# MCG 4322A
## Optimization Tutorial

In advance of the tutorial session, do the following:

1. Set up the client software for uOttawa's RemoteLabs *https://it.uottawa.ca/students/remote_labs* .
2. It is strongly advised to use **the student network drive** for all files (H: or Z:) and follow the given file organization scheme.
3. Download the GUI template files from Brightspace, save it to the remote H: or Z: drive, then extract the zip file.
4. With RemoteLabs, start Solidworks app, new part file.
5. Also with RemoteLabs, start Matlab, open the folder containing the GUI template files.

# Remote Apps state as of 2024

Seriously, carefully read the documentation for this!
https://www.uottawa.ca/faculty-engineering/it-services/remote-apps

Most important points up front:

1. It is essential to set up a remote desktop client to enable the recommended file transfer between your local drive and remote drive.

2. Work with a good, stable internet connection.

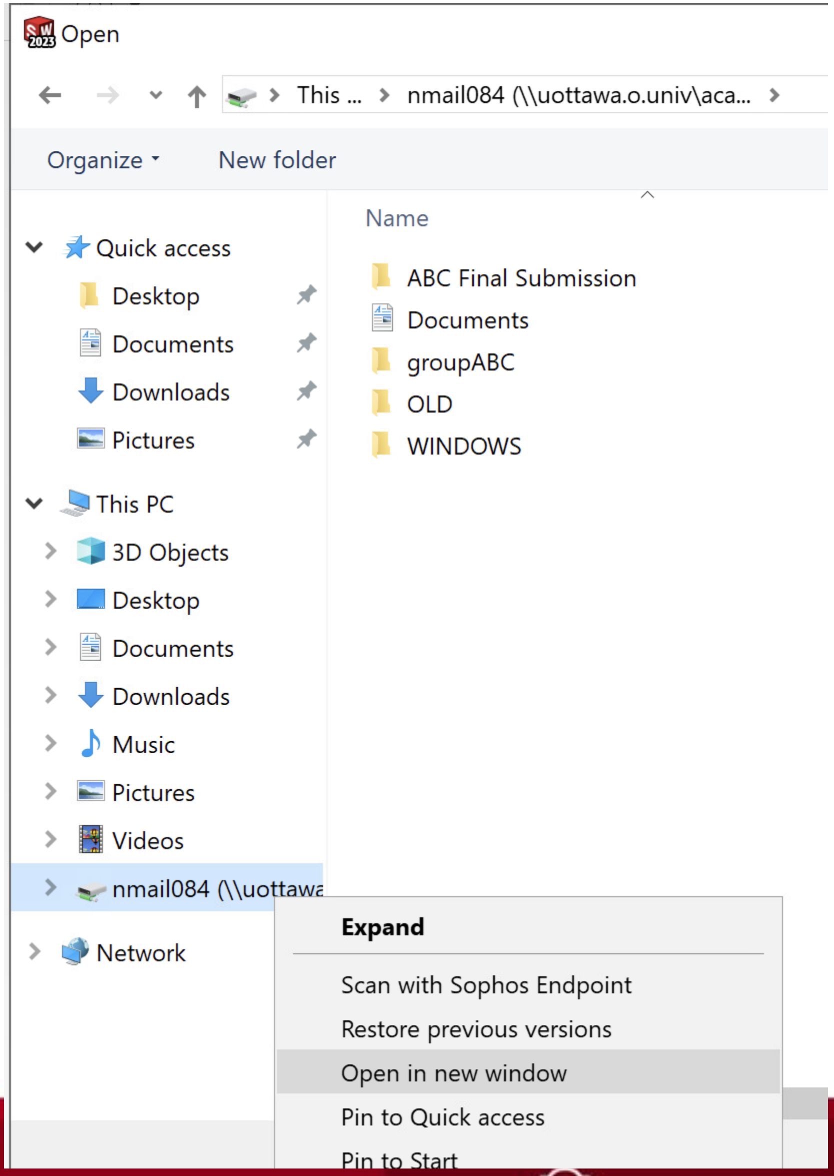
3. Solidworks and Matlab is the most consistently functional when using files on your student network drive (H: or Z:) .

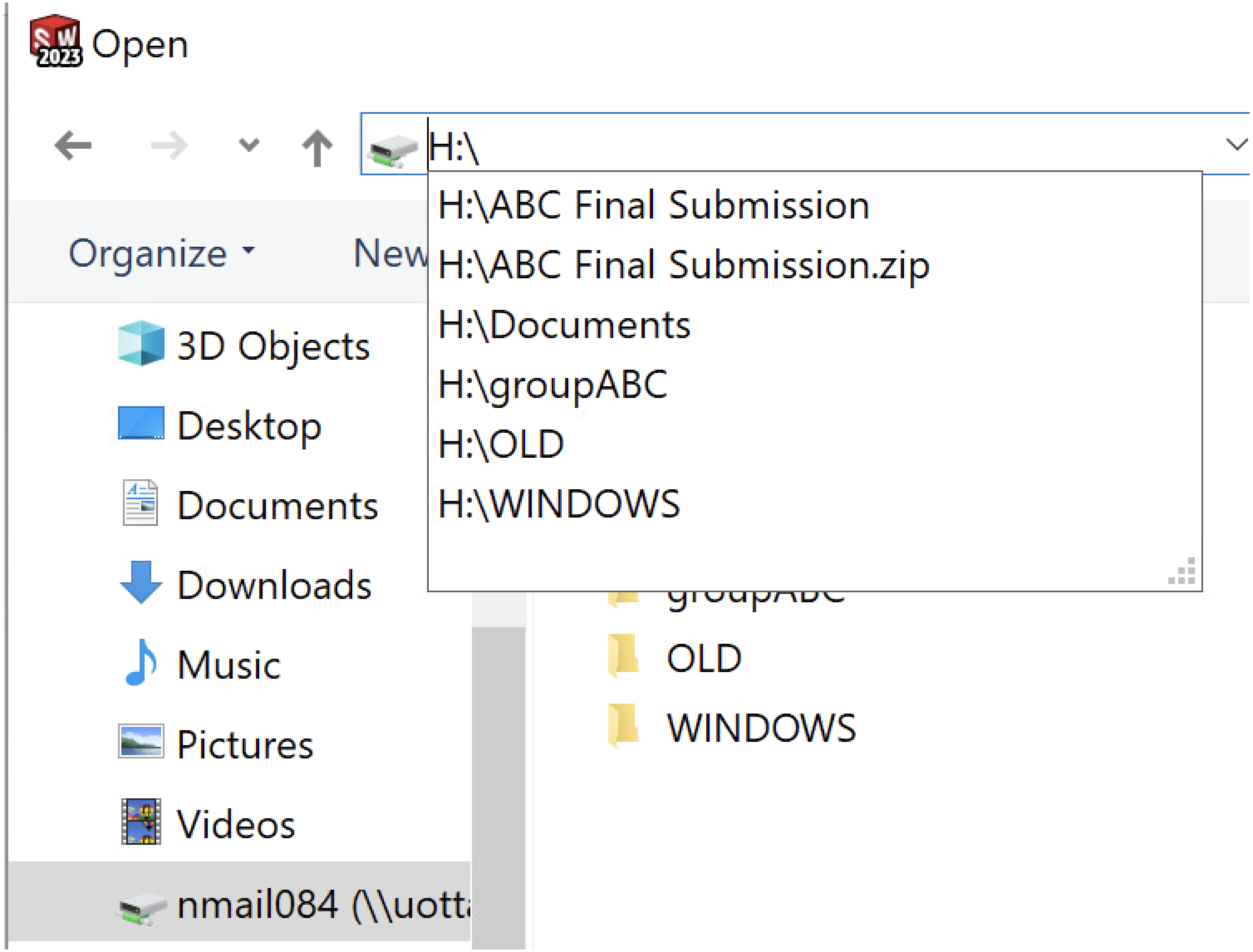
4. **Save OFTEN**. Historically, bad network connections and Solidworks being Solidworks have caused the most tears to be shed when students lose their work.

# Remote Apps file system

To access the remote file explorer:

- Pick any "open file/folder" prompt in the software you have started,
- Right click your remote drive,
- Select "open in new window",
- A new windows file explorer window will open!




Open
H:\
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New
3D Objects
Desktop
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H:\groupABC
H:\OLD
H:\WINDOWS
OLD
WINDOWS

# Use YOUR uOttawa network drive!!!

## Do use

uOttawa network drive (Network locations)

- **You should use this drive** for saving your work, because it is the fastest and because it is available to you across campus on all lab computers.
- In Remote Apps, the location of your network drive should start with **\\uottawa.o.univ\acadhomes\...** This is your uOttawa network drive, to which the Remote App server has high-speed access.
- This appears as under Network locations as your Z: drive if you are a student, or or H: drive if you are an employee.

