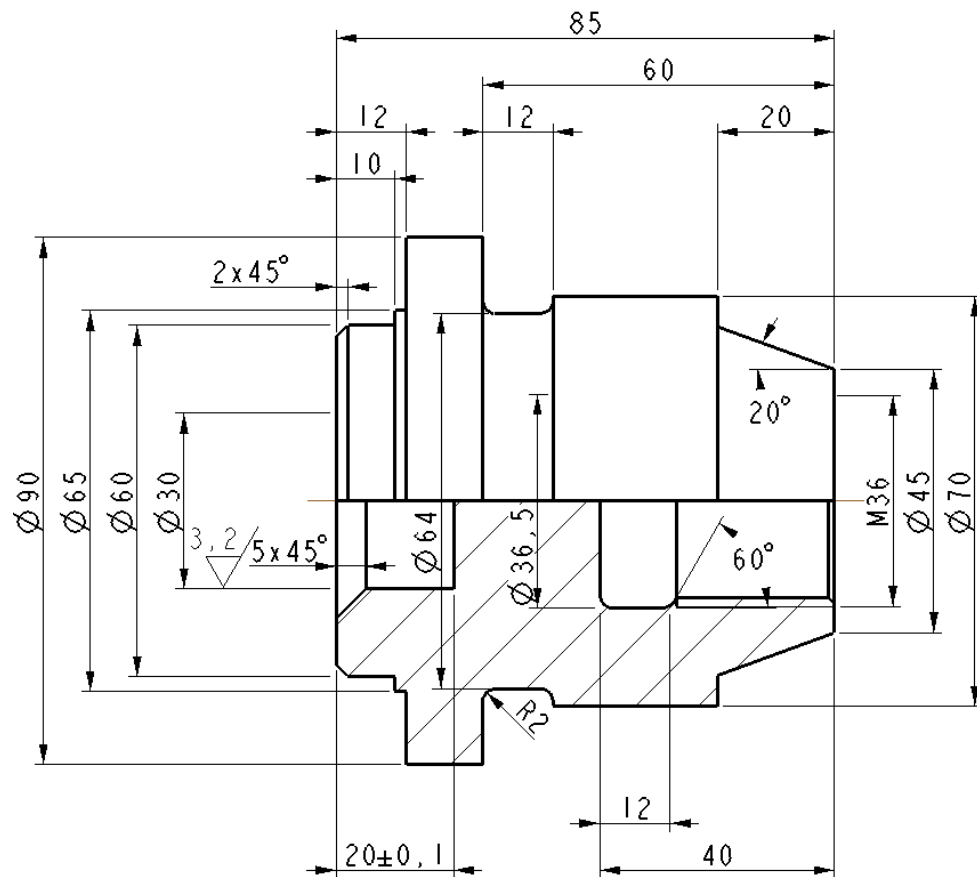# Parametric Design

Kaur Jaakma

16.11.2020

A"
Aalto University
School of Engineering

The curse of CAD

Computer Aided Drawing

The curse of CAD

Computer Aided Design

2D is just a view
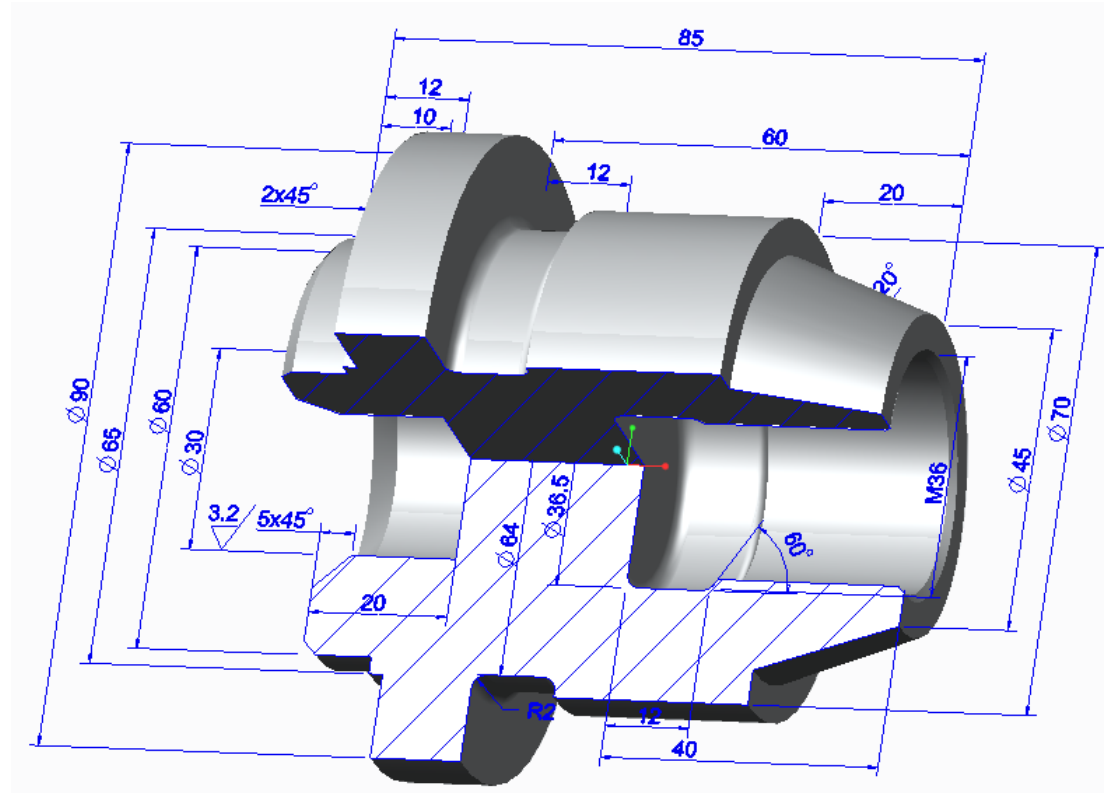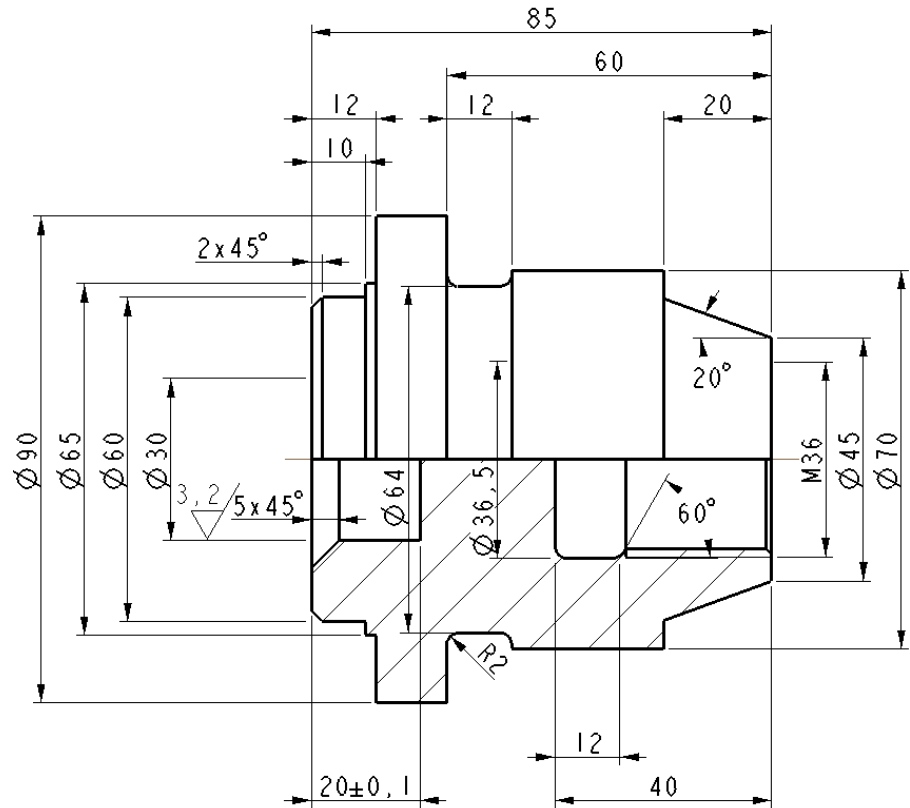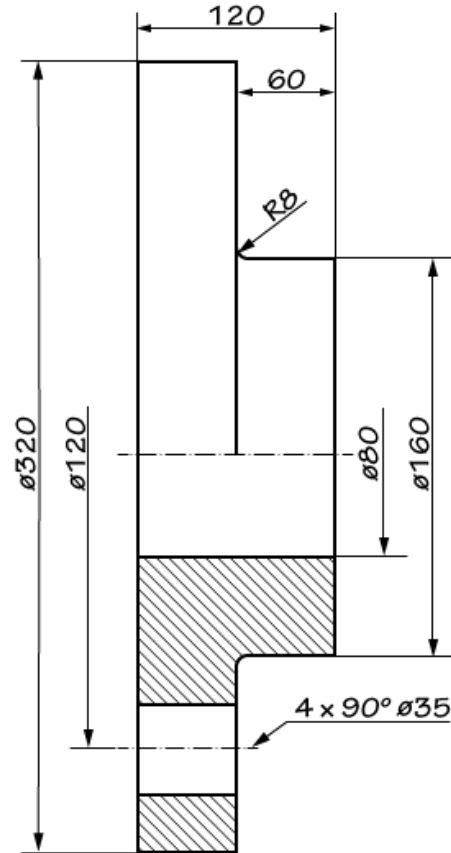
Simple Example 1/2

