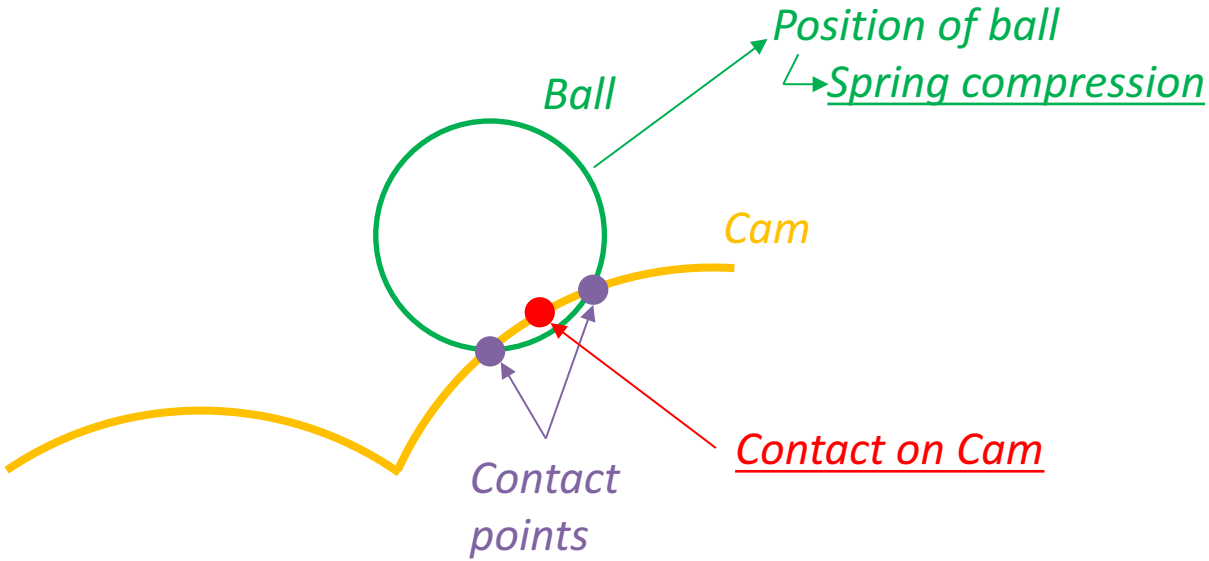
- Rotate 2D sections
  ↓
- Create 3D surface
  ↓
- Iteratively lower the ball until contact
  Get spring tension
  ↓
- Find contact point



WORKFLOW

For each angle of dial:

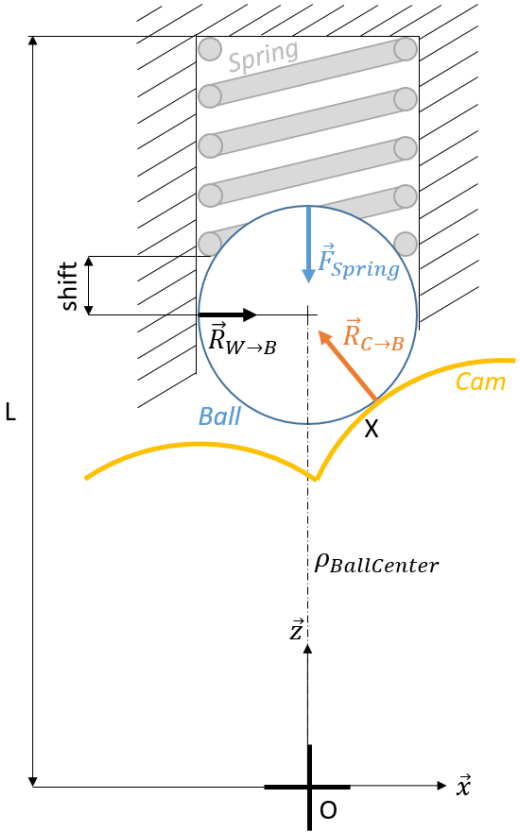
- Rotate 2D sections
  ↓
- Create 3D surface
  ↓
- Iteratively lower the ball until contact
  Get spring tension
  ↓
- Find contact point



WORKFLOW

For each angle of dial:

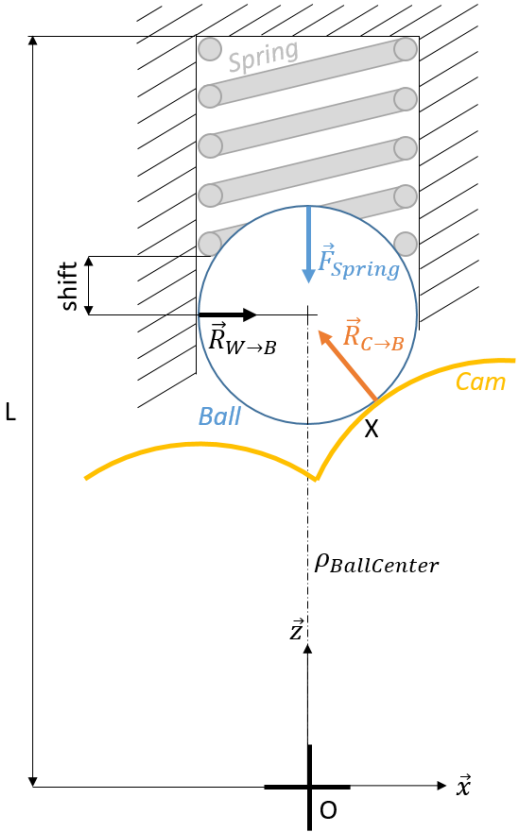
- Rotate 2D sections
  ↓
- Create 3D surface
  ↓
- Iteratively lower the ball until contact
  Get spring tension
  ↓
- Find contact point
  ↓
- Calculate projection and then torque

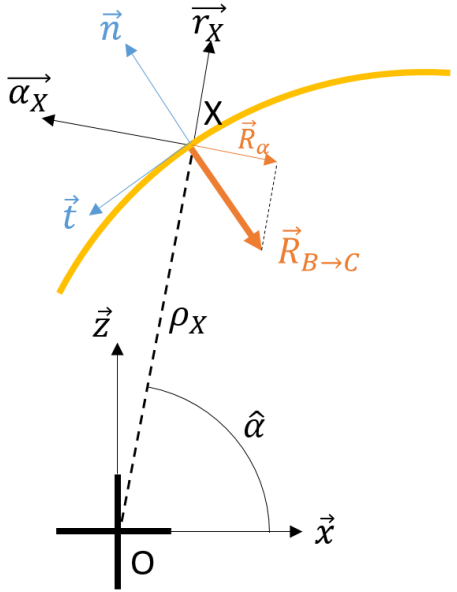


WORKFLOW

For each angle of dial:

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

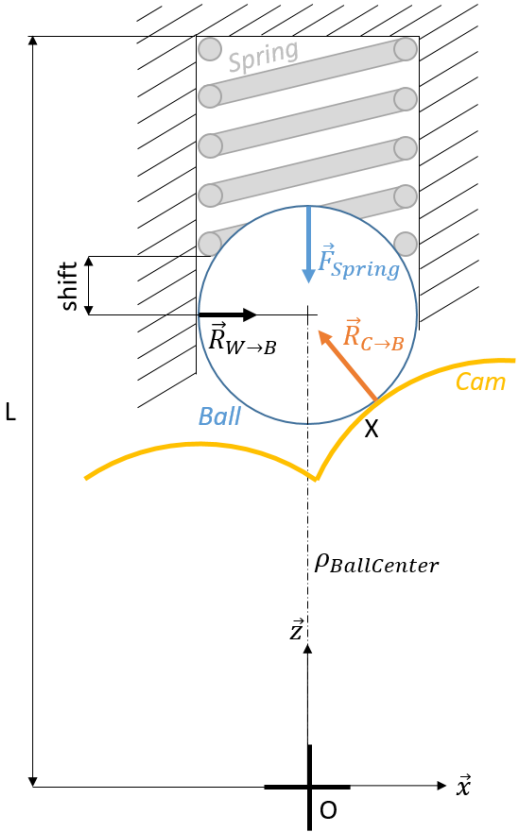


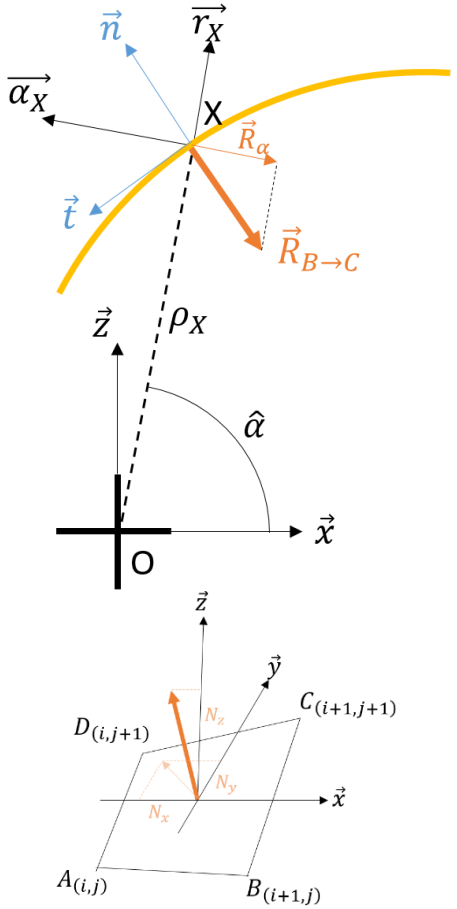


WORKFLOW

For each angle of dial:

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

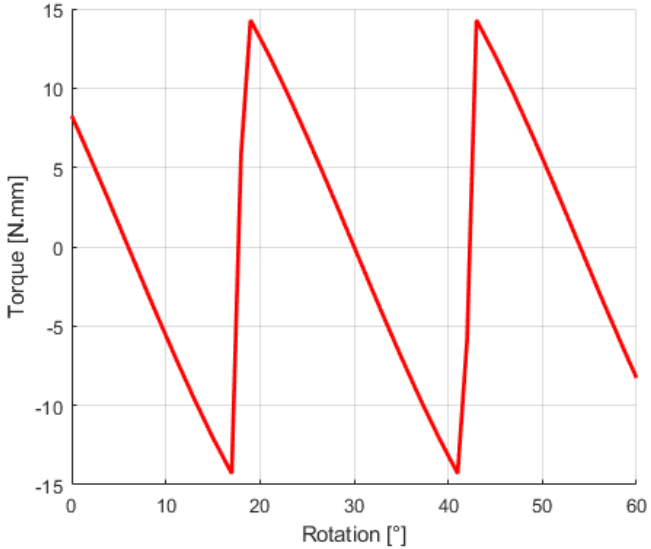




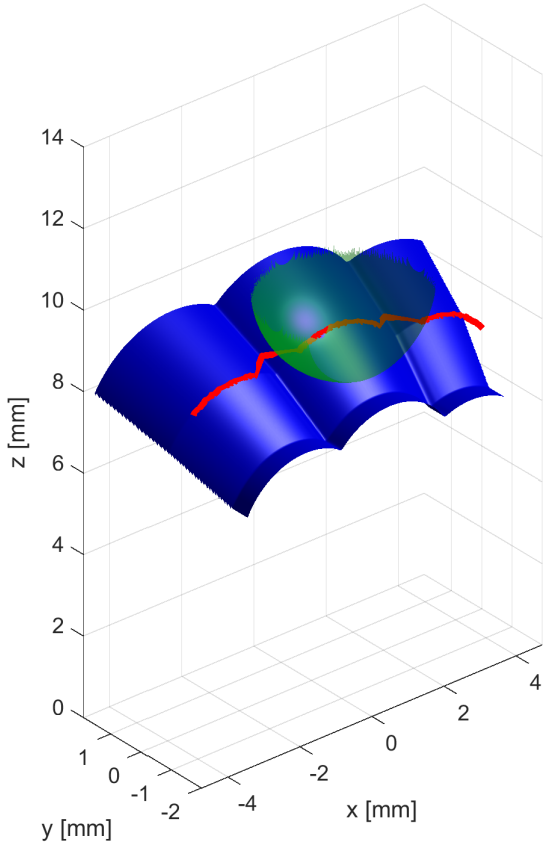
WORKFLOW

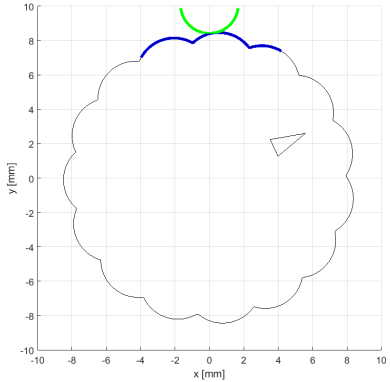
For each angle of dial:

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



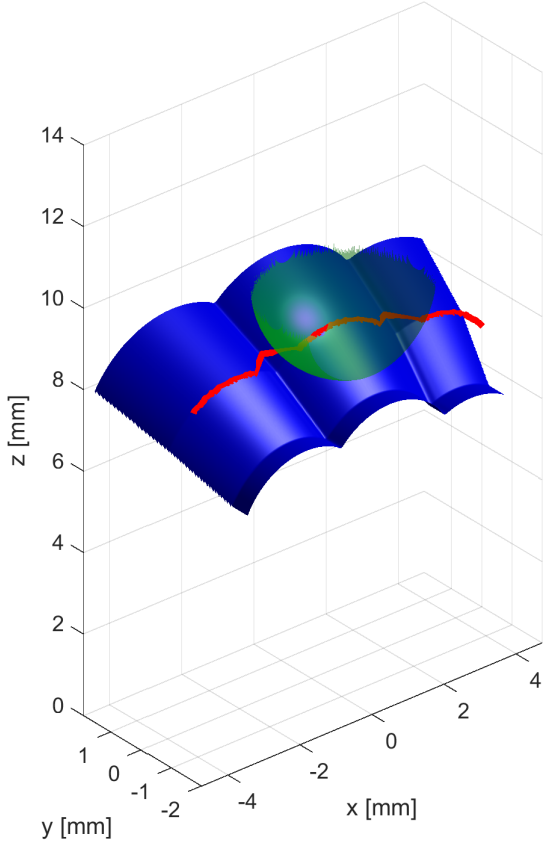
VALIDATION

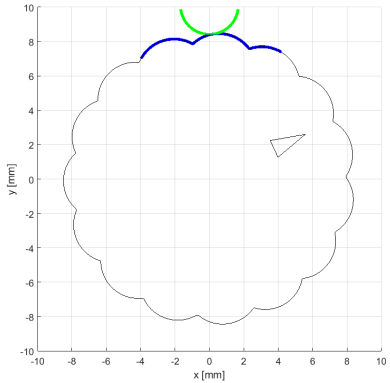


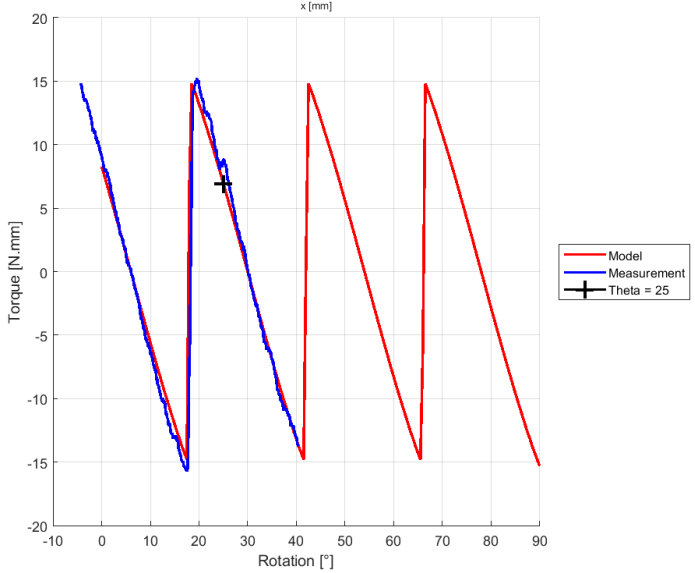


FISHER & PAYKEL

VALIDATION







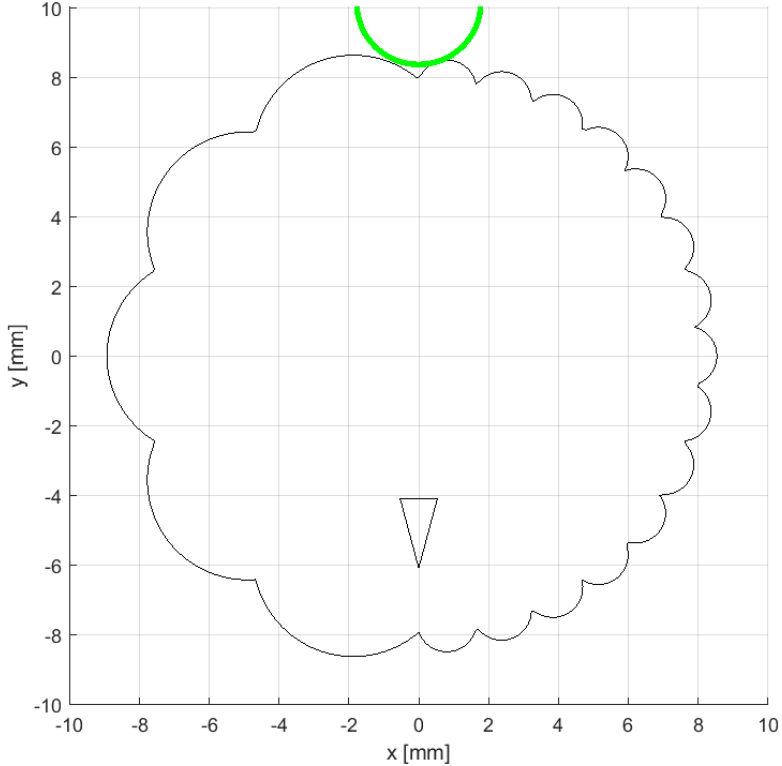
FISHER & PAYKEL

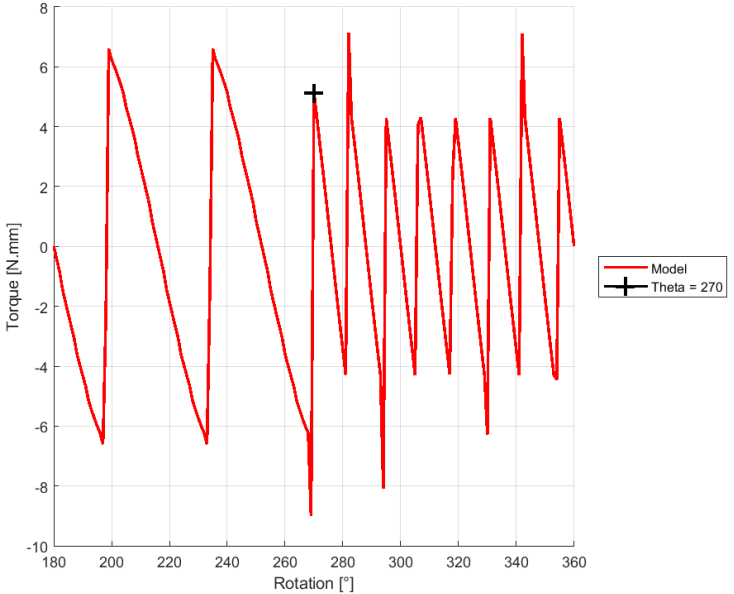
PARAMETRIC STUDY

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

PARAMETRIC STUDY

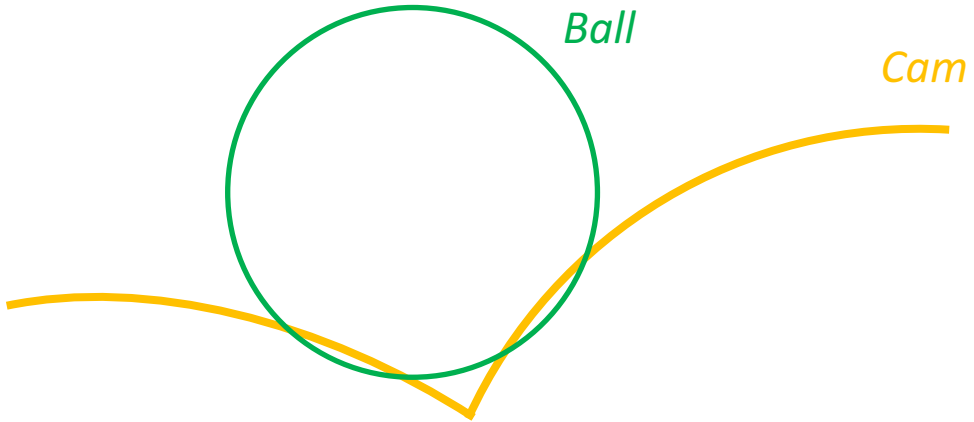
- Push curve
- Spring ratio
- Ball radius
- Ball shape
- Cam shape
- …



