# Inventor Nastran - Hands on Simulation Tips and Tricks

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# This Class is for…


Users just starting out in Life (Simulation!)


I hope experts may pick up one or two tips.

# The goal of this lab is…

Results are not as I expected

Which analysis results do I use for my design

Why do I need to run more than one analysis

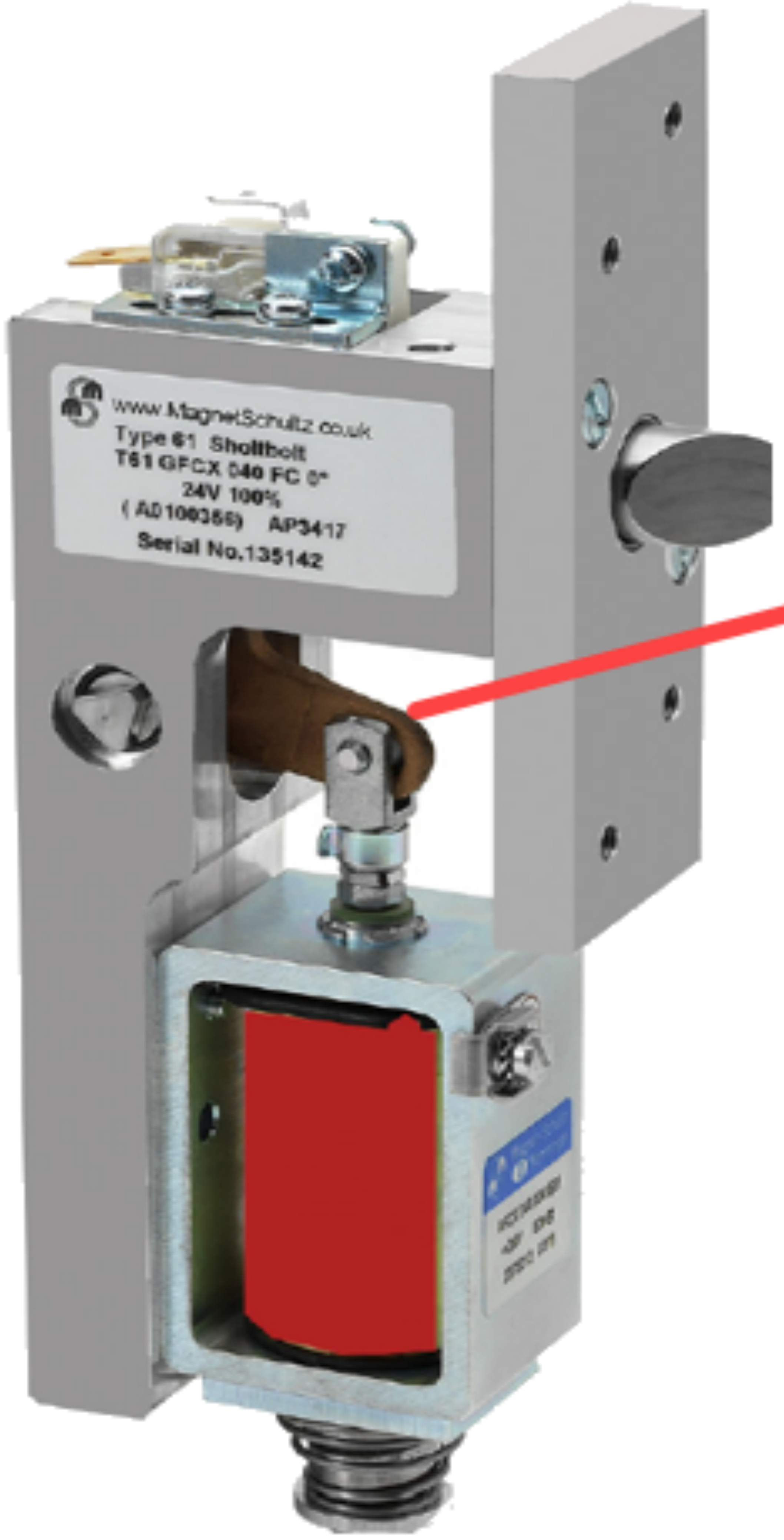
What mesh size do I use

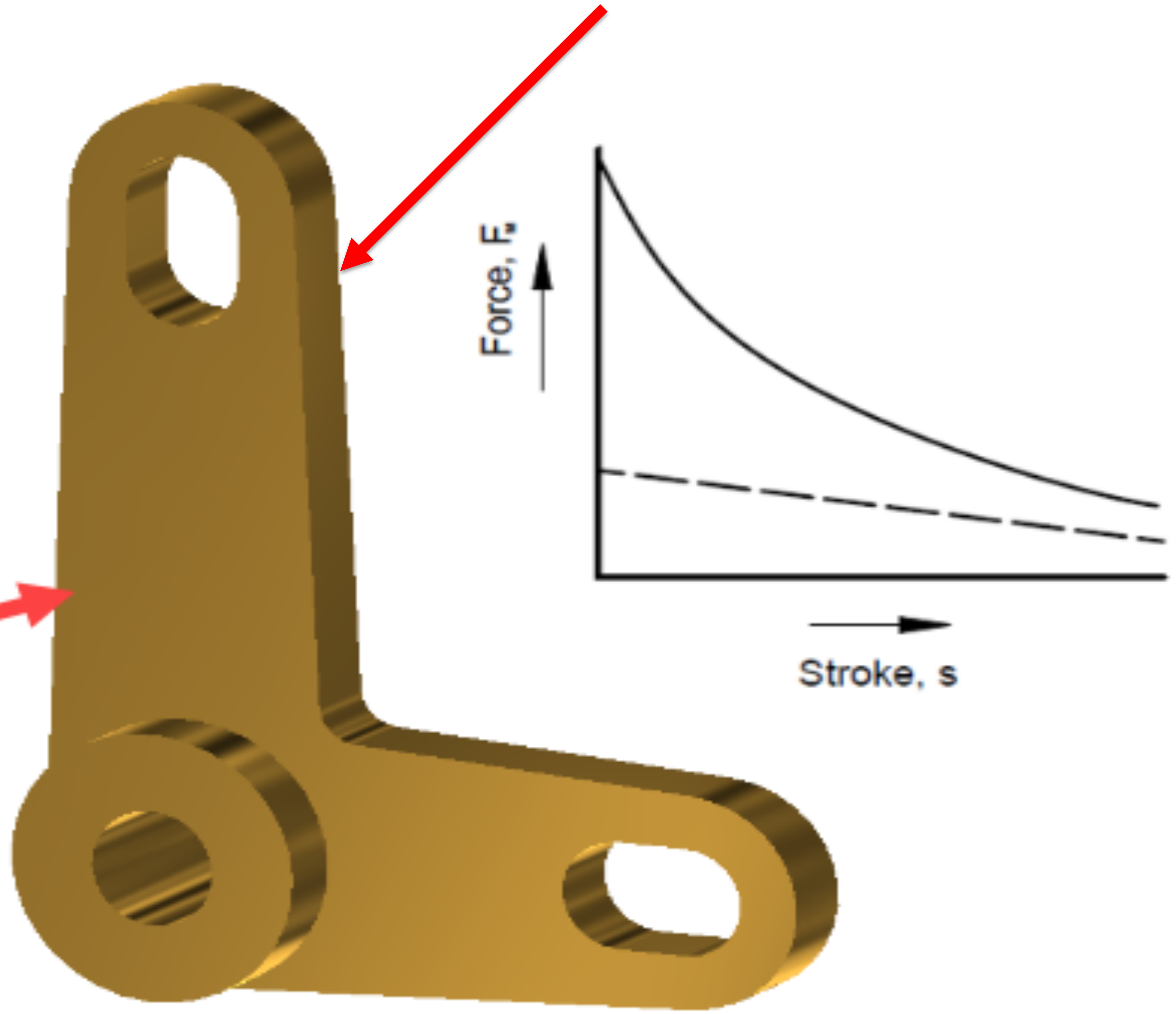
To help increase your confidence in using Simulation