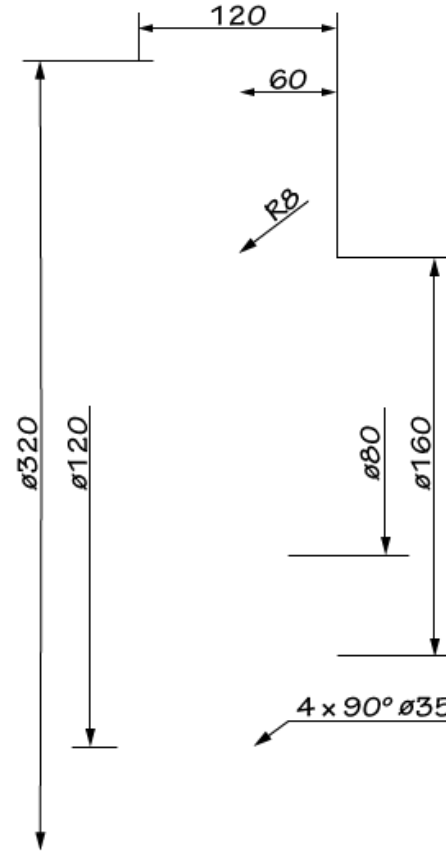**Traditional method is to first draw the lines…**
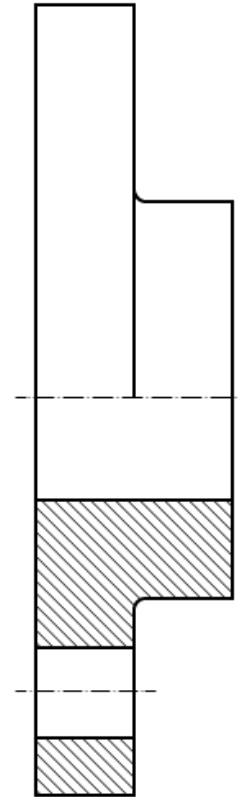
Simple Example 2/2

…and then to add dimensions

What we should do 1/2

We have a group of demands and requirements

What we should do 2/2

We use those limits to find out a geometry
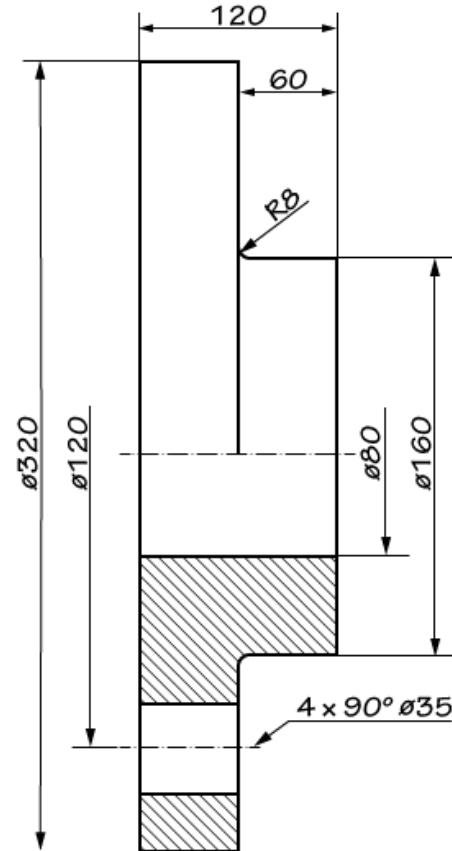
Reality is not that simple
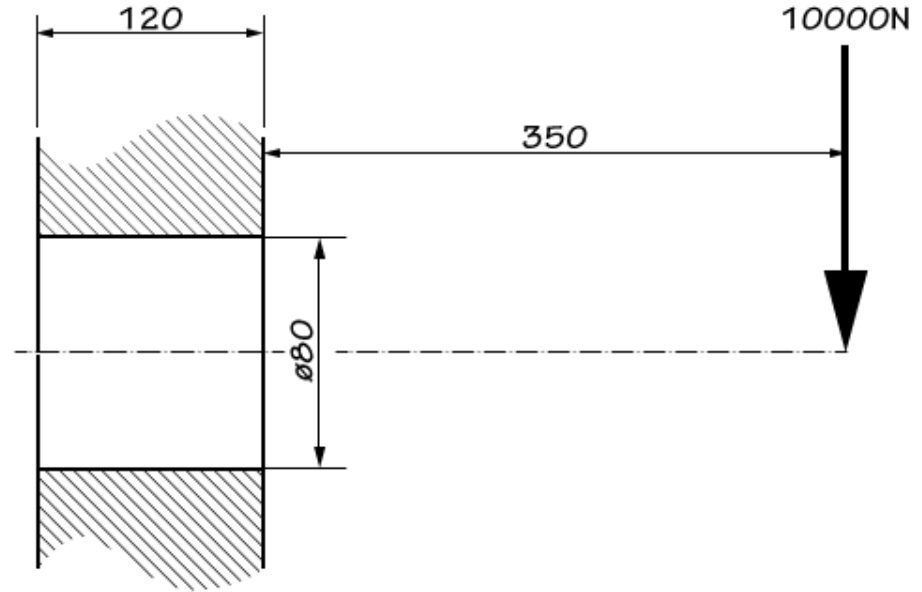
Usually we know something like this

The case can be quite complex

Unknown things

Known things are **subject to change**

What CAD is?