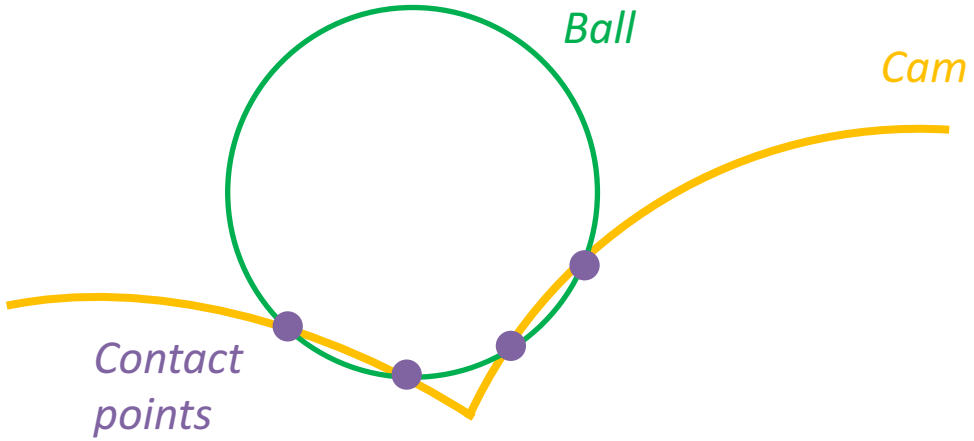


FISHER & PAYKEL

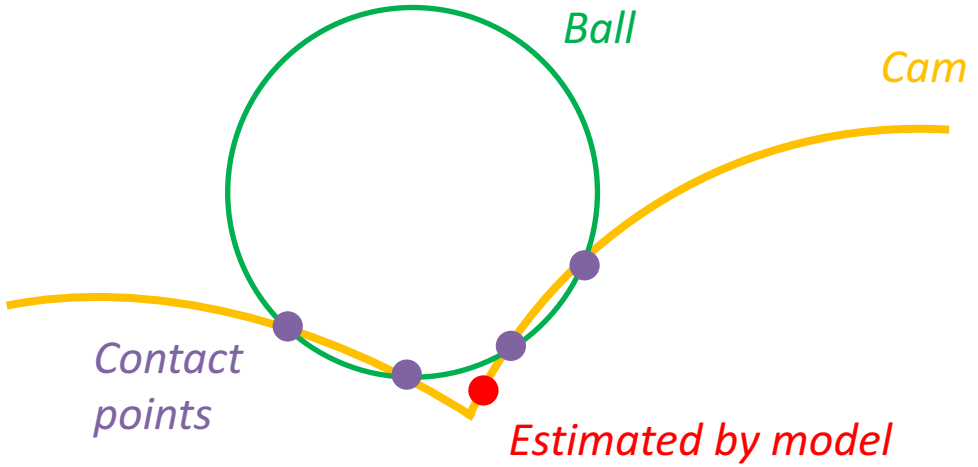
ROOM FOR HIGHER FIDELITY MODELLING



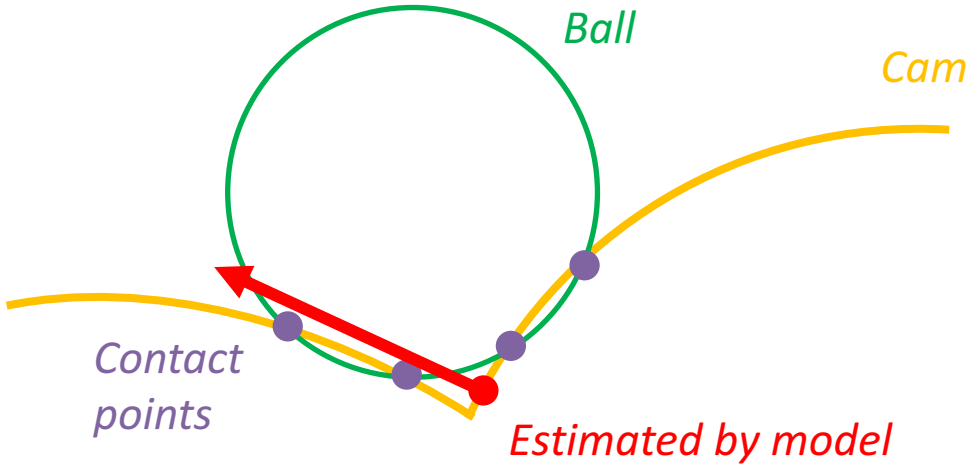
ROOM FOR HIGHER FIDELITY MODELLING



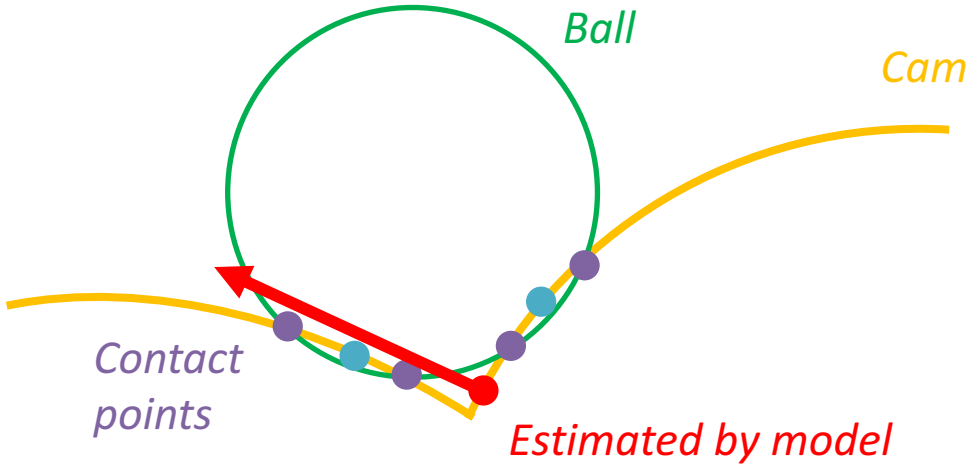
ROOM FOR HIGHER FIDELITY MODELLING



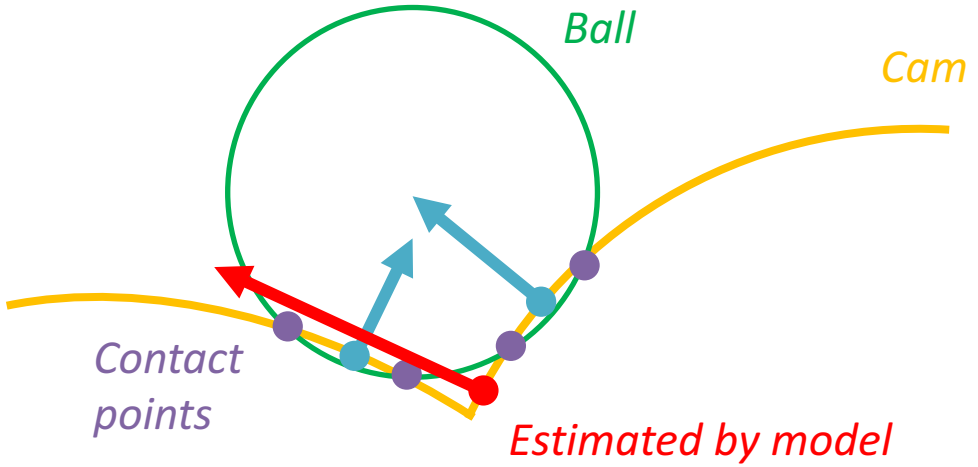
ROOM FOR HIGHER FIDELITY MODELLING



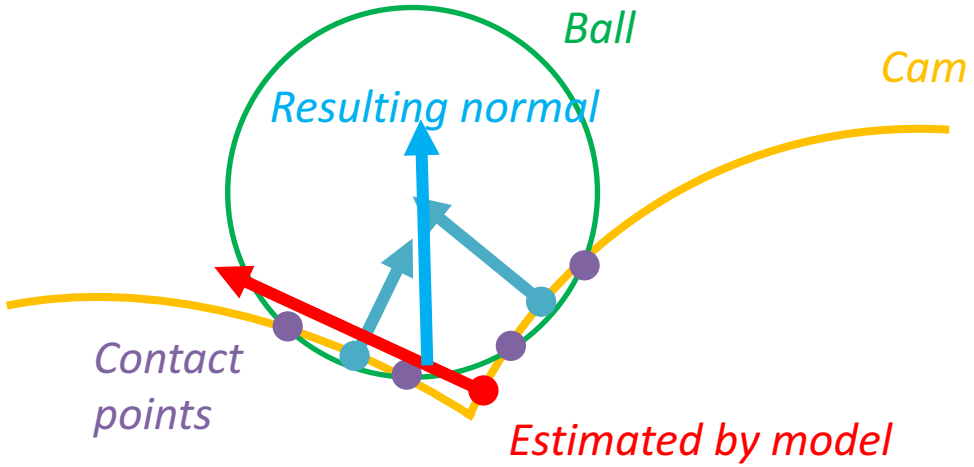
ROOM FOR HIGHER FIDELITY MODELLING



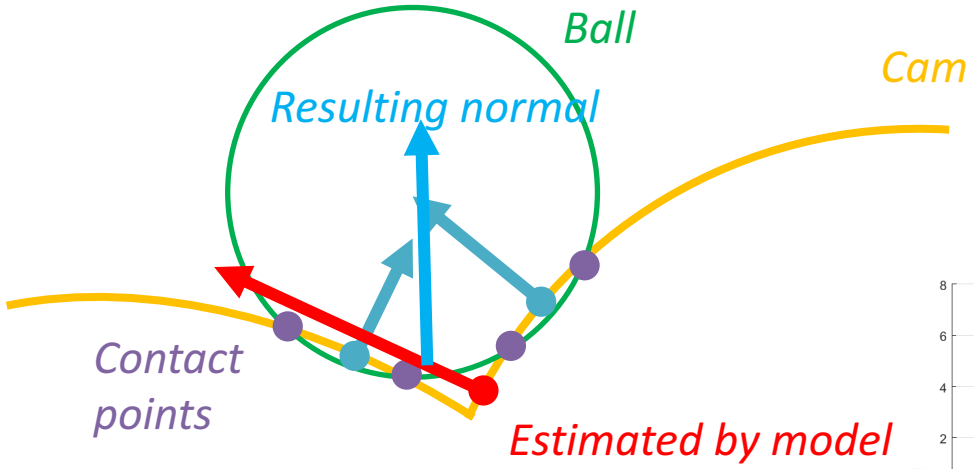
ROOM FOR HIGHER FIDELITY MODELLING

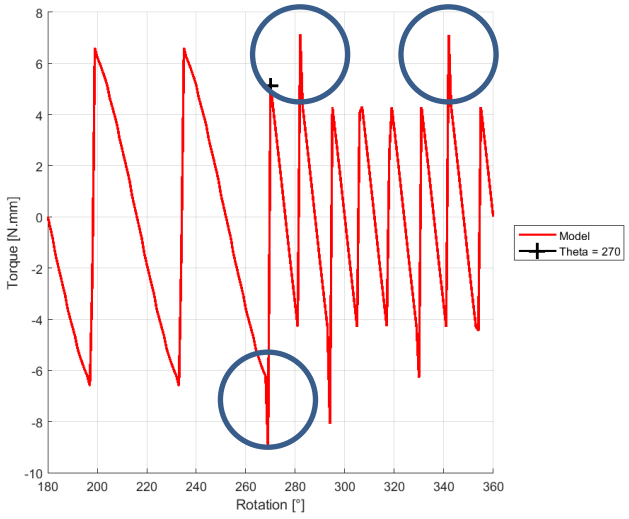


ROOM FOR HIGHER FIDELITY MODELLING



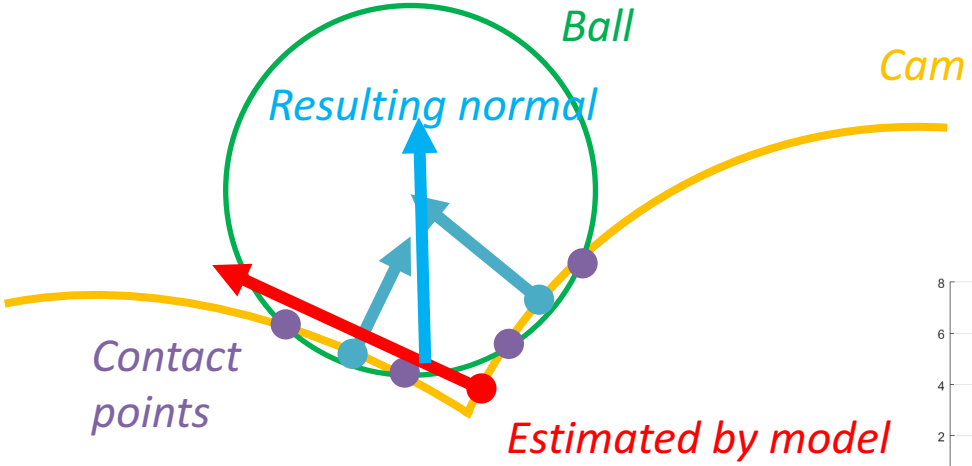
ROOM FOR HIGHER FIDELITY MODELLING

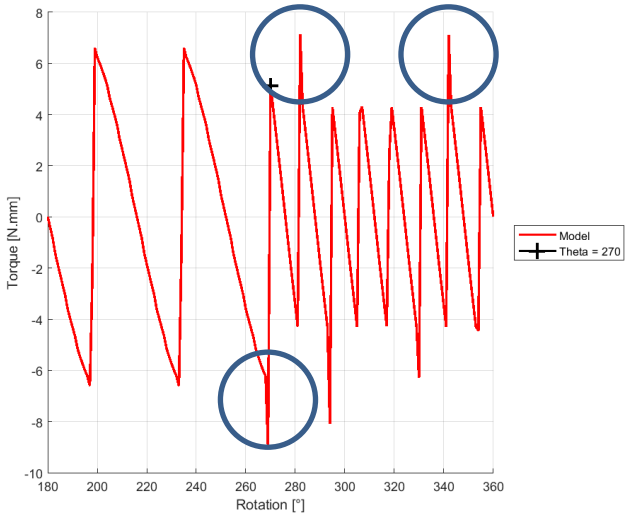




Over estimation of torque at some locations

ROOM FOR HIGHER FIDELITY MODELLING

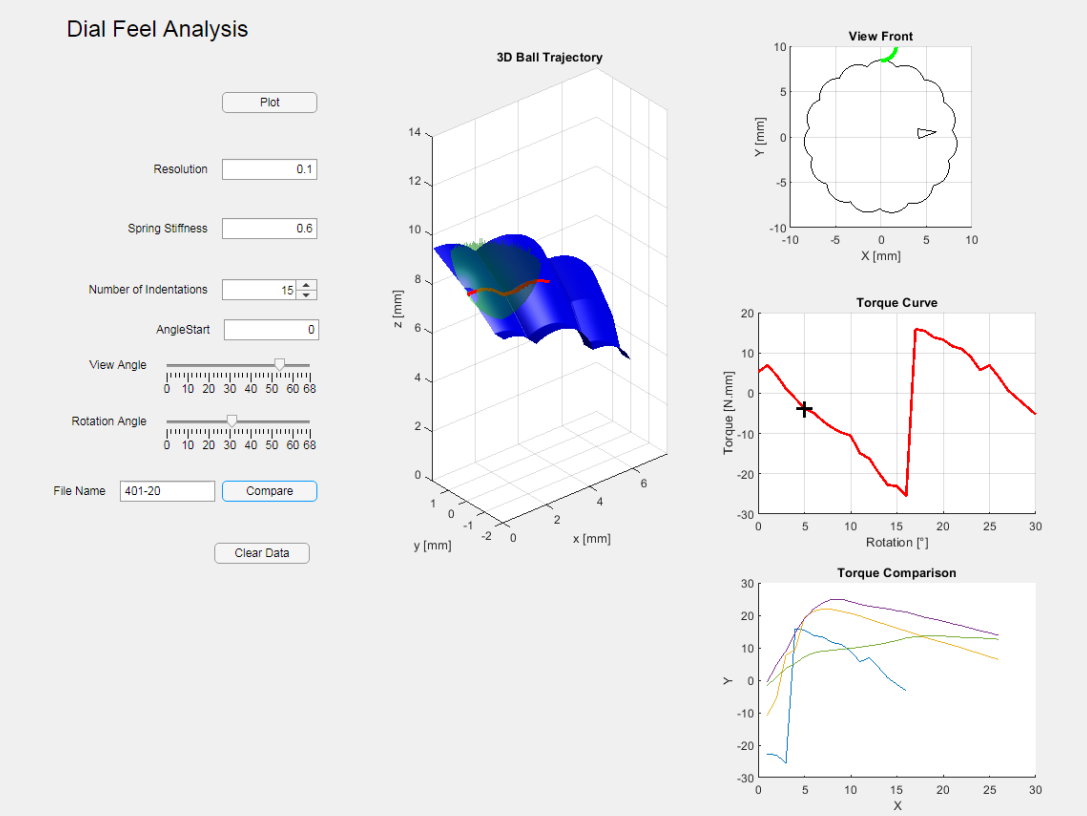




Over estimation of torque at some locations