## Avoid using

### Personal computer drives (Devices and drives)

These are drives on your personal computer. Although it is convenient to access files stored on your personal computer with Remote Apps, we recommend not using them directly with remote applications for performance reasons: When you use Remote Apps, the application displayed is running on a server within the University's network. Files on your computer will be accessed via network using the RDP protocol, which is not designed for fast file access. This considerably reduces the performance of your remote session. We recommend instead that you transfer your files to your uOttawa network drive (Z:), then open them from that location.

### Remote App server folders (Folders)

You should never use these folders to store your files. Files saved in these folders will be destroyed at the end of your remote session.

# To make the point clear

**Saving files in the Network drive is better (Z: or H: drive.** It's faster since it is on the same network as the remote apps tool itself. This will make a big difference in using Solidworks. Save your work here, as you go along.

**Saving files on your local drive is worse (C: drive).** Using this drive will affect performance especially with applications that frequently write to the file - like Solidworks, since all of the file information must traverse much slower networks to get to and from your local machine.

# File transfer between local and remote drive

As simple as copy and pasting files between windows...

But only if you have set up permissions for the remote client app, client and system dependent!

https://www.uottawa.ca/about-us/information-technology/remote/lab

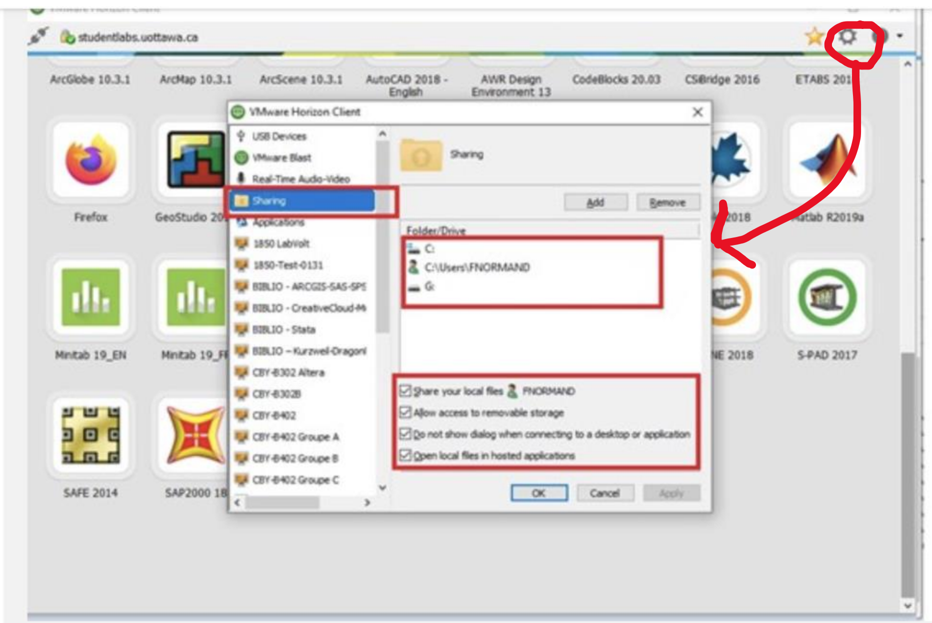
## Steps

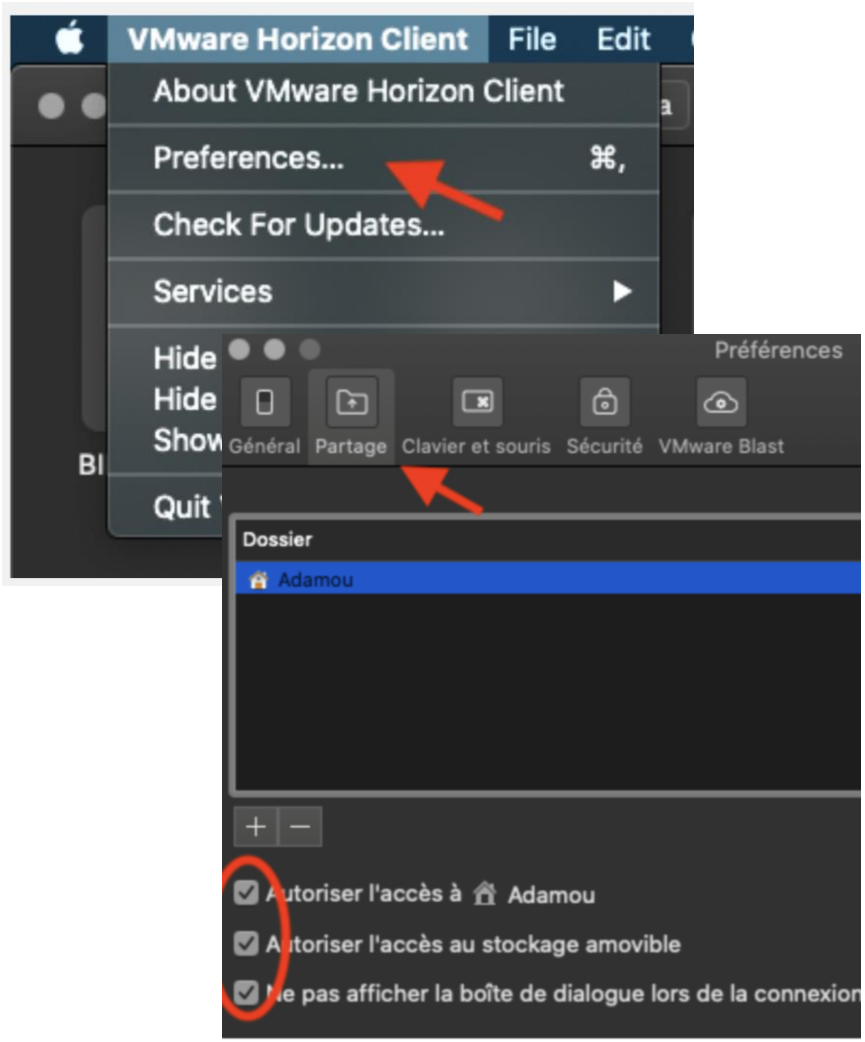
On this page you will find how to connect to the portal from your personal devices and work efficiently with the University's licensed softwares and applications.

**Before using uOlabsPlus:** You will need to self-enrol your account for Multi-Factor Authentication (MFA).

Connect to uOlabsPlus | Working with files | Saving and file performance | **Share and transfer**

# File transfer between local and remote drive



# Purpose of Algorithmic Design Optimization

Algorithmic design optimization allows us to automatically:

- Verify the entire analysis for operational criteria.
- Check if the design can be adapted for situations adjacent to nominal operation.
- Improve the robustness of your CAD model for changes from algorithmic process.

A critical tool for *efficient* mechanical design

# Relationship between Parametric Design and Optimization

*Parametrize*

To express in terms of parameters.

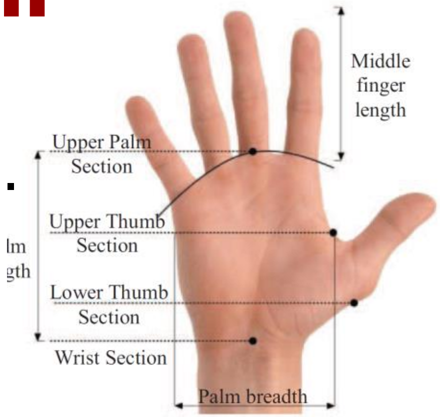
*Parametrization*

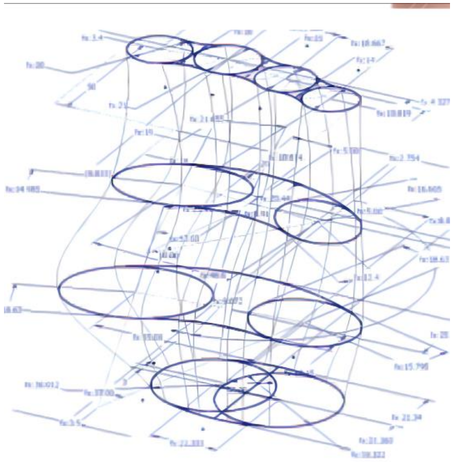
Process to express a model as a function of a set of independent quantities, i.e. the *parameters*.