CAD is not a documentation tool, it is a **design** tool

Use it to streamline your **design process**

Parametric Design

What is parametric design?

Microsoft Word example

Word is parametric text processor

- Computer-aided tool

Two different documents

Main Heading

First Heading

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Phasellus rhoncus augue in nulla venenatis sagittis. Quisque suscipit mauris non neque.

Praesent ac neque quis ipsum vehicula laoreet. In iaculis sodales justo vitae iaculis. Pellentesque habitant morbi tristique senectus et netus.

Second Heading

Proin vehicula, arcu sit amet egestas pretium, dolor felis mattis elit, eget sodales magna urna et massa. Ut feugiat rhoncus.

Maecenas accumsan, arcu quis tincidunt sagittis, velit diam pellentesque nunc, nec ullamcorper augue enim in metus. Sed at libero ante.

Third Heading

Etiam in tortor pulvinar ipsum varius placerat. Pellentesque risus urna, iaculis vel porta vitae, tincidunt sed nunc. Vivamus in dolor.

Main Heading

First Heading

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Phasellus rhoncus augue in nulla venenatis sagittis. Quisque suscipit mauris non neque.

Praesent ac neque quis ipsum vehicula laoreet. In iaculis sodales justo vitae iaculis. Pellentesque habitant morbi tristique senectus et netus.

Second Heading

Proin vehicula, arcu sit amet egestas pretium, dolor felis mattis elit, eget sodales magna urna et massa. Ut feugiat rhoncus.

Maecenas accumsan, arcu quis tincidunt sagittis, velit diam pellentesque nunc, nec ullamcorper augue enim in metus. Sed at libero ante.

Third Heading

Etiam in tortor pulvinar ipsum varius placerat. Pellentesque risus urna, iaculis vel porta vitae, tincidunt sed nunc. Vivamus in dolor.

A? Aalto University
School of Engineering

Let's look under the hood

¶

Two different documents?

Main Heading¶

First Heading¶

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Phasellus rhoncus augue in nulla venenatis sagittis. Quisque suscipit mauris non neque.¶

Praesent ac neque quis ipsum vehicula laoreet. In iaculis sodales justo vitae iaculis. Pellentesque habitant morbi tristique senectus et netus.¶

Second Heading¶

Proin vehicula, arcu sit amet egestas pretium, dolor felis mattis elit, eget sodales magna urna et massa. Ut feugiat rhoncus.¶

Maecenas accumsan, arcu quis tincidunt sagittis, velit diam pellentesque nunc, nec ullamcorper augue enim in metus. Sed at libero ante.¶

Third Heading¶

Etiam in tortor pulvinar ipsum varius placerat. Pellentesque risus urna, iaculis vel porta vitae, tincidunt sed nunc. Vivamus in dolor.¶

- **Main Heading¶**

- **First Heading¶**

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Phasellus rhoncus augue in nulla venenatis sagittis. Quisque suscipit mauris non neque.¶

Praesent ac neque quis ipsum vehicula laoreet. In iaculis sodales justo vitae iaculis. Pellentesque habitant morbi tristique senectus et netus.¶

- **Second Heading¶**

Proin vehicula, arcu sit amet egestas pretium, dolor felis mattis elit, eget sodales magna urna et massa. Ut feugiat rhoncus.¶

Maecenas accumsan, arcu quis tincidunt sagittis, velit diam pellentesque nunc, nec ullamcorper augue enim in metus. Sed at libero ante.¶

- **Third Heading¶**

Etiam in tortor pulvinar ipsum varius placerat. Pellentesque risus urna, iaculis vel porta vitae, tincidunt sed nunc. Vivamus in dolor.¶

A? Aalto University
School of Engineering

Real differences

Smart use of styles
- Headlines
  - Distance from previous paragraph
  - Distance to next paragraph
- Main text paragraphs
  - Empty line after paragraph

Aalto University
School of Engineering

·Main·Heading¶

·First·Heading¶

Lorem· ipsum· dolor· sit· amet,· consectetur· adipiscing· elit.· Phasellus· rhoncus· augue· in· nulla· venenatis· sagittis.· Quisque· suscipit· mauris· non· neque.¶

Praesent· ac·neque· quis·ipsum· vehicula· laoreet.· In·iaculis· sodales· justo·vitae· iaculis.· Pellentesque· habitant· morbi· tristique· senectus· et·netus.¶

·Second·Heading¶

Proin· vehicula,· arcu·sit· amet·egestas· pretium,· dolor·felis· mattis· elit,· eget·sodales·magna· urna·et·massa.· Ut·feugiat· rhoncus.¶

Maecenas· accumsan,· arcu·quis·tincidunt· sagittis,· velit· diam· pellentesque· nunc,· nec·ullamcorper· augue· enim·in·metus.· Sed· at·libero· ante.¶

·Third·Heading¶

Etiam· in· tortor·pulvinar· ipsum· varius· placerat.· Pellentesque· risus·urna,· iaculis· vel· porta·vitae,· tincidunt· sed·nunc.· Vivamus· in· dolor.¶

Real differences

No styles
- Manually changed colors and font sizes
- Empty paragraphs

Imagine how easy is to change this document…

No reusability value

¶
Main·Heading¶
¶
First·Heading¶
¶
Lorem· ipsum· dolor· sit· amet,· consectetur· adipiscing· elit.· Phasellus· rhoncus· augue· in· nulla· venenatis· sagittis.· Quisque· suscipit· mauris· non· neque.¶
¶
Praesent· ac·neque· quis· ipsum· vehicula· laoreet.· In· iaculis· sodales· justo· vitae· iaculis.· Pellentesque· habitant· morbi· tristique· senectus· et·netus.¶
¶
Second·Heading¶
¶
Proin· vehicula,· arcu·sit· amet·egestas· pretium,· dolor·felis· mattis· elit,· eget·sodales·magna· urna· et·massa.· Ut·feugiat· rhoncus.¶
¶
Maecenas· accumsan,· arcu· quis· tincidunt· sagittis,· velit· diam· pellentesque· nunc,· nec·ullamcorper· augue· enim· in·metus.· Sed· at·libero· ante.¶
¶
Third·Heading¶
¶
Etiam· in· tortor·pulvinar· ipsum· varius· placerat.· Pellentesque· risus· urna,· iaculis· vel· porta·vitae,· tincidunt· sed·nunc.· Vivamus· in·dolor.¶
¶

Know your tools

CAD programs can do many things
- But you must know that those things exists

Knowing one CAD well will help you to learn how other CAD programs work

Almost all mechanical CADs have same principles
- Main difference is what the user is allowed to do

What is parametric design?