Create great products

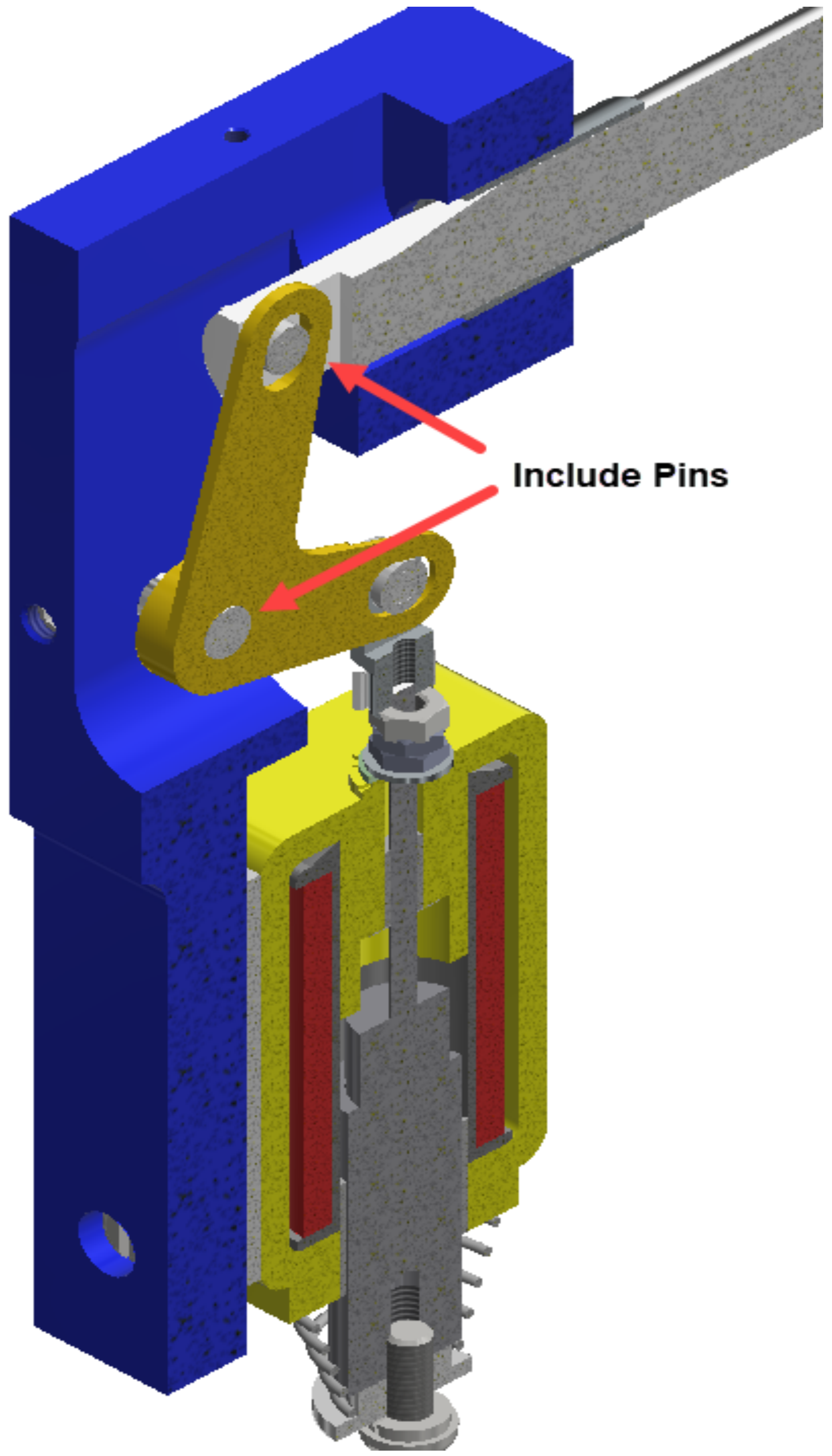
Avoid Over-engineering

# Design Problem… Analyse the lever




| Type 60, 61 | | | |
|---|---|---|---|
| Operating mode - Duty Rating ED | | S1 100% | |
| Stroke s (mm) | | Magnetic force $F_M$ (N) | Spring return-force (N) |
| | 0 | 30 | 9 |
| | 15 | 3.3 | 2.8 |
| Rated Power $P_{20}$ | (W) | 14 | |
| Weight | (kg) | 1 | |
| Radial bolt load, max allowable | (N) | 3000* | |