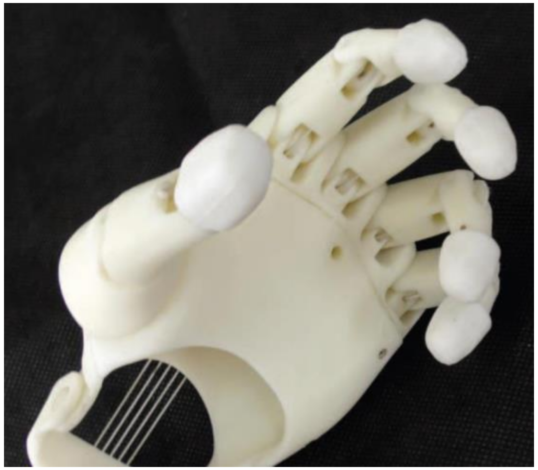
*Parametric design*

A set of parameters defines an optimal candidate via algorithmic procedure,

e.g. hand prosthesis design

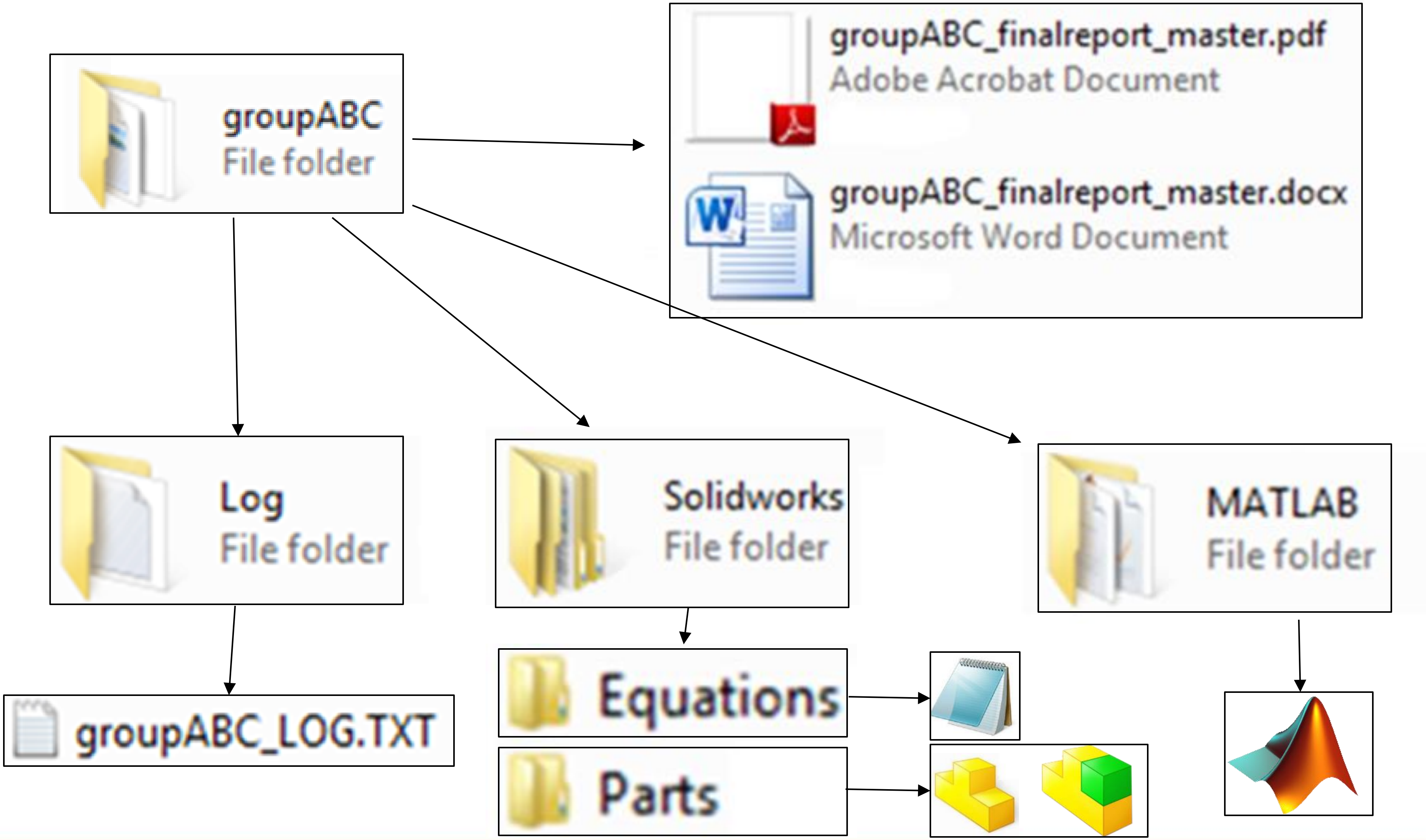




M. Bustamante et al., "A Parametric 3D-Printed Body-Powered Hand Prosthesis Based on the Four-Bar Linkage Mechanism," *2018 IEEE 18th International Conference on Bioinformatics and Bioengineering (BIBE)*, 2018, pp. 79-85.

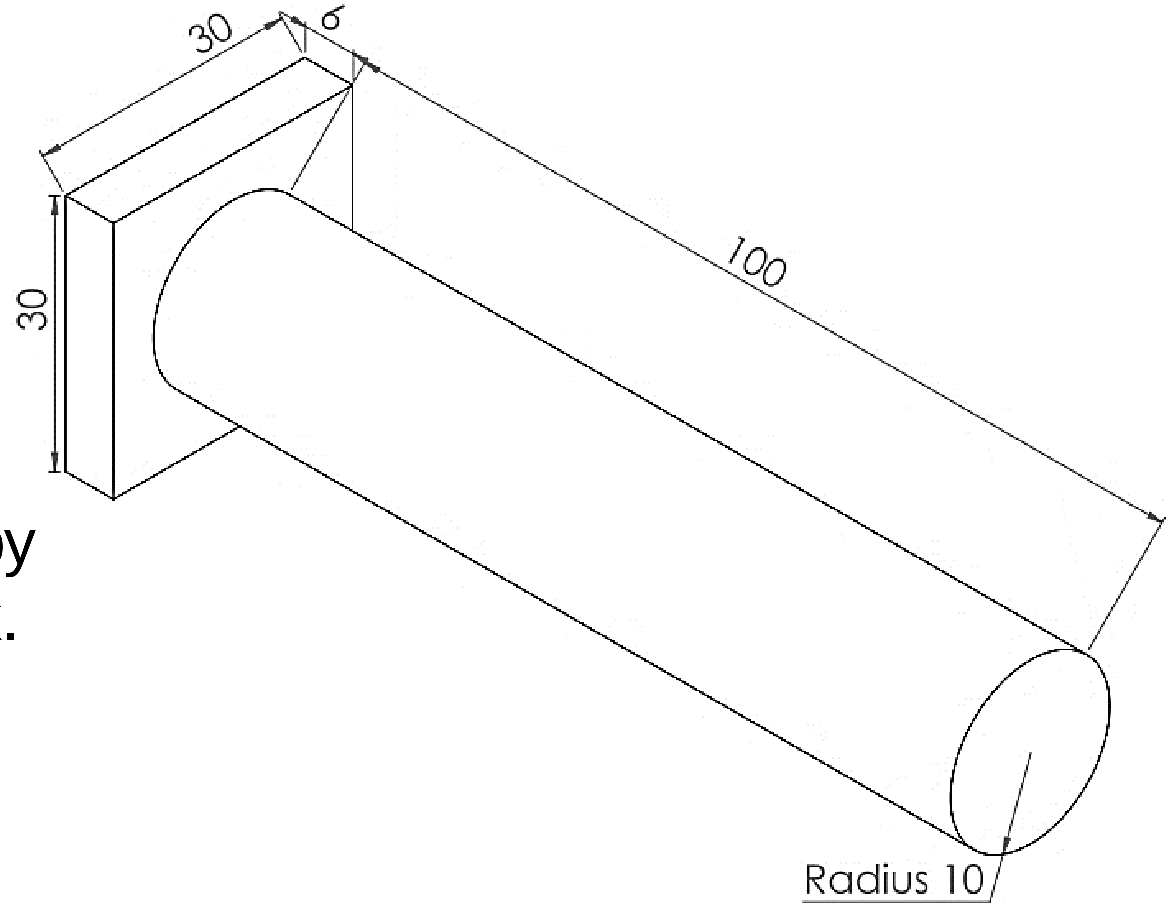
# Required Final Submission File Organization



# Step 1: Draft a cantilever beam

In Solidworks, model a beam with the following:

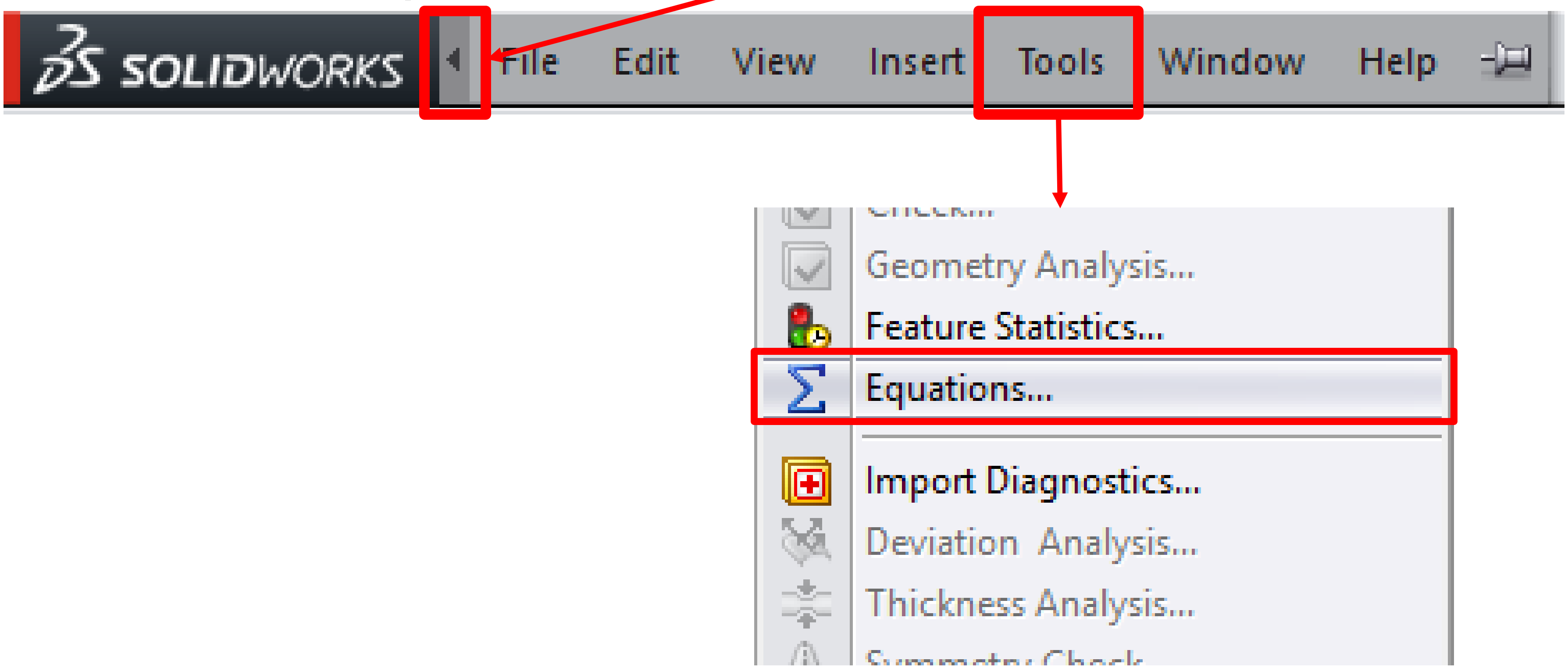
- Round cross section with 20mm diameter and 100mm length,
- Square base 30mm by 30 mm by 6 mm thick.




Save as: *shaft.sldprt*
in H:/groupABC/Solidworks/Parts

# Step 2: Declaring global variables

In top toolbar, hover over the arrow and navigate to Tools → Equations

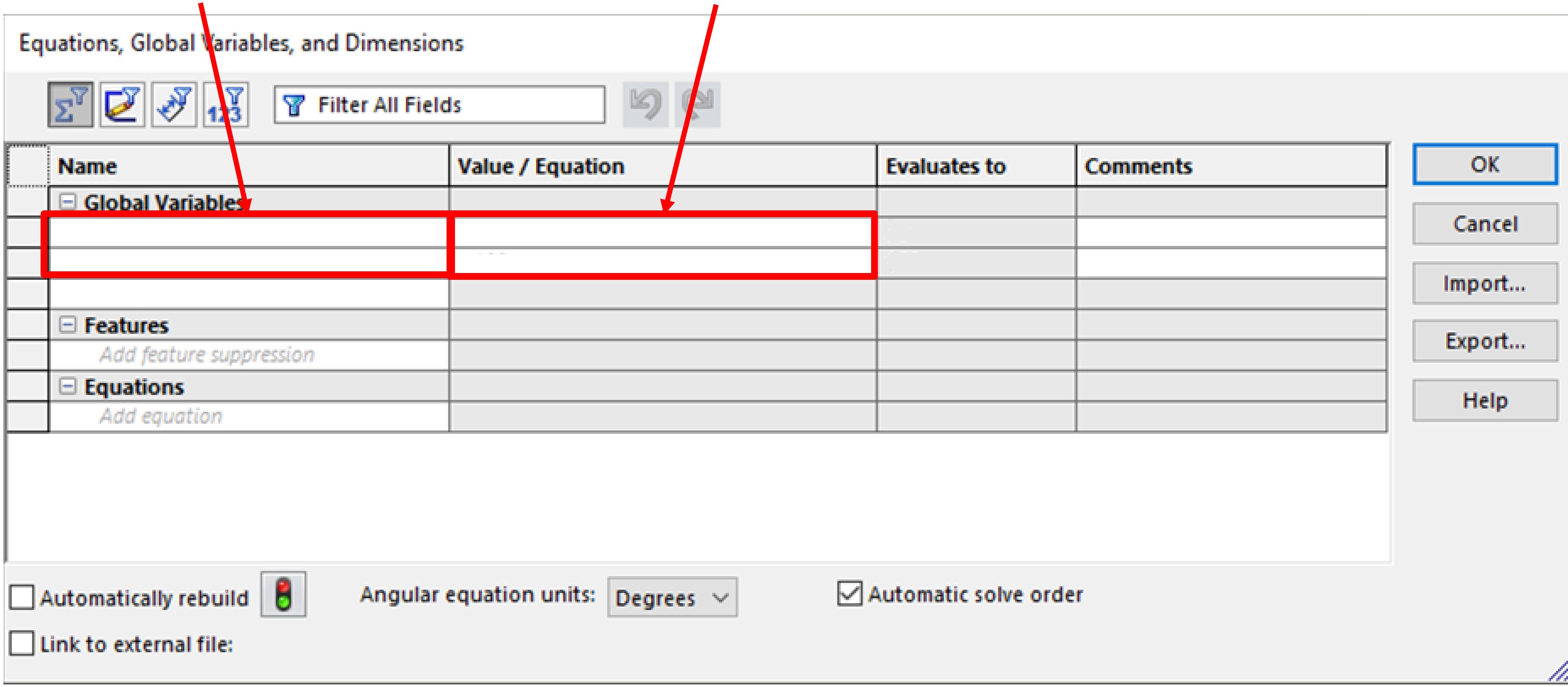


# Step 2: Declaring global variables

Add two variables with exactly these names/values:

“Diameter” = 20 mm

“Length” = 100 mm



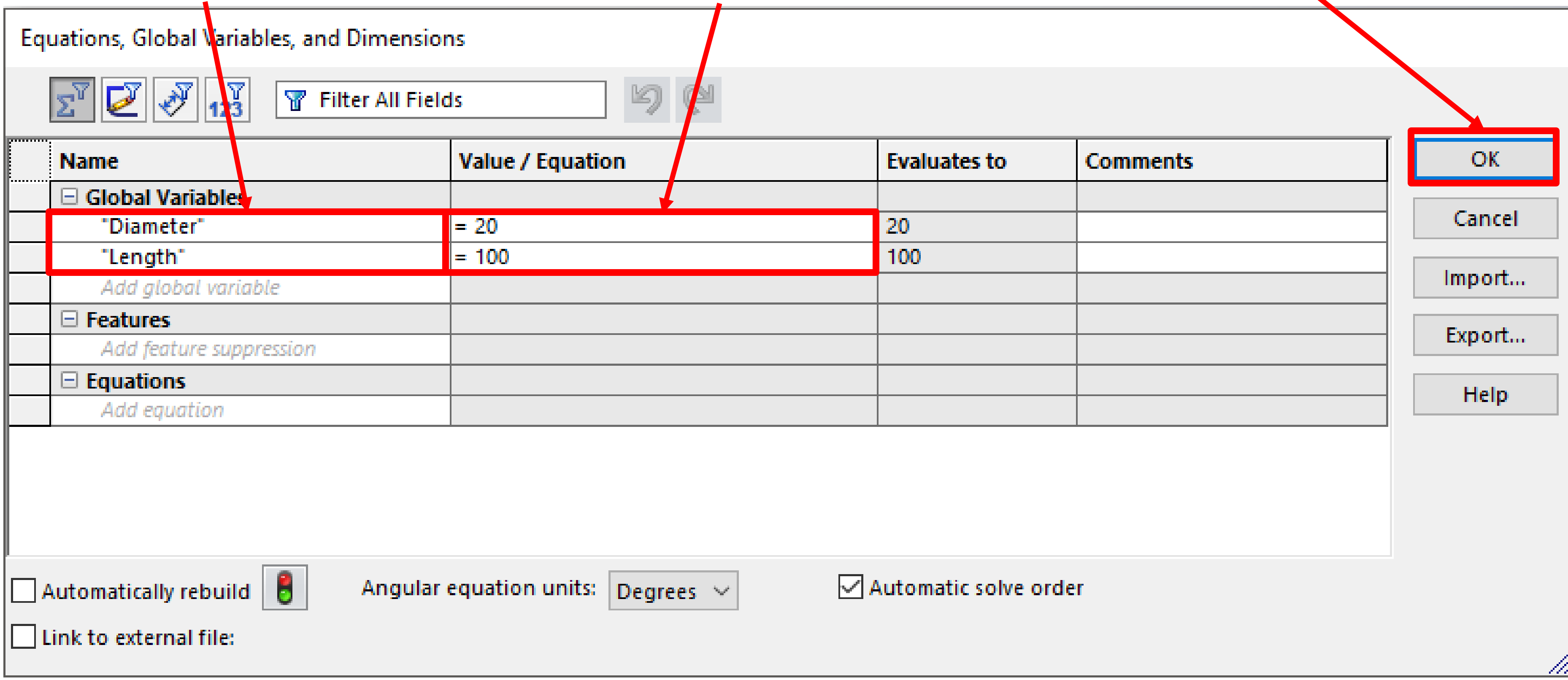
# Step 2: Declaring global variables

Add two variables with exactly these names/values:

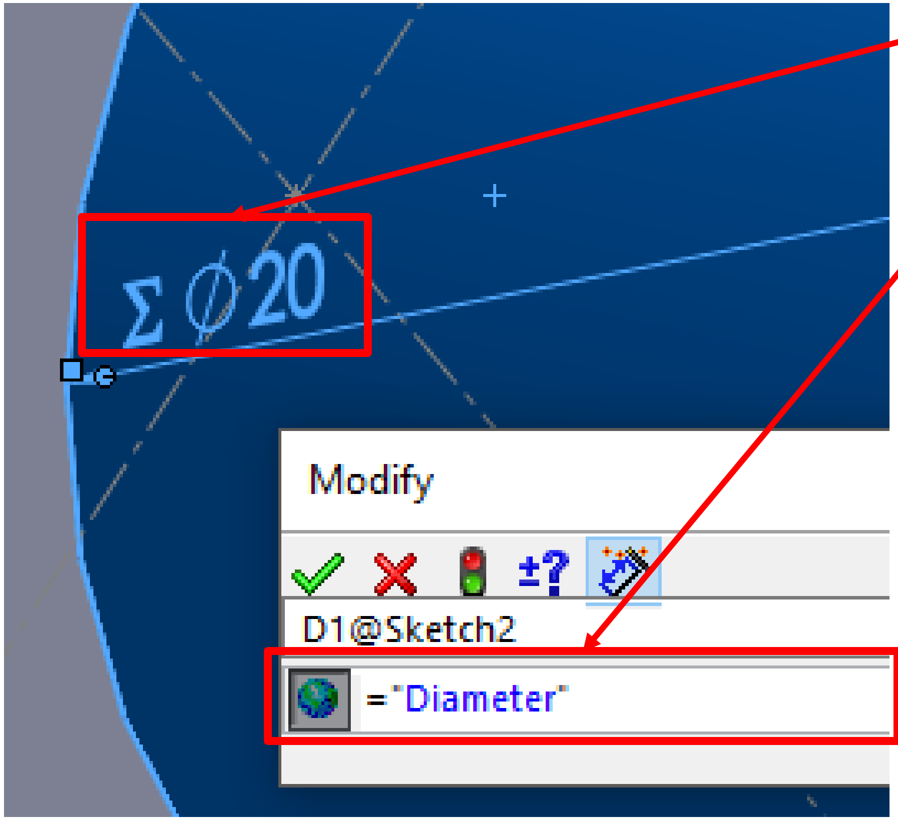
"Diameter" = 20 mm

"Length" = 100 mm

When done, hit 'OK'



# Step 3: Link dimension to a variable




- Double click beam diameter dimension,
- Click on input value field, type exactly:

  = "Diameter"
- Assign beam length dimension, exactly:

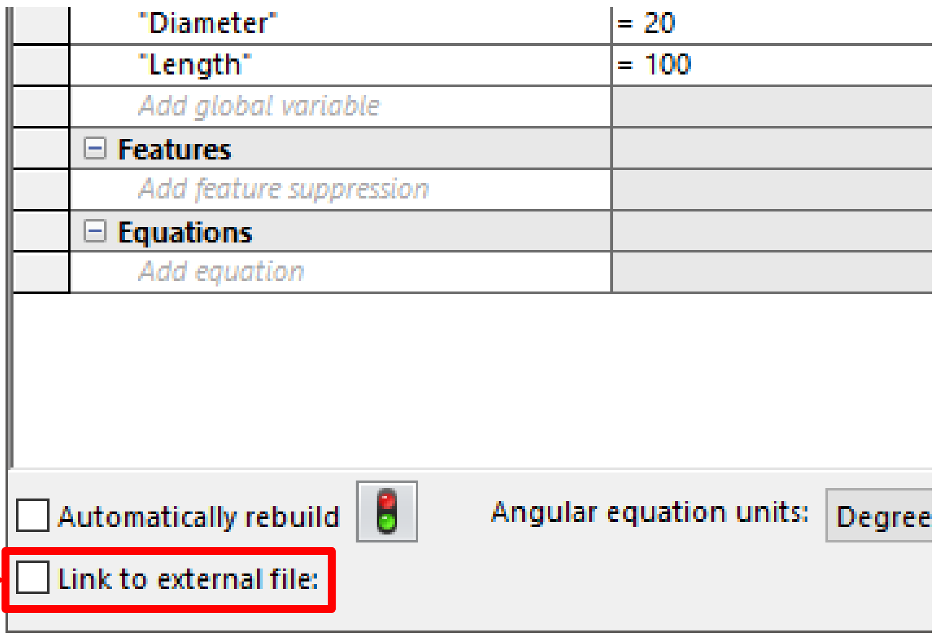
  = "Length"

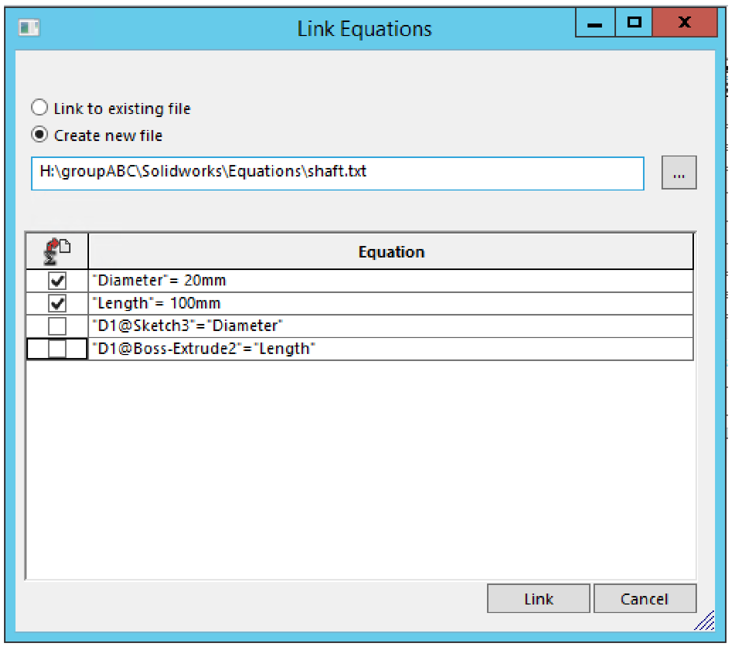
Variables are now linked to dimensions!

Indicated by the sigma Σ, next to the dimension.