CAD models are made for to be changed
- Engineering design is an iterative process
- Within limits

Dimensioning matters
- Main design parameters as model drivers
- Dimensions matter, not their values

Thing before you do

Meaningful dimensioning

Is this you design?
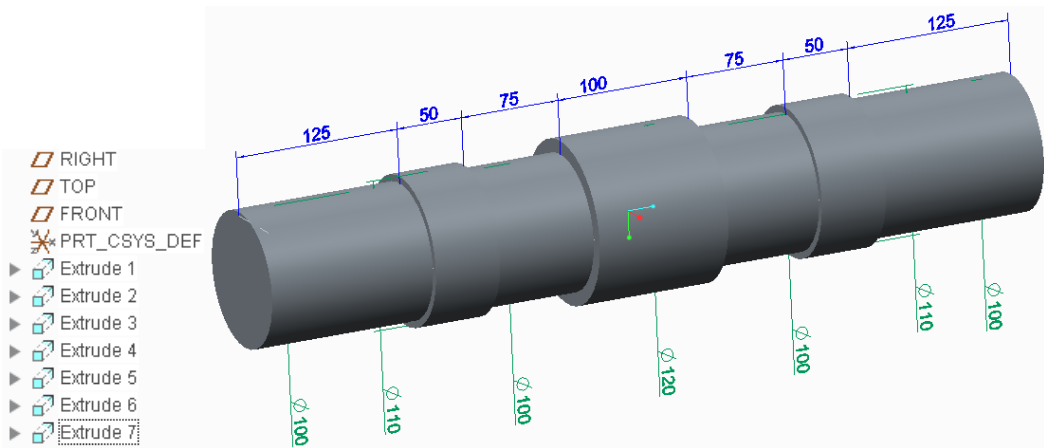
Or does this make more sense?
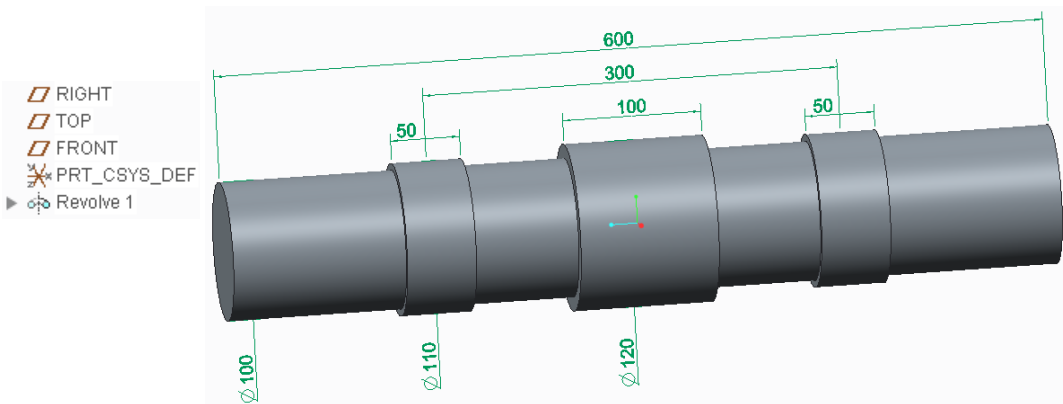
Meaningful dimensioning

Select dimensions that support engineering design
- i.e. main shaft length, distance between bearings

Avoid unnecessary mental arithmetic
- i.e. main length is sum of several shape's lengths

Minimize change workflow
- Four times more changes is four times more mistakes

Design Intent

In CAD, it matters **how** the model is created

Models may look same, but how they response to changes?

Even with same dimensioning, **the model creation process** matters
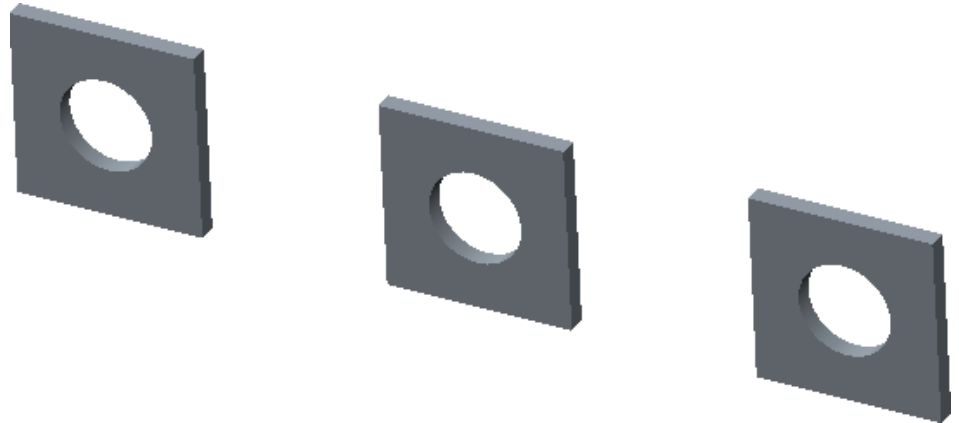
Many ways to create the shape

VK_VARIABLE.PRT
- RIGHT
- TOP
- FRONT
- PRT_CSYS_DEF
- Sketch 1
- ▶ Sweep 1
- Datum Point id 153
- Curve id 156
- ▶ Sweep 2
- ▶ Sweep 3
- A_1
- Sketch 3
- Sketch 2
- ▶ Pattern 1 of Sweep 4
- ➜ Insert Here

MID_TERM_EXAM.PRT
- RIGHT
- TOP ✔
- FRONT
- PRT_CSYS_DEF
- ▶ Revolve 1
- ▶ Extrude 1
- ▶ Extrude 2
- ▶ Mirror 1
- ▶ Pattern 1 of Extrude 3
- ➜ Insert Here

VK_UPPERCUT_NOPATTERN.PRT
- RIGHT
- TOP
- FRONT
- PRT_CSYS_DEF
- ▶ Extrude 1
- ▶ Extrude 2
- ▶ Extrude 3
- ▶ Extrude 4
- ▶ Extrude 5
- ▶ Extrude 6
- ➜ Insert Here
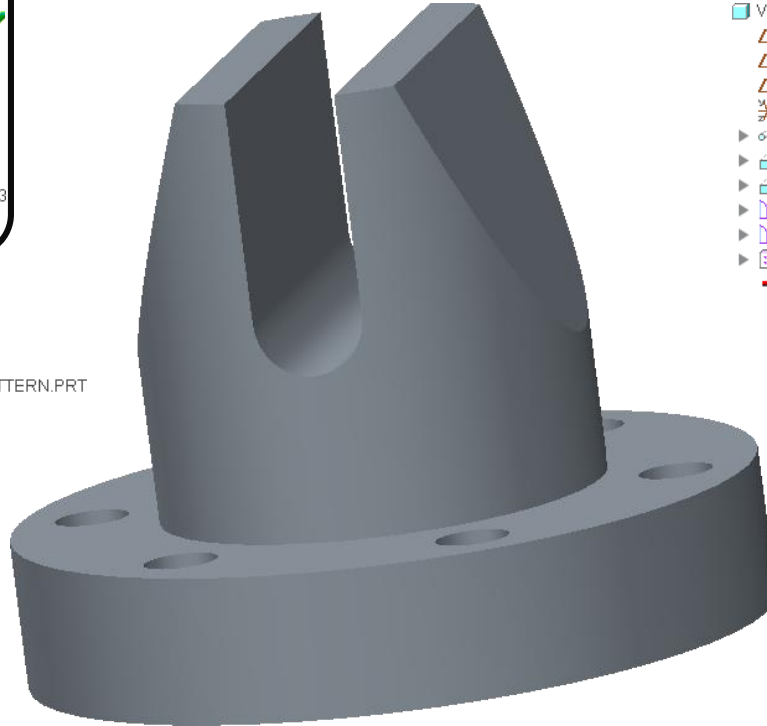
VK_MIRRORS.PRT
- RIGHT
- TOP
- FRONT
- PRT_CSYS_DEF
- ▶ Revolve 1
- ▶ Extrude 1
- ▶ Extrude 2
- ▶ Mirror 1
- ▶ Mirror 2
- ▶ Pattern 1 of Extrude 3
- ➜ Insert Here