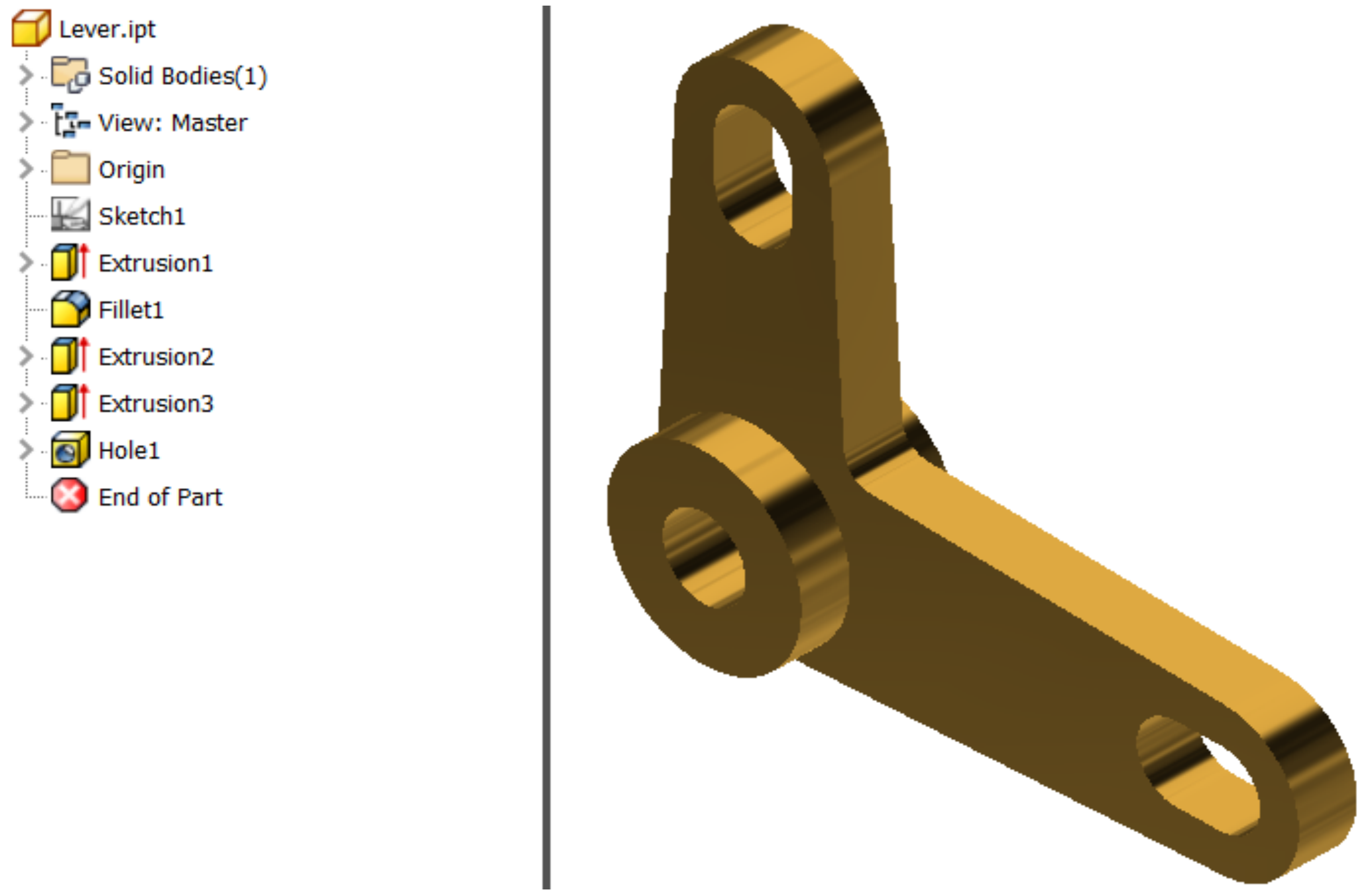



Single Part or Assembly

# Part or Assembly ?