Good enough to take decision without building prototypes

MATLAB APP DESIGNER



FISHER & PAYKEL

WHAT DID WE GAIN?

Classical Way:

With Matlab:

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)

With Matlab:

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

With Matlab:

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : 4 prototypes
Rotational curve profile : 5 prototypes
Ball radius : 3 prototypes
Spring ratio : 3 prototypes

With Matlab:

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : 4 prototypes
Rotational curve 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

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : ~~4~~ 1 prototypes
Rotational curve 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

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : ~~4~~ 1 prototypes
Rotational curve profile : ~~5~~ 1 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

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : ~~4~~ 1 prototypes
Rotational curve profile : ~~5~~ 1 prototypes
Ball radius : ~~3~~ 0 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

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : ~~4~~ 1 prototypes
Rotational curve profile : ~~5~~ 1 prototypes
Ball radius : ~~3~~ 0 prototypes
Spring ratio : ~~3~~ 0 prototypes

With Matlab:

3 weeks to choose a modelling strategy
1 week to code the model
Few minutes to get a result

WHAT DID WE GAIN?

Classical Way:

Prototyping ! (A lot)
Each prototype:
- $300
- 3 days to design, 2 weeks to manufacturer and ship, 2 days to test

Push curve profile : ~~4~~ 1 prototypes
Rotational curve profile : ~~5~~ 1 prototypes
Ball radius : ~~3~~ 0 prototypes
Spring ratio : ~~3~~ 0 prototypes

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

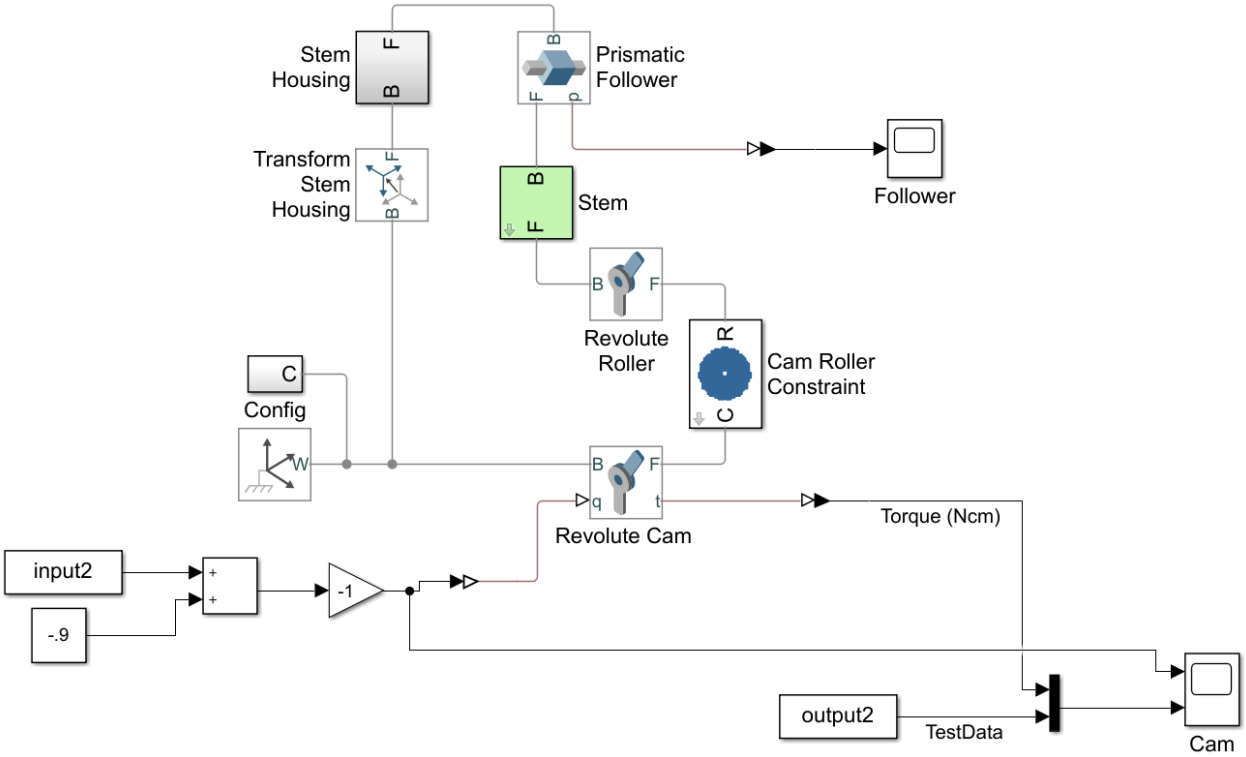
Steady-state model:

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

Dynamic model (Simscape):

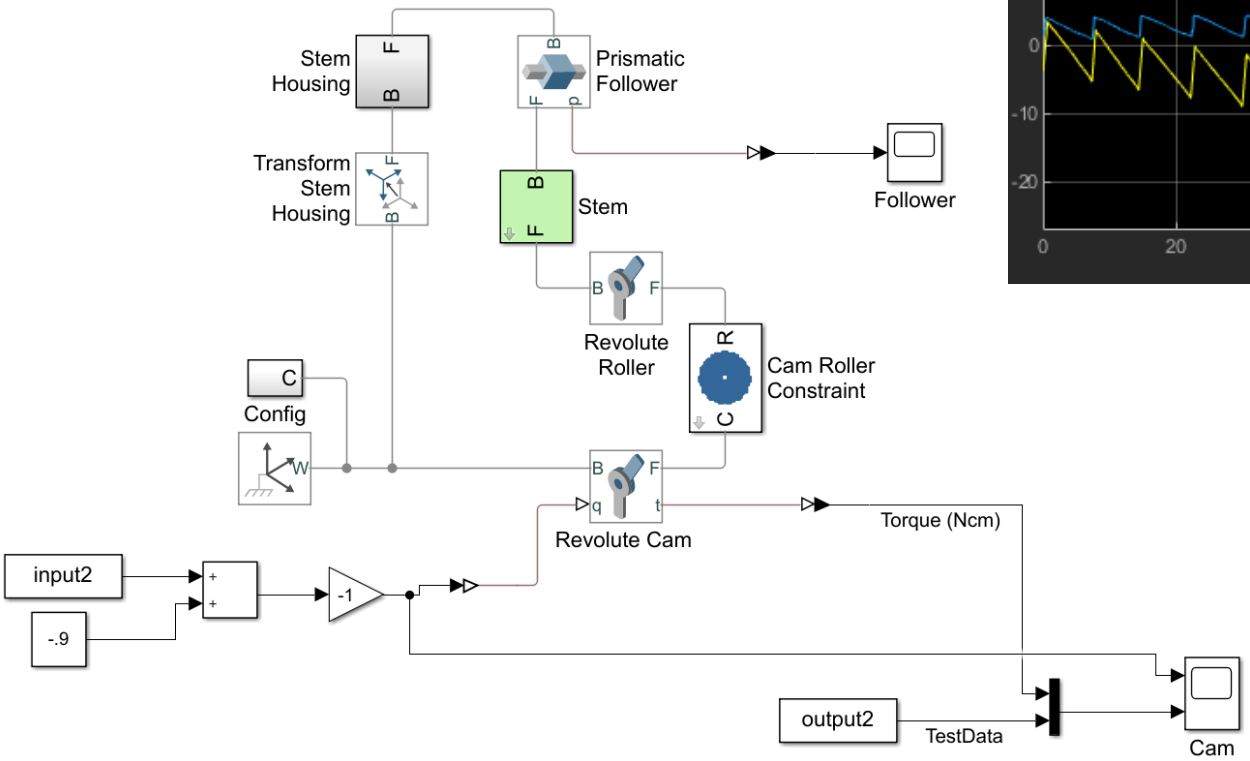
- Investigate what we can learn

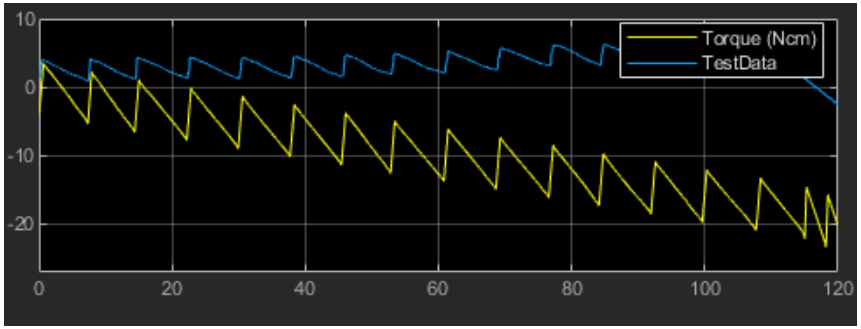
A DYNAMIC MODEL?