VK_BOUNDARY_BLEND_ONE_EXTRUDION.PRT
- RIGHT
- TOP
- FRONT
- PRT_CSYS_DEF
- Sketch 1
- Sketch 2
- PNT1
- DTM1
- PNT2
- DTM2
- Sketch 3
- Sketch 4
- DTM4
- Sketch 6
- DTM5
- Sketch 7
- Boundary Blend 1
- Boundary Blend 4
- Boundary Blend 5
- Merge 1
- Boundary Blend 2
- Boundary Blend 3
- Merge 2
- Boundary Blend 6
- Merge 3
- Merge 4
- Merge 5
- Sketch 8
- Sketch 9
- ▶ Pattern 1 of Boundary Blend 7
- ▶ Pattern 2 of Merge 6
- ▶ Extrude 1
- ➜ Insert Here

A? Aalto University
School of Engineering

Making Design Intent clear

Plan ahead
- Just doing may seem fast, but changeability will suffer
- Save time in the end, not in the beginning

Use test models
- Test different approaches
- Throw bad models away

Model needs to have a purpose
- Model for communication is not a good engineering design model

Feature per function

Makes understanding model easier
- You don't need to save in the amount of features
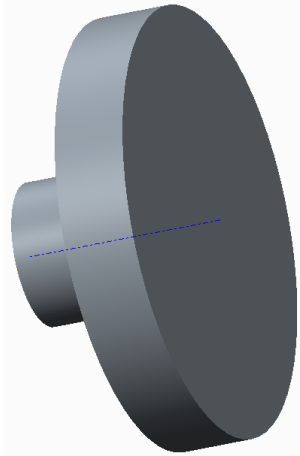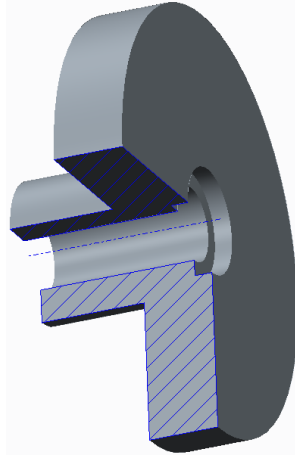
Raw material   Hole for shaft   Groove for   Ready belt wheel
                                              belt wheel
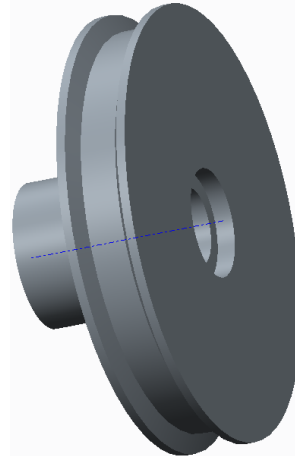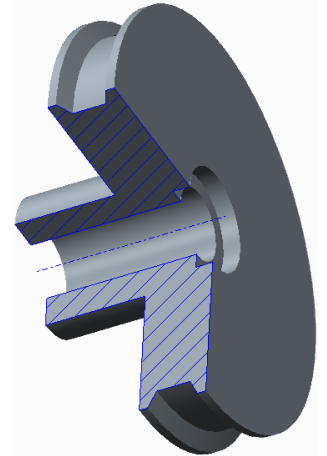
Symmetry and patterns

If the model is symmetrical, benefit from it
- Don't over-mirror

If you can use patterns, do it
- Can even streamline assembly process
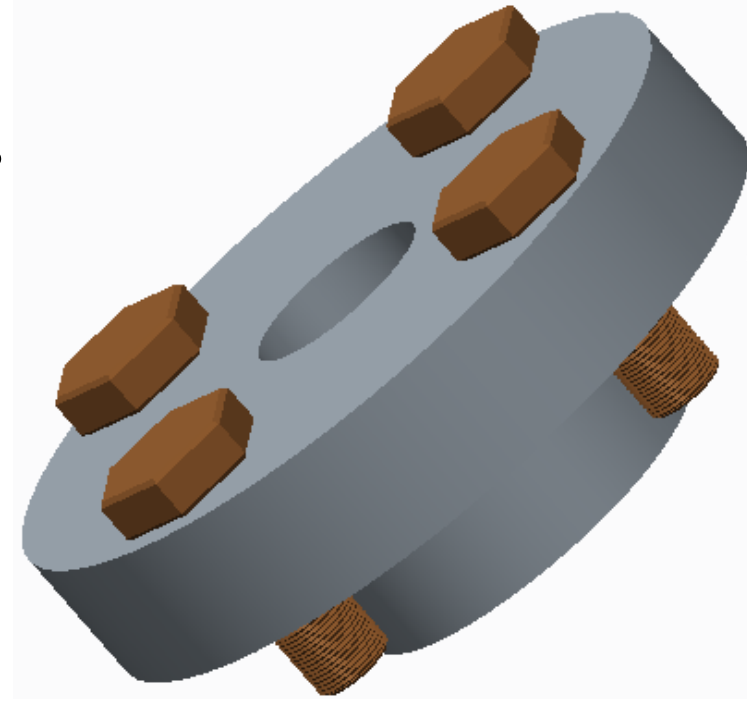
Sketching Order
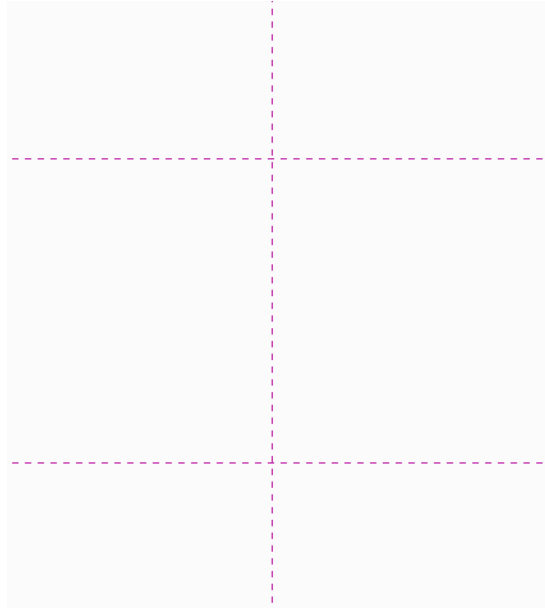
References
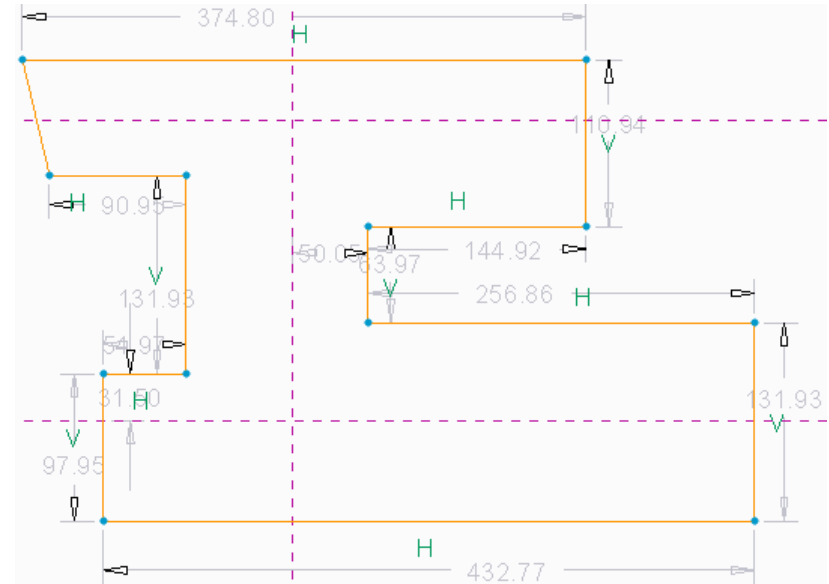
Geometry