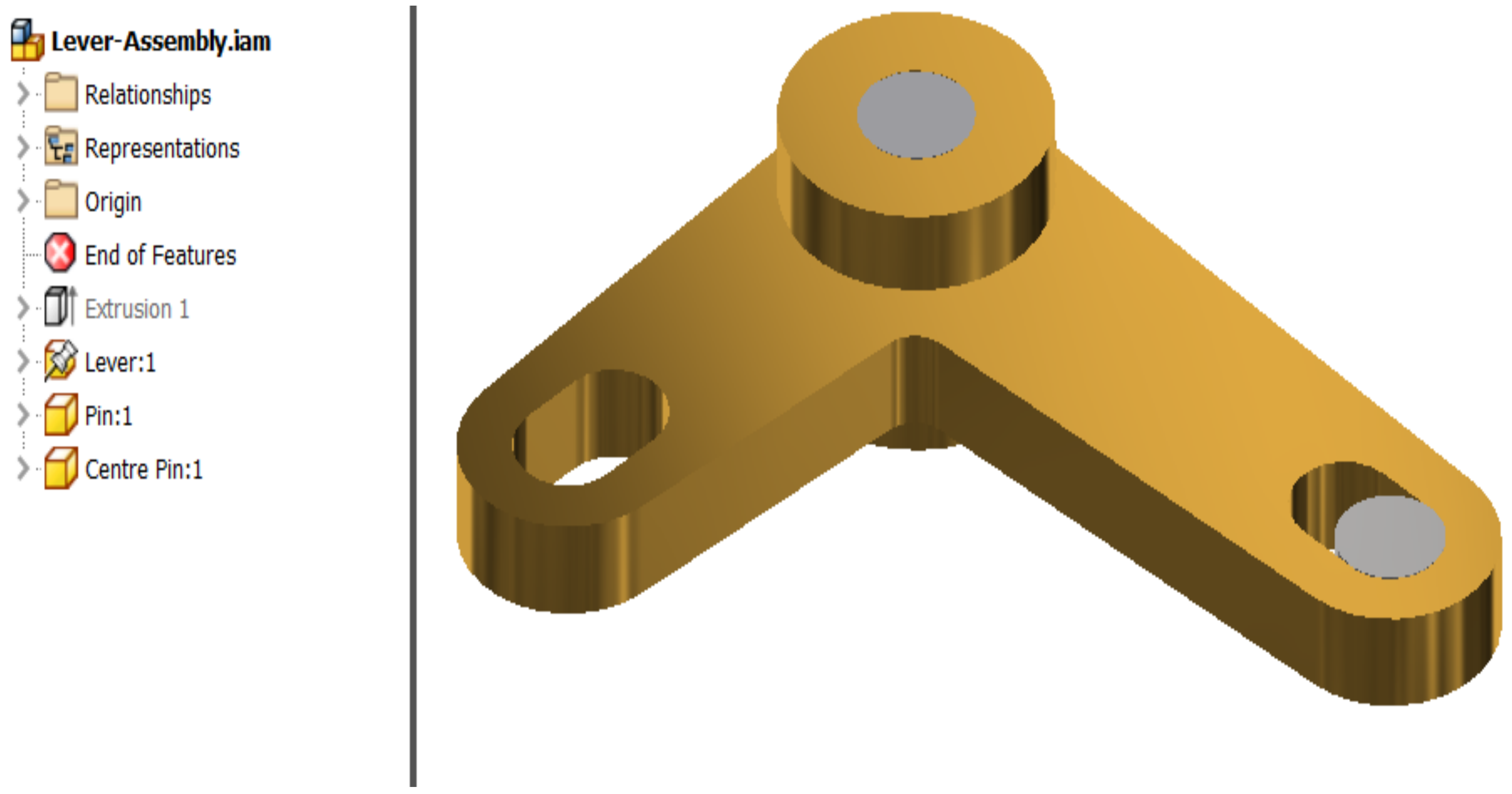
**Pro**
Easier setup
Less Elements
No contacts