# Step 4: Linking variables to text file

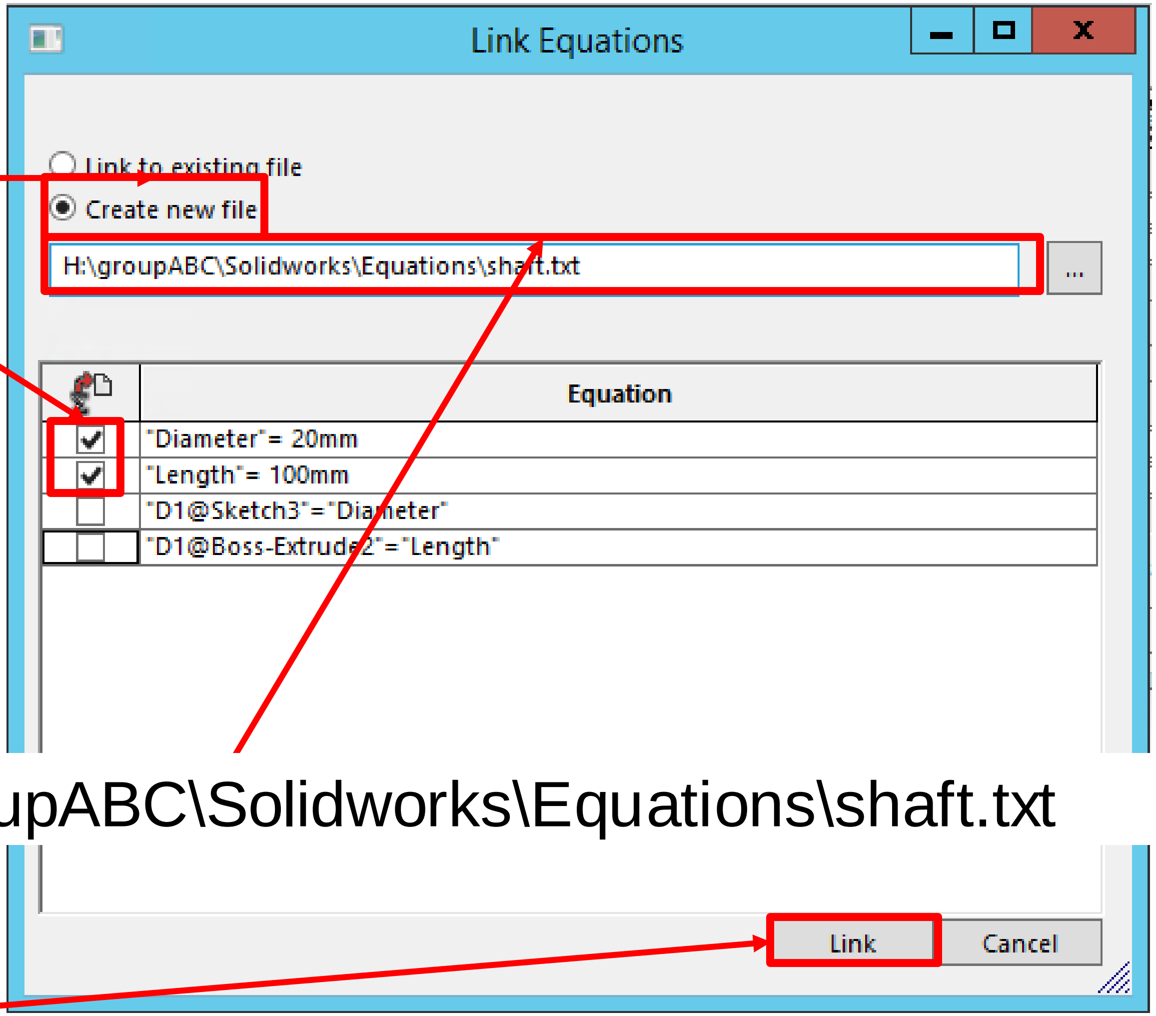
- Go back to the Equations menu, (Tools → Equations)
- Bottom left, click "Link to external file:"
- The "Link Equations" pop-up menu will open.



# Step 4: Linking variables to text file

- Select 'Create new file',
- **Only** select variable entries,
- Define new text file, with the **correct** filepath:

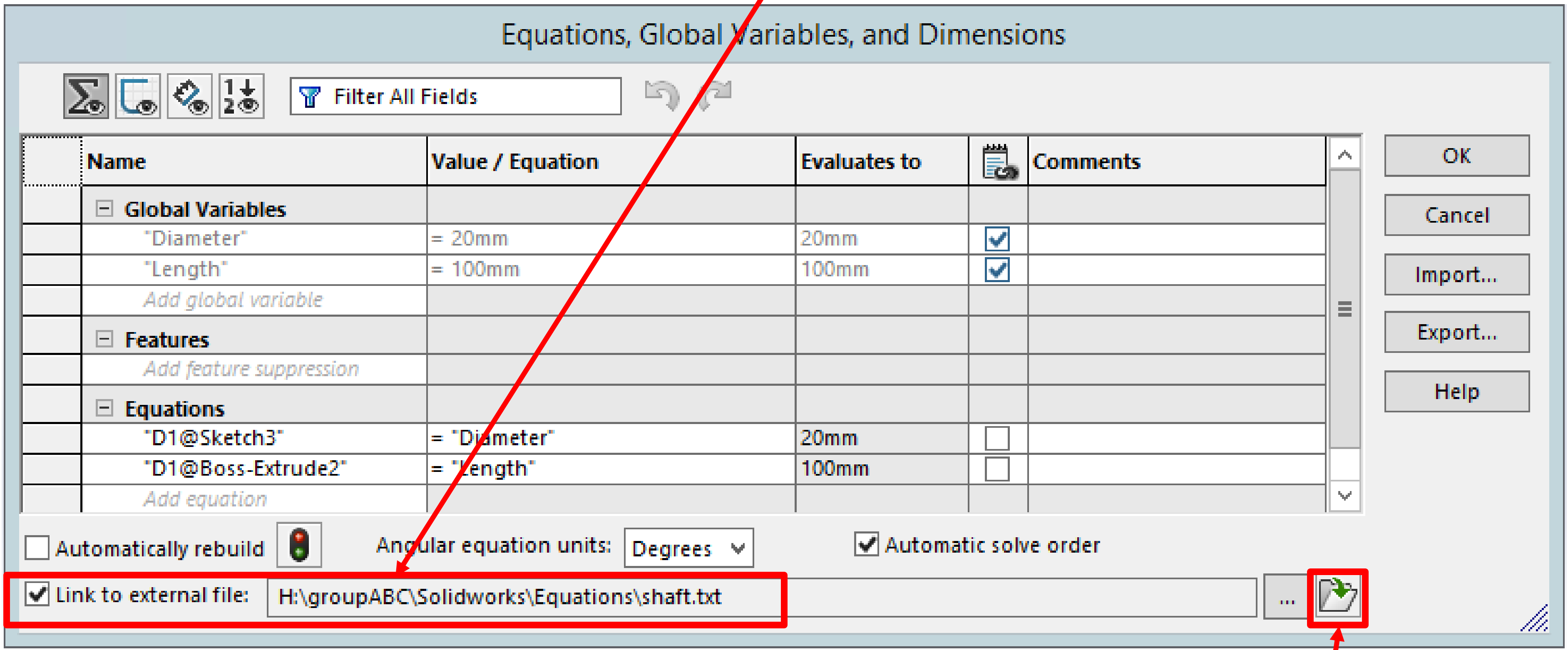



<DIRECT-PREFIX>\groupABC\Solidworks\Equations\shaft.txt

- Hit 'Link' Button. Should now have new file in folder.

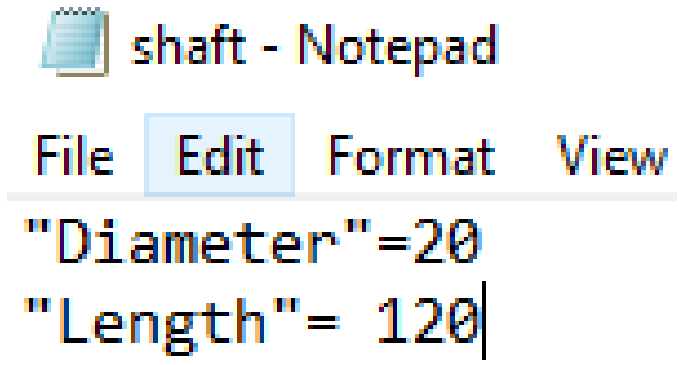
# Step 4: Linking variables to text file

Checkbox filled and the file path included if all is good.



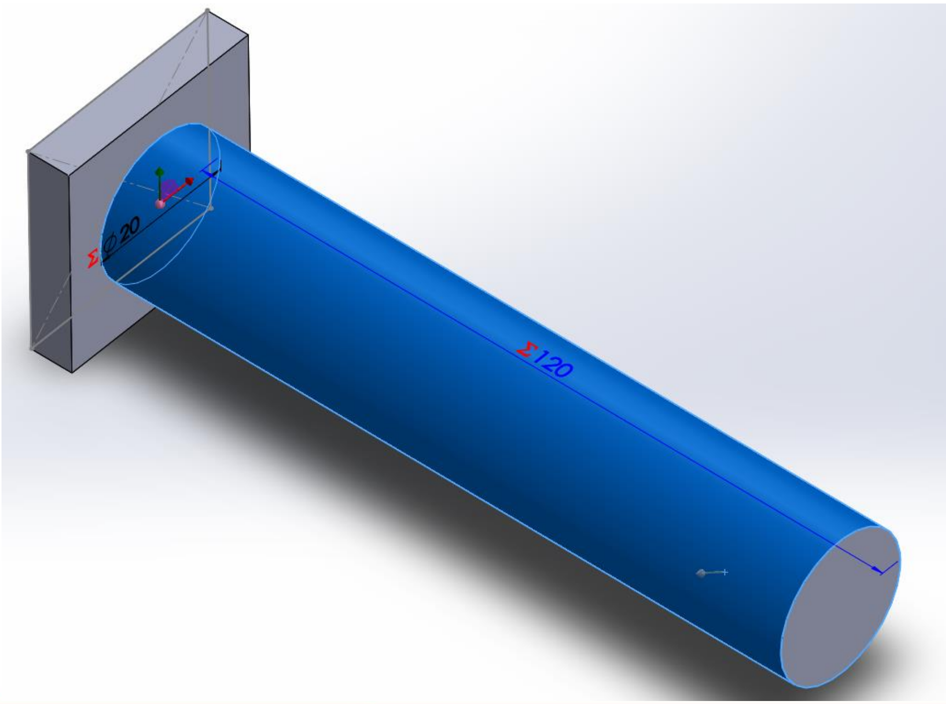

Next, click this to open linked text file, or open it directly from shared local drive.