Sketching Order
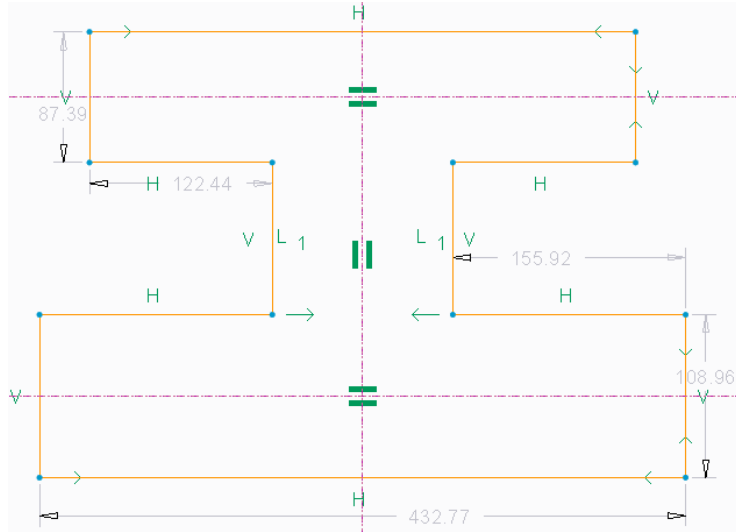
Constrains and dimensions

Values

Aalto University
School of Engineering
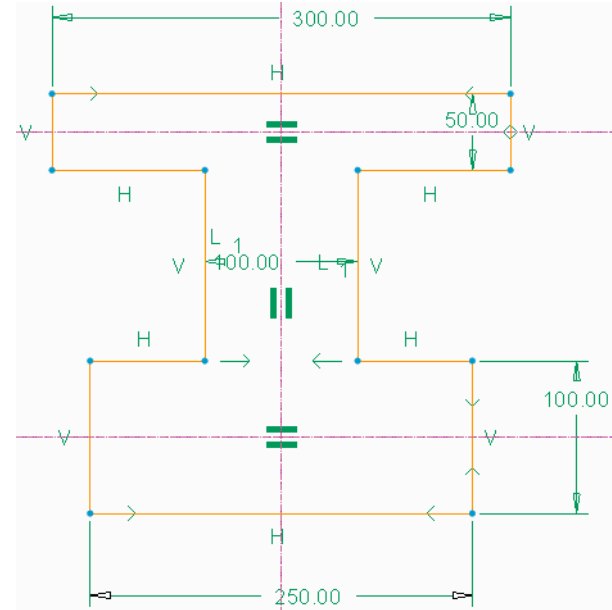
The goal of parametric design

Reduce the configure-to-order times

Reducing costs

Improving your value

Speed up iteration cycles

Better communication

Making life easier

The hard part

There are no one correct way

Your skills will improve when practicing

Use your time to fix mistakes
- You learn most while fixing it

Do not hesitate to change bad plan
- Do not try to save it

Parameters & relations

Tools in Creo

Can be found in *Model Intent* group
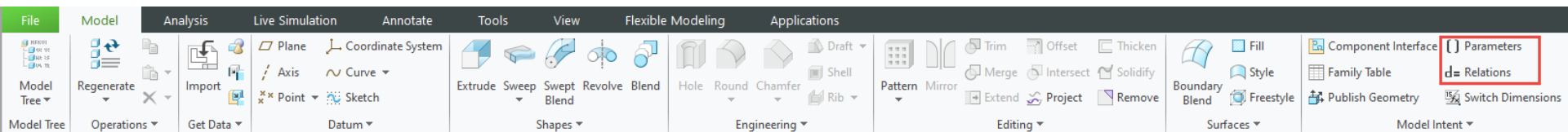
Parameters

Lists all parameters in the model
- Can add/remove those

Four types
- Integer (for ex. 3)
- Real Number (for ex. 3.14)
- String (for ex. "Steel")
- Yes No i.e. Boolean

**Aalto University
School of Engineering**
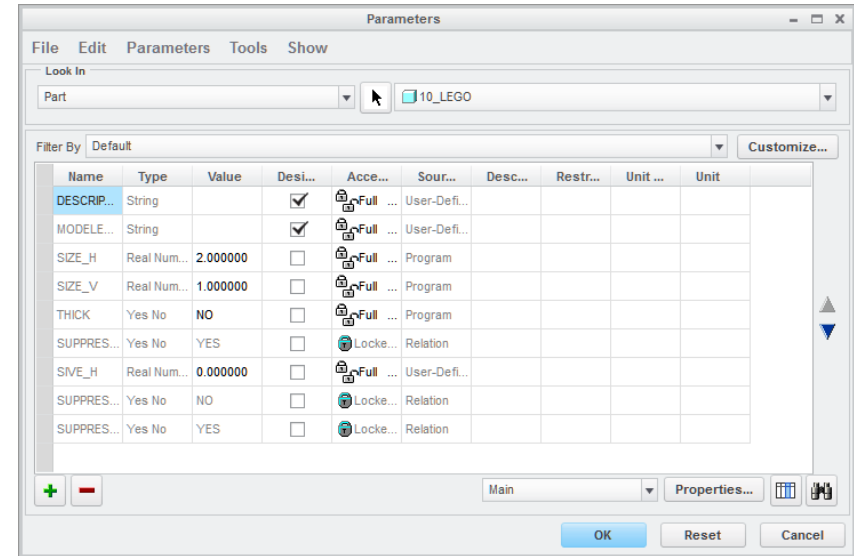
Relations

Lists relations (i.e. model code) in the model. Relations between dimensions and parameters.
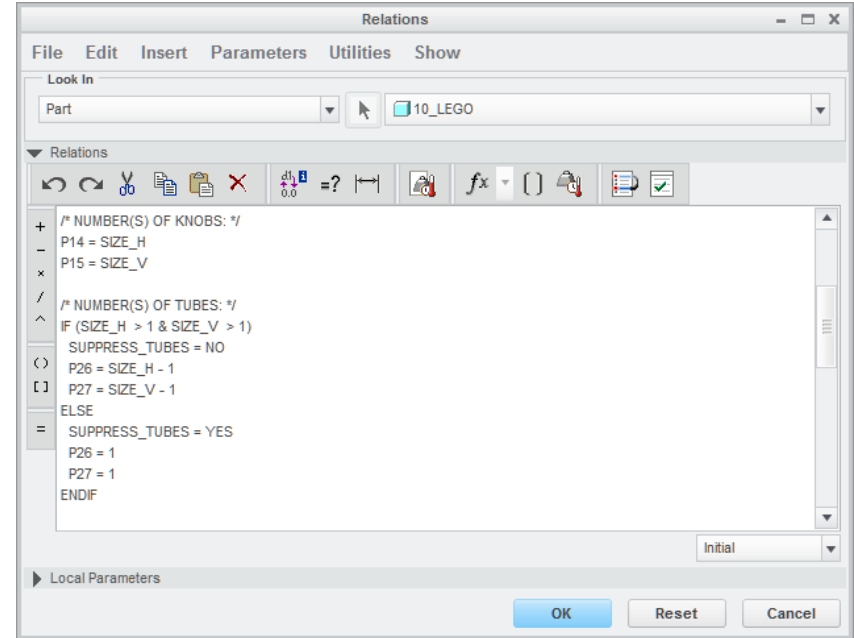
If Else