**Cons**
Over stiffness




**Pro**
Better Pin/Lever behaviour

**Cons**
Longer runtimes

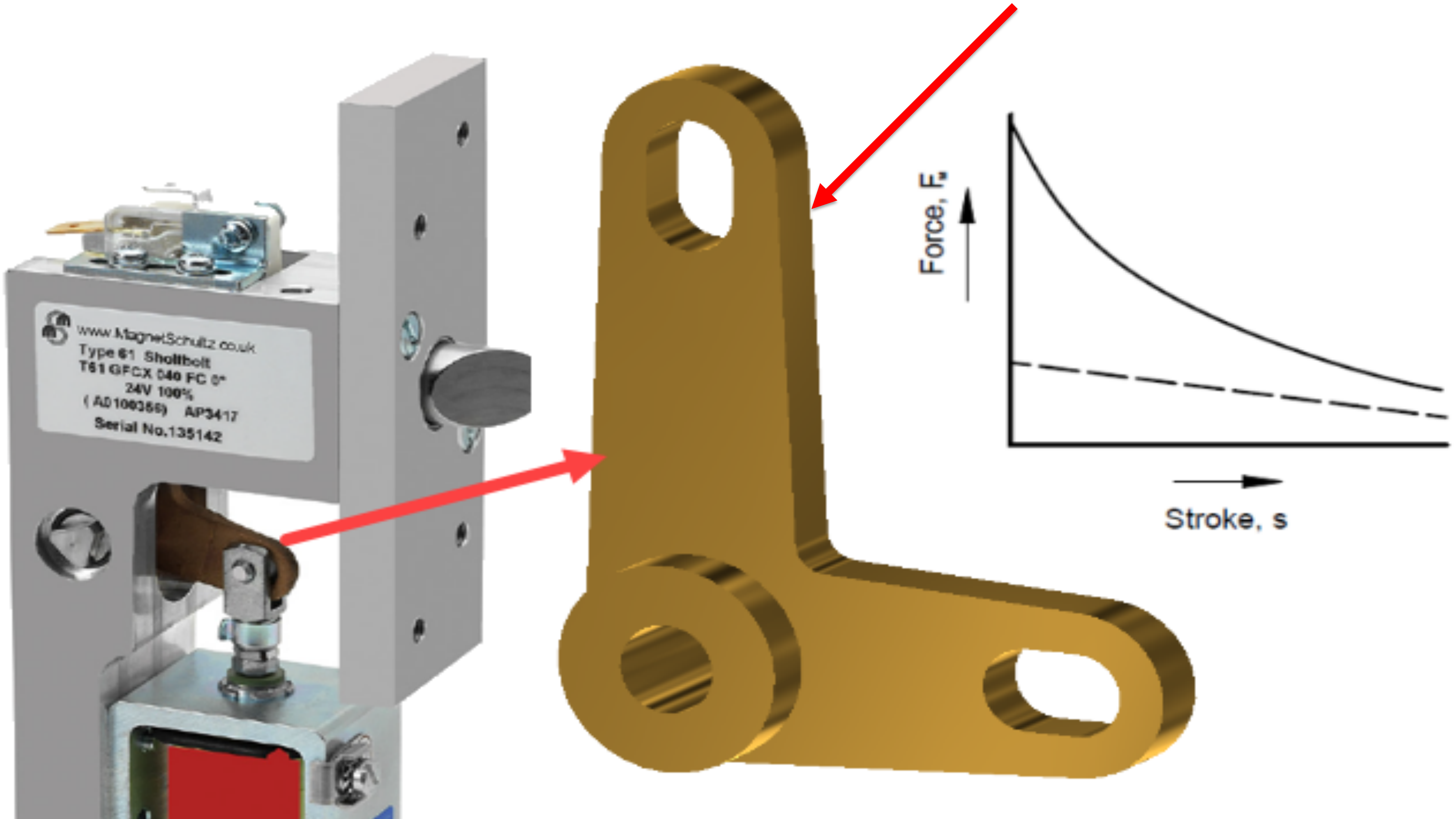


# The Big Myth

<u>Question</u>

…. How do I know my results are correct?

# Exercise 1 – Part Analysis

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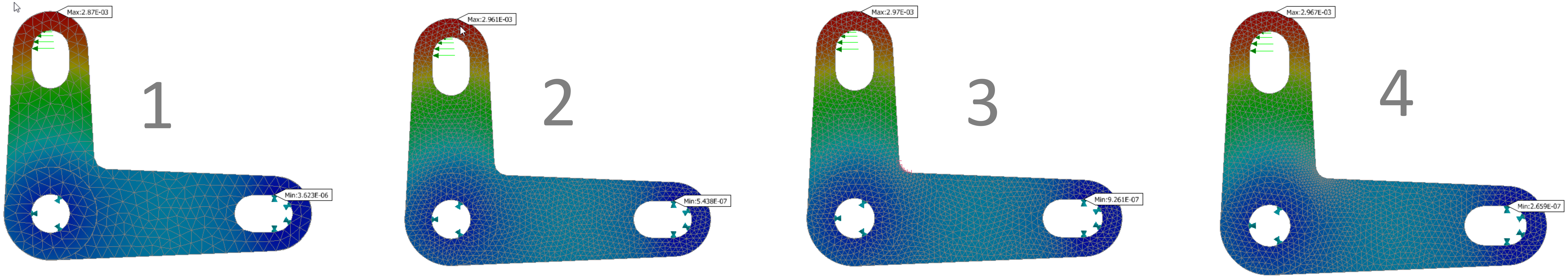
| | 0 | 30 | 9 |
| | 15 | 3.3 | 2.8 |
| Rated Power $P_{20}$ | (W) | 14 | |
| Weight | (kg) | 1 | |
| Radial bolt load, max allowable | (N) | 3000* | |