# Step 5: Change text file, rebuild part




- Change dimension values,
- Keep identical format, change **only** numerical values.
- Save the text file,

- Rebuild Solidworks part...




…hopefully…

…it has changed!

# Code expectations

**IMPORTANT:** Include Code comments with MATLAB code

In MCG4322A:

- All code has to be done with MATLAB, no Octave, Python, etc.
- Code comments are required, keep clear and concise.
- Informs reviewers (e.g. the course instructor, T.A.s) on the purpose of the code.
- Assist with the debugging process, by clearly describing the intended purpose of code.

# MATLAB GUI Template

The template's MATLAB folder consist of two files:

1. MAIN.mlapp

   - Graphic User Interface (GUI) template,
   - uses MATLAB's built-in 'App Designer' tool,
   - passes user selected parameters to Design_code.m,
   - displays log file generated by Design_code.m ,

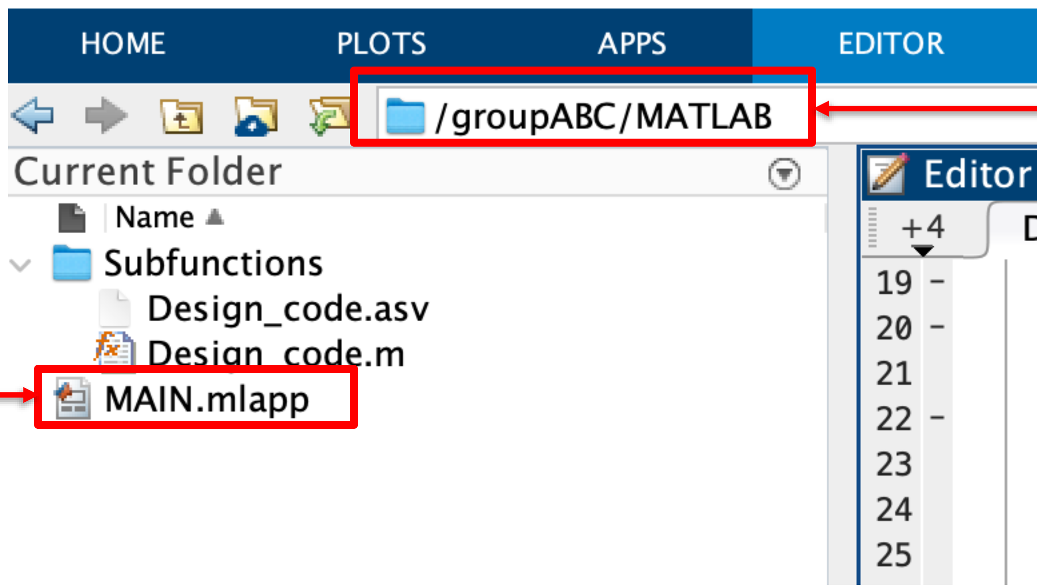
   https://www.mathworks.com/help/matlab/app-designer.html

2. Subfunctions folder

   - Contains Design_code.m, (and other files you may add),
   - Design code is where ALL the analysis equations, functions, and optimization algorithms are programmed.

# Step 6: MATLAB file navigation

1. In current directory field, input project MATLAB folder directory, ...\groupABC\MATLAB,
2. Current folder pane shows file structure.
3. Open MAIN.mlapp



# Step 7: App Designer – design interface

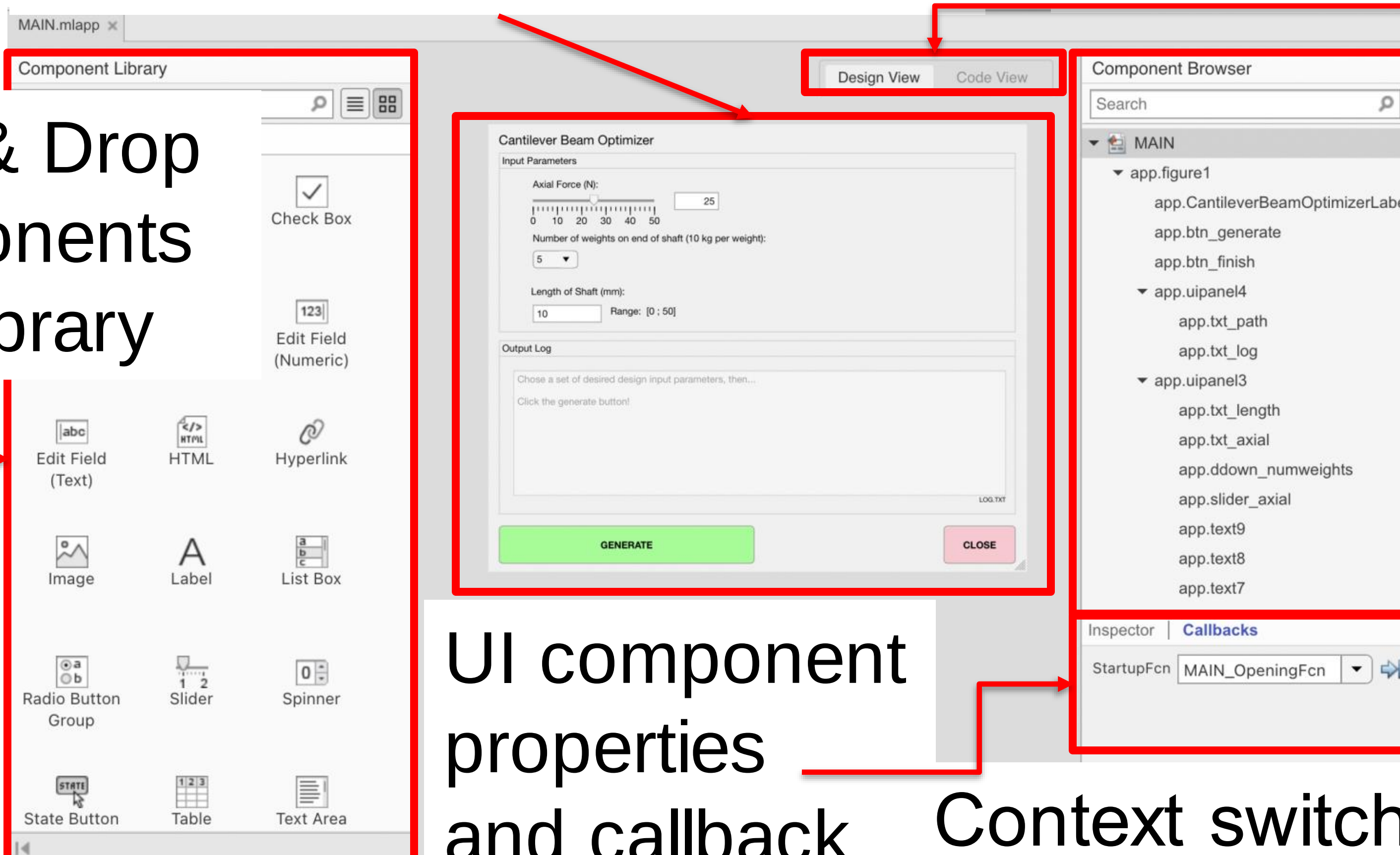
Dynamic selection of UI elements to be modified

UI component browser tree

Drag & Drop components from library

UI component properties and callback functions

Context switcher … select ‘Code View’



# Step 8: App Designer – code interface

Code that GUI uses


Left side now shows 'Code Browser',

- auto generated by added UI callbacks,
- right click -> delete to remove callback functions

# Step 9: Translate GUI inputs to code

Template GUI has 3 input elements corresponding to three parameters.