IF (condition)

…

ELSE

…

…

ENDIF

IF to state condition
- For ex. IF (d7>4)

ELSE if statement not right
- Optional

ENDIF closes the IF loop
- No bracets

An Example

If the height of the part (d0) is over 100, then thickness (d4) is 10%

An Example

100

101
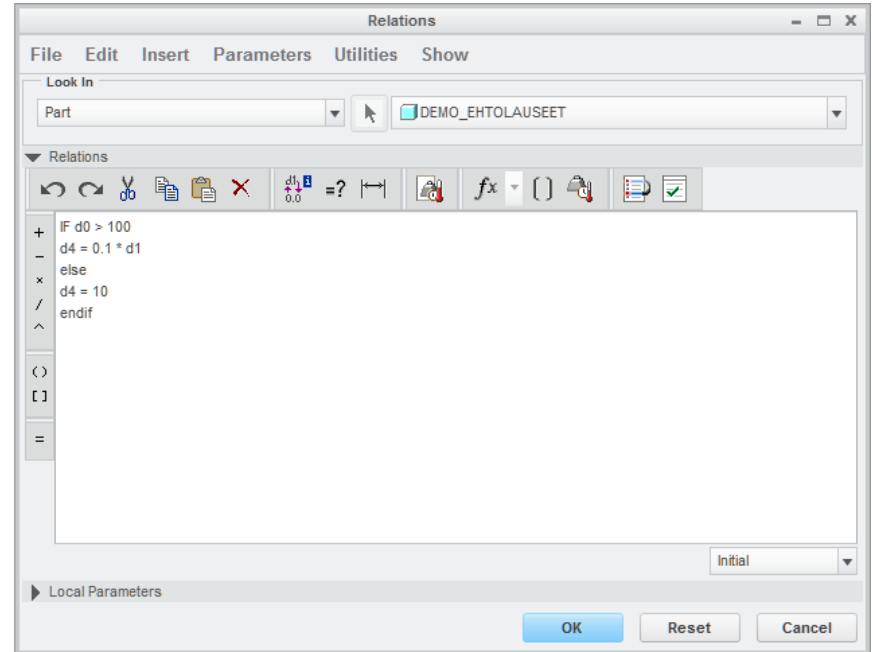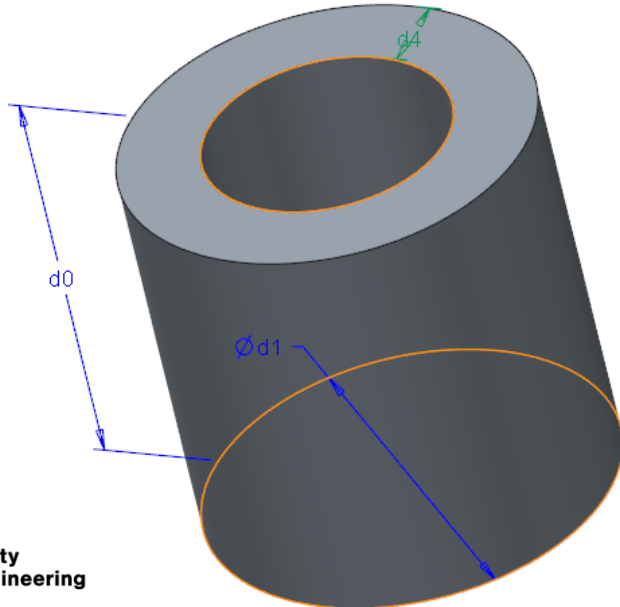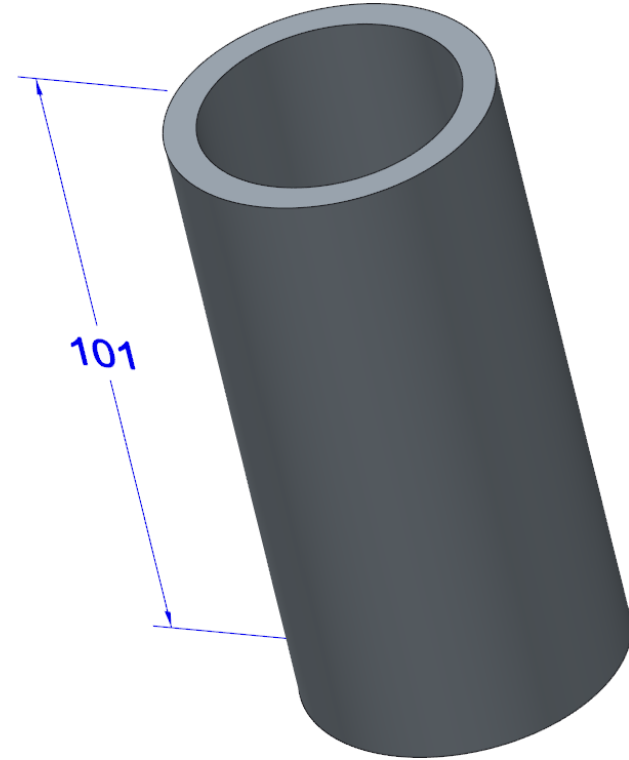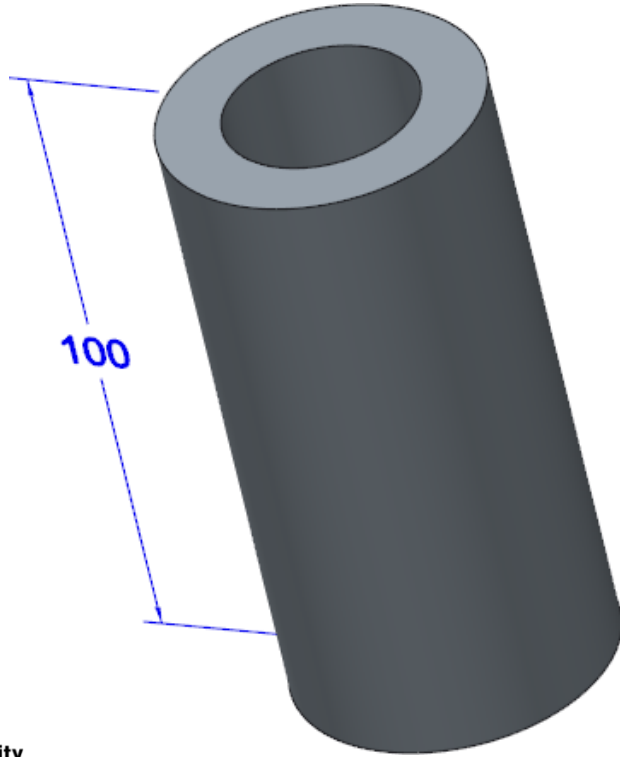
Logical Operators

> greater than, => equal or greater than

< smaller than, =< equal or smaller than

== equal

& and

| or

Dimensions' Symbols

d# feature dimension
- Real number

p# amount of patterned features
- Integer (for ex. 3.6 → 3), can't be zero

sd# sketch's dimension

Program creates numbers (#) automatically

Suppressing Features

Features can be scribed to be suppressed
- Thru Program tool in Model Intent

You suppress feature, not to remove it
- Symbol black box before feature's name　　Extrude 2