FISHER & PAYKEL

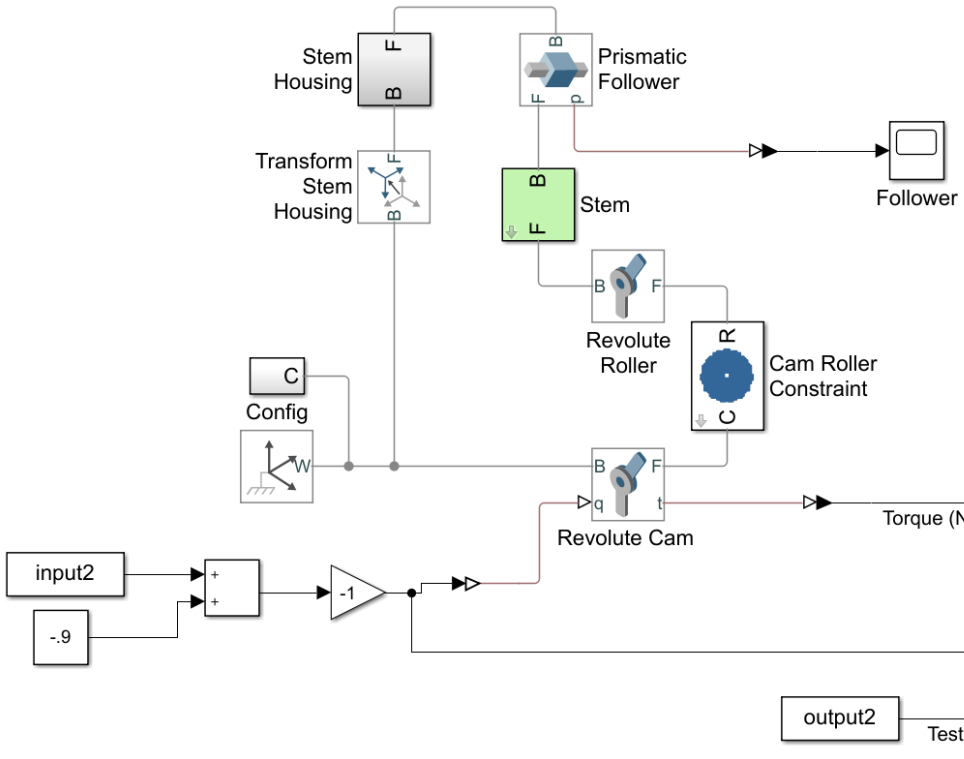
A DYNAMIC MODEL?

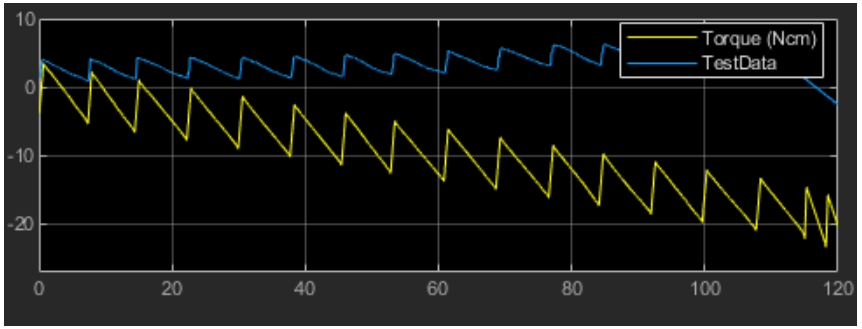




FISHER & PAYKEL

A DYNAMIC MODEL?

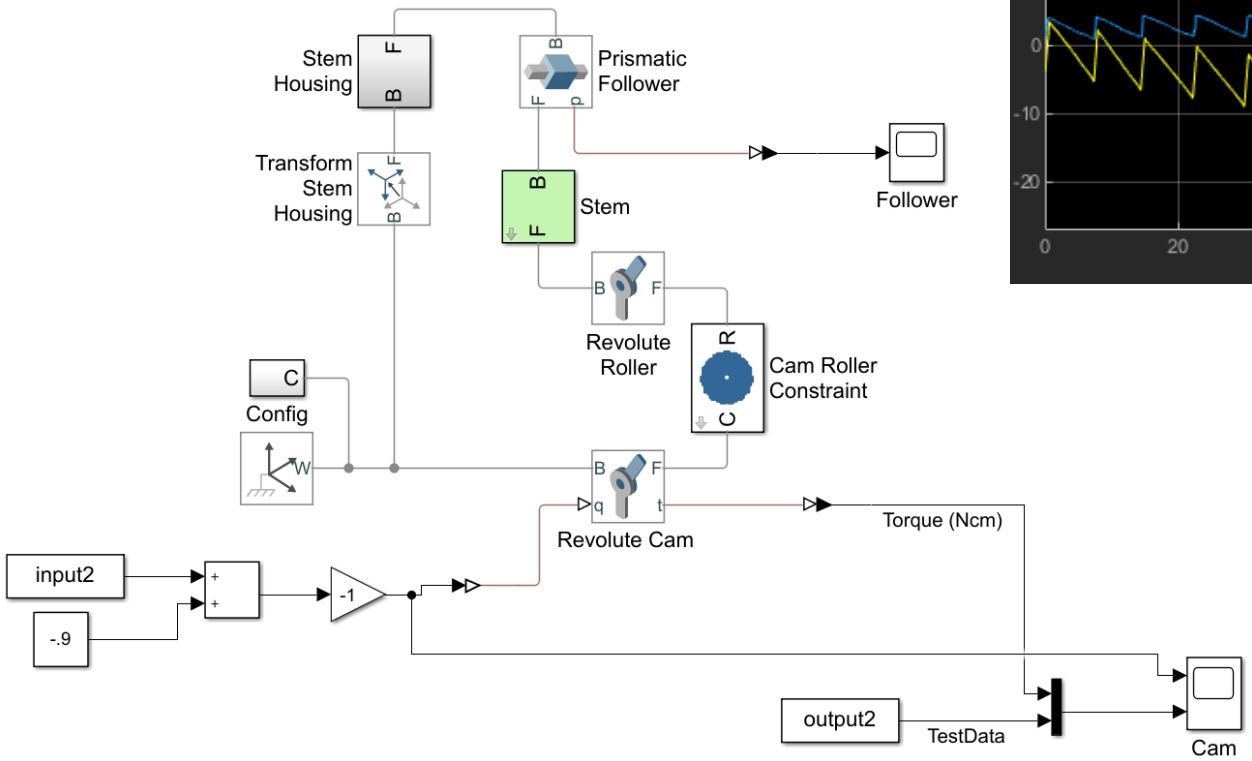


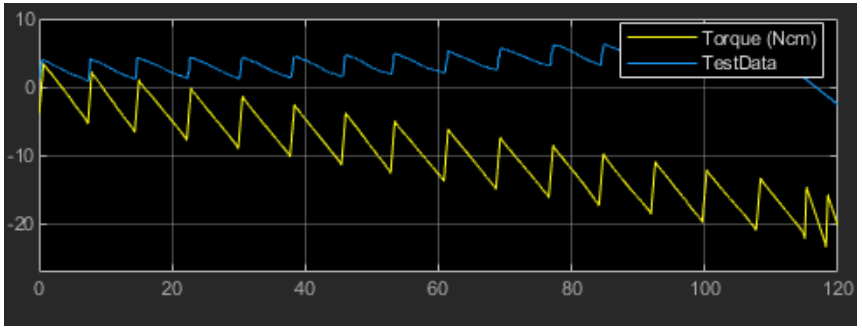


Expected benefits:

- 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

OTHER POTENTIAL PROJECTS USING MATLAB AT FISHER & PAYKEL DUNEDIN

Dish performance assessment with **image recognition**

OTHER POTENTIAL PROJECTS USING MATLAB AT FISHER & PAYKEL DUNEDIN

Dish performance assessment with **image recognition**

Design a self/soft-closing self-locking drawer with **Physical Modelling**

OTHER POTENTIAL PROJECTS USING MATLAB AT FISHER & PAYKEL DUNEDIN

Dish performance assessment with **image recognition**

Design a self/soft-closing self-locking drawer with **Physical Modelling**

Model based design and product logic

THANK YOU