# Hands on Session 1 – Lets Start

# Exercise 1 – Displacement Results




0.00287mm

0.00296mm

0.00297mm

0.002967mm

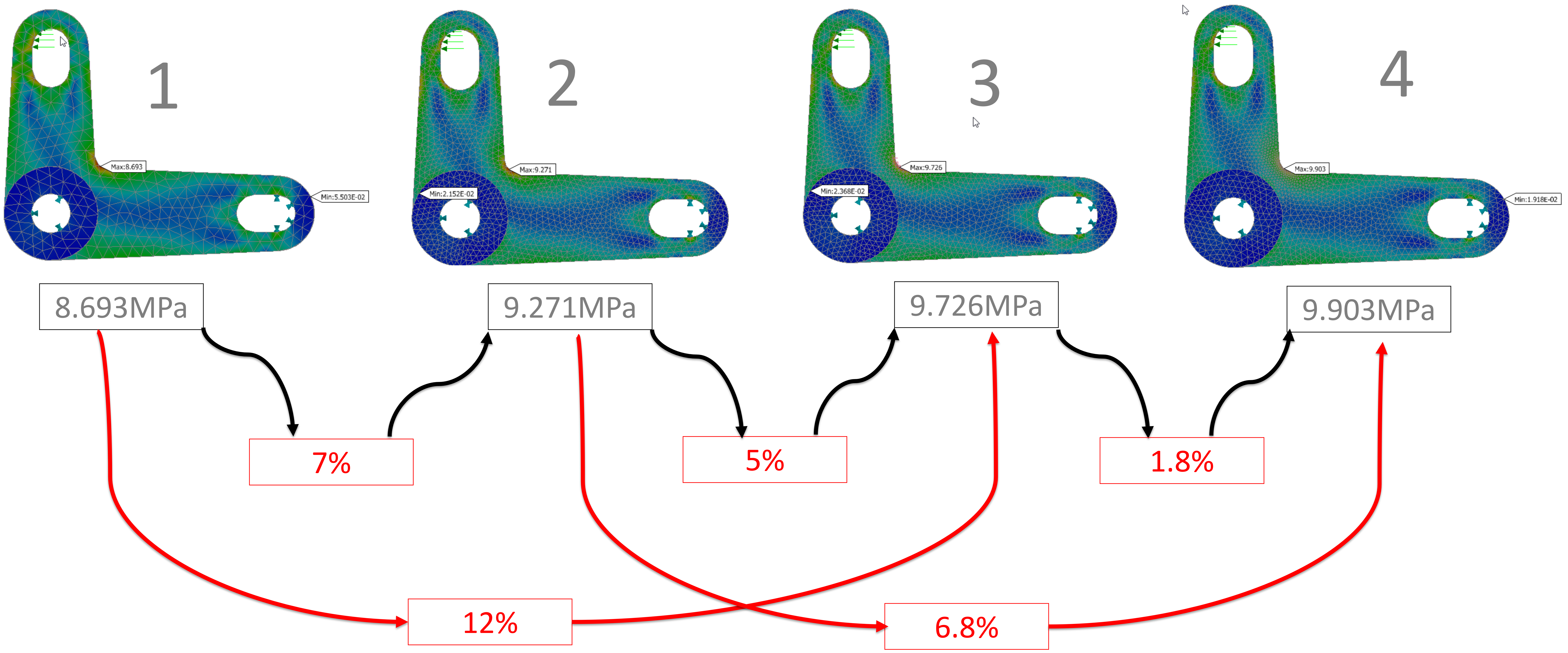
3%

0%

0%

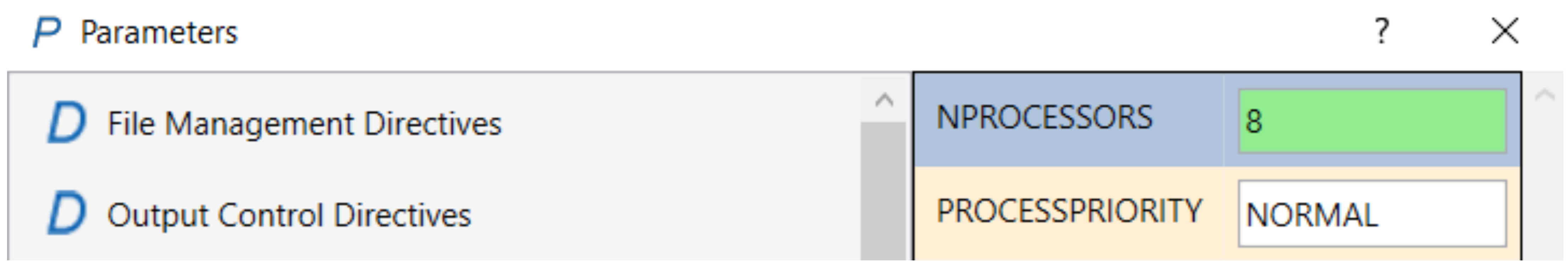
3.5%

# Exercise 1 – Stress Results Convergence

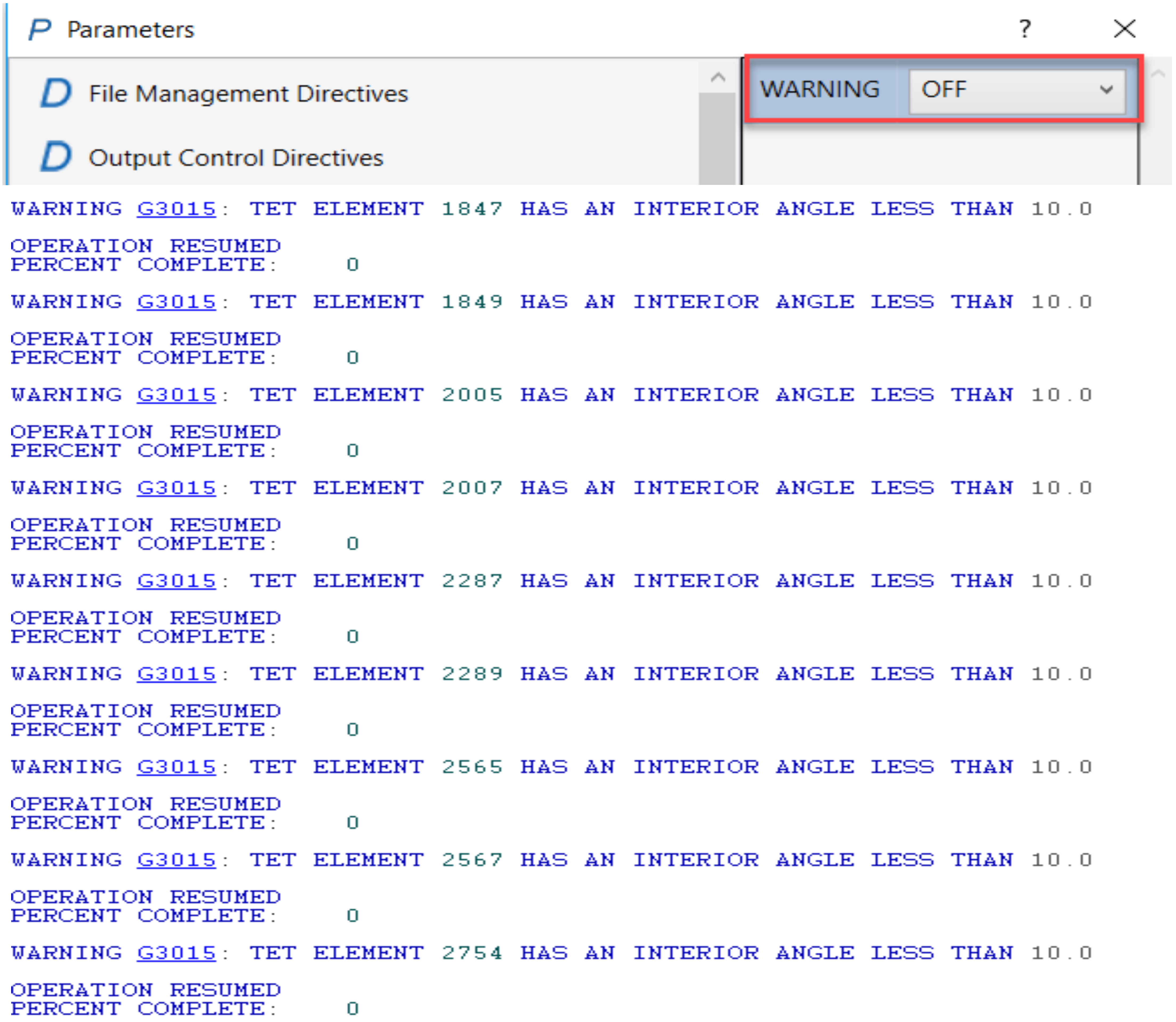


# Exercise 1 – Parameters

## NPROCESSORS