Suppressing Features

Parameter POIS for stating the status of the feature

- Does not yet suppress it!
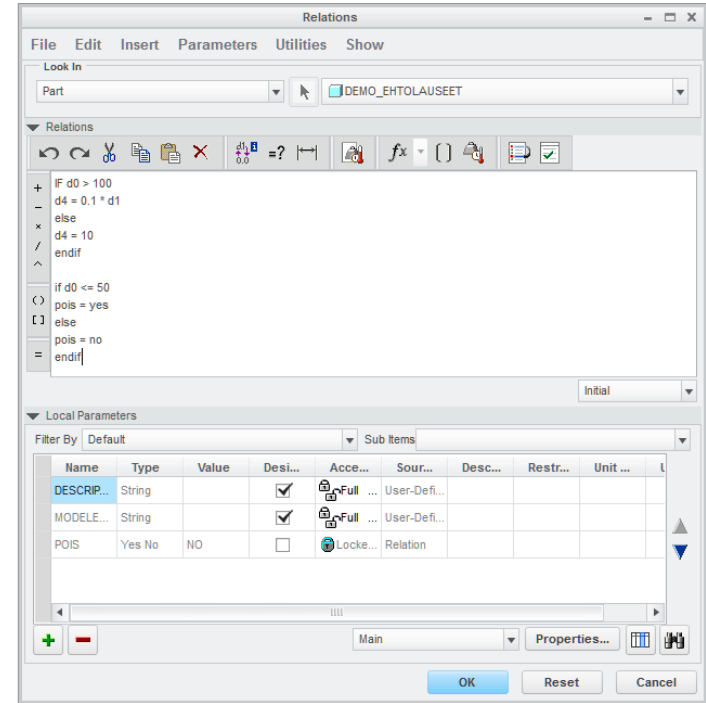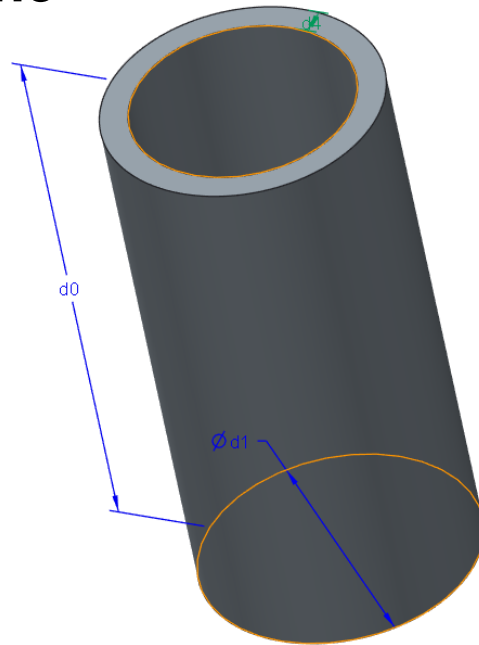
Suppressing Features

Program **list is a guide how to build model**

- A text file

You can create own conditions to the list

- IF – END IF structure

Suppressing Parts

Same tool, but in assembly level
- ADD PART – END ADD

Good tool for creating a configurable models

Parametric Parts

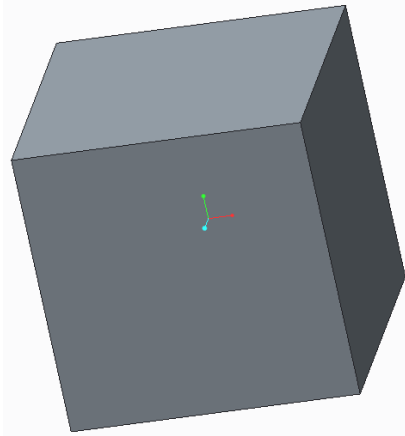# Parametric Assembly
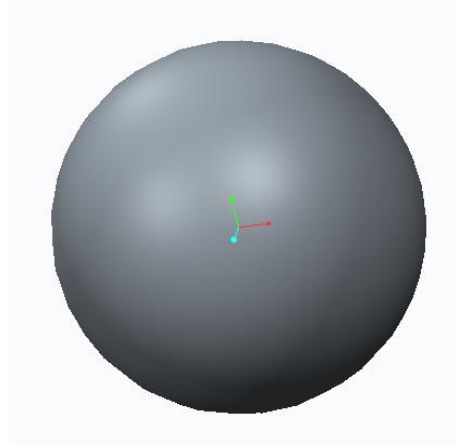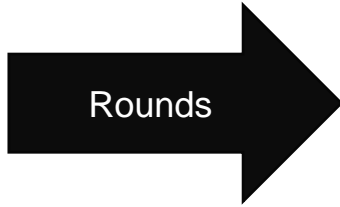

Parameter
change
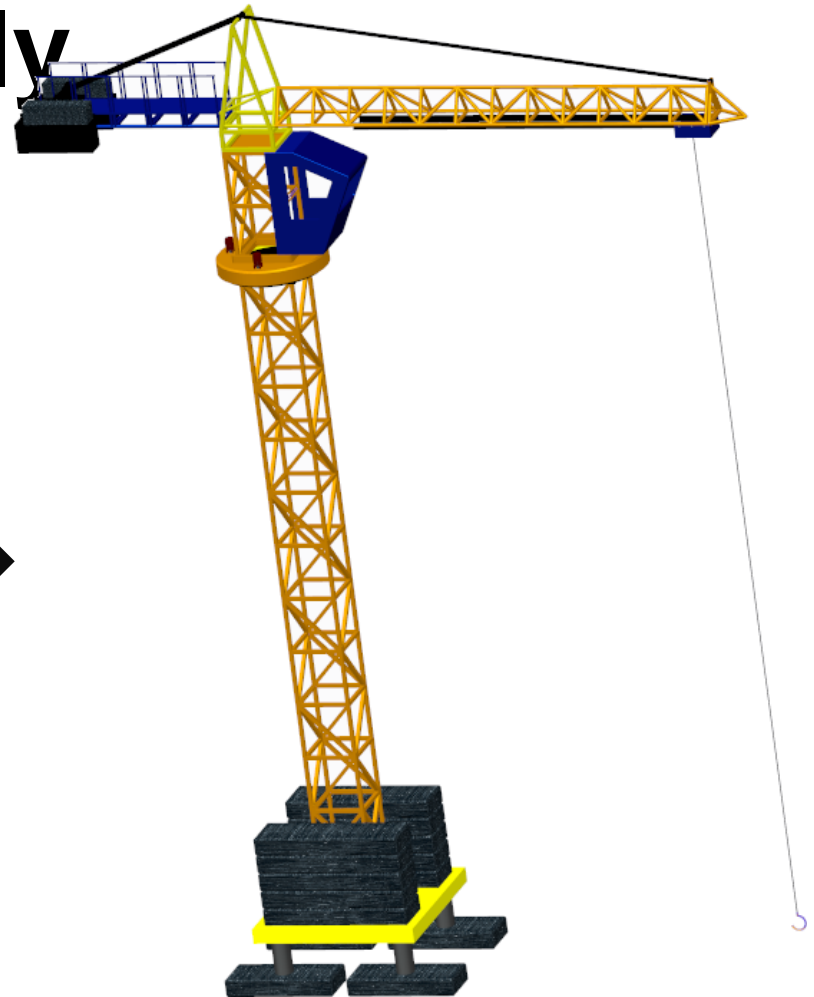
How NOT to create a ball

How NOT to create a ball

Round and Chamfer are tools for fine-tune models, not to create primary shapes!

Extrude 1

Rounds

aalto.fi

Aalto University
School of Engineering