*1. Slider*

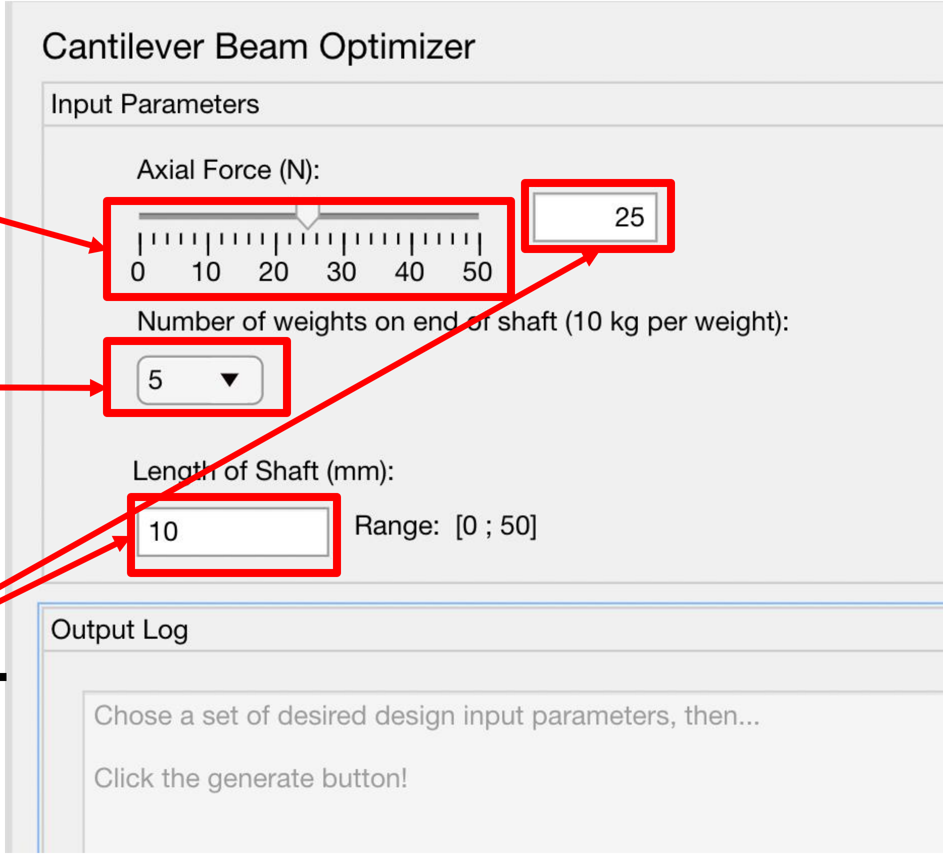
Takes the axial force acting on cantilever beam.

*2. Drop down list*

Selection from a range of possible number of weights hanging on the end of beam.

*3. Edit text field*

Reads the value input into the text box for shaft length.



# Step 9: Translate GUI inputs to code

Specific examples of code in MAIN.mlapp

- Lines 109-113, we define variables for each input by reading values from GUI

```
axial_force = app.slider_axial.Value;
```

- Line 117, we call the Design_code subfunction, passing our inputs as *arguments*.

```
Design_code(axial_force, num_weights,
shaft_length)
```

- Lines 122-130, we display output of log file.

```
log_contents = char(fread(fid)');
```

# Step 10: Analysis and design code

1. Open the **Design_code.m** file,
2. Line 1, function definition. Arguments: only sequence and data types matter.

```
function Design_code(axial_force,
   number_of_weights, shaft_length)
```

3. Line 16, call the shaft optimization subfunction
4. This function *returns* an output, the optimized shaft diameter,

Study the optimization algorithm example at the end of the file in the subfunction definition.

# Step 10: Analysis and design code

Design_code.m represents an example for a **single** analysis calculation set.

You will use **many separate files,** with each corresponding to each set of analysis calculations from your analysis report.

In other words, many design code subfunctions.

This approach ensures that your analysis calculations are easy to review independently.

# Step 11: Modify text files with MATLAB

We use MATLAB built-in text editing functions to write to the equation and log text files.

- Directories are hard-coded, so if you change them you need to update code accordingly,
- Text output from MATLAB code **must have the same format** as the original SW's equation file,
- Common errors: Changing character spacing, incorrect variable names, changing line order/spacing, missing variables,

Verify! When MATLAB changes equation file, check that Solidworks rebuilds properly for all scenarios.

# Step 11: Modify text files with MATLAB

How to access text files with MATLAB code:

1. Save directory prefix (Required only once per function)

```
directory_prefix_string = extractBefore(pwd,
                                          "groupABC");
```

2. Define the filepath of text file to be modified, save into string variable:

```
your_file =
     strcat(directory_prefix_string,'\groupABC\
FOLDER\YOURFILE.TXT');
```

3. Use string variable to open text file for writing:

```
    fid = fopen(your_file, 'w+t');
```

# Step 11: Modify text files with MATLAB

How to write to text files with MATLAB code:

4. Use *fprintf()* *to write* to the text file:

```
fprintf(fid,strcat('Your text goes here', …
                                             num2str(x), '\n'));
```

- *strcat* combine multiple strings and variables into a single string
- https://www.mathworks.com/help/matlab/ref/fprintf.html

5. When done writing to file, terminate the filestream:

```
fclose(fid);
```

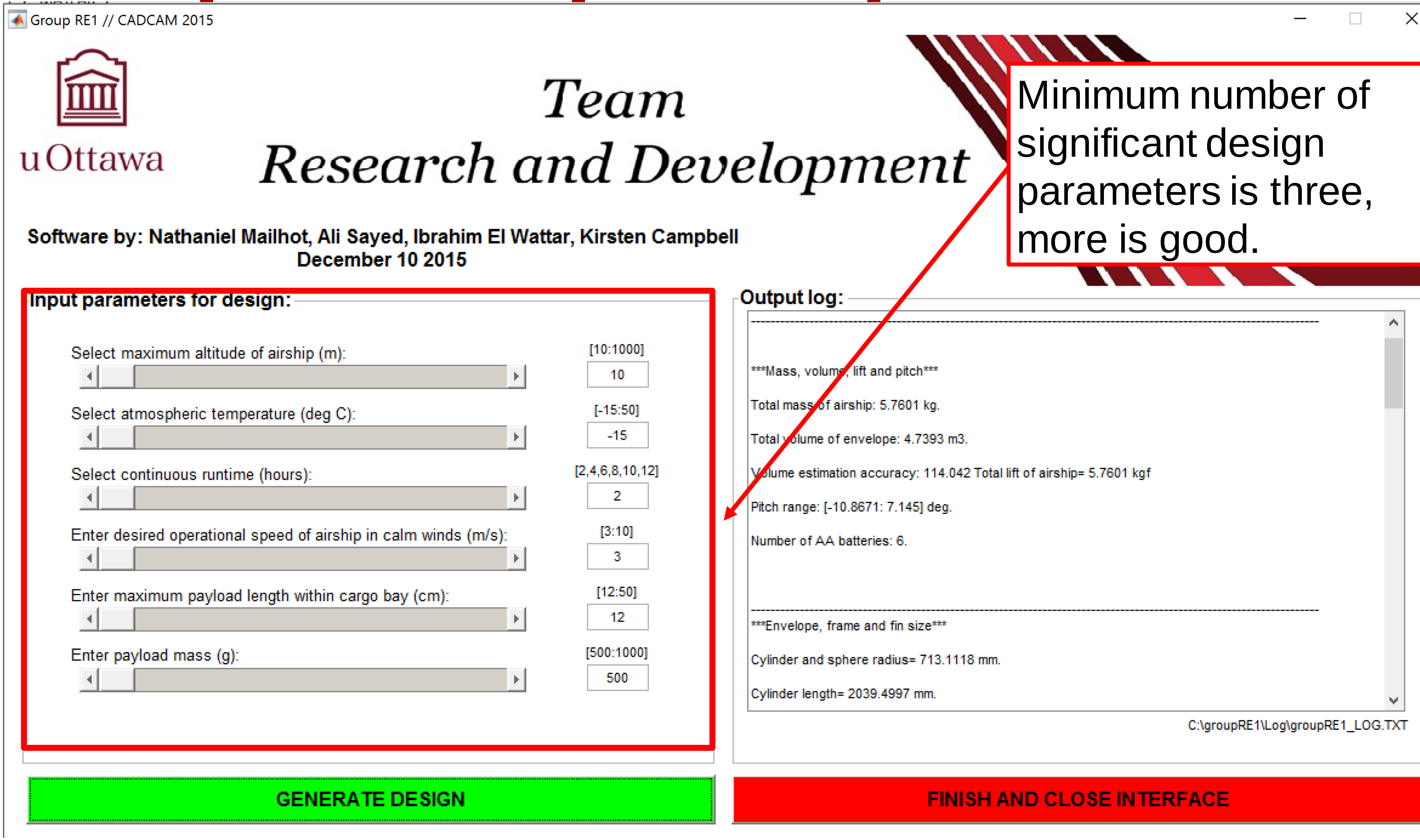
# Step 12: Log text file for results output

The output log file is where you display all results. The log text file is your responsibility to format. Make sure that it is:

- clear and human-readable,
- input parameters selected by user are displayed first,
- displays full set of calculated outputs, including values that do not reflect as Solidworks model changes.

Be creative and optimize for at-a-glance information!

# Example of Completed Optimization GUI




Minimum number of significant design parameters is three, more is good.

# Debugging MATLAB

Brief, live example of debugging with MATLAB.

- Play
- Console input, output and workspace context
- Step
- Continue
- End

Documentation (extremely useful to save you time!)

https://www.mathworks.com/help/matlab/matlab_prog/debugging-process-and-features.html

https://www.mathworks.com/help/matlab/matlab_prog/set-breakpoints.html

https://www.mathworks.com/help/matlab/matlab_prog/examine-values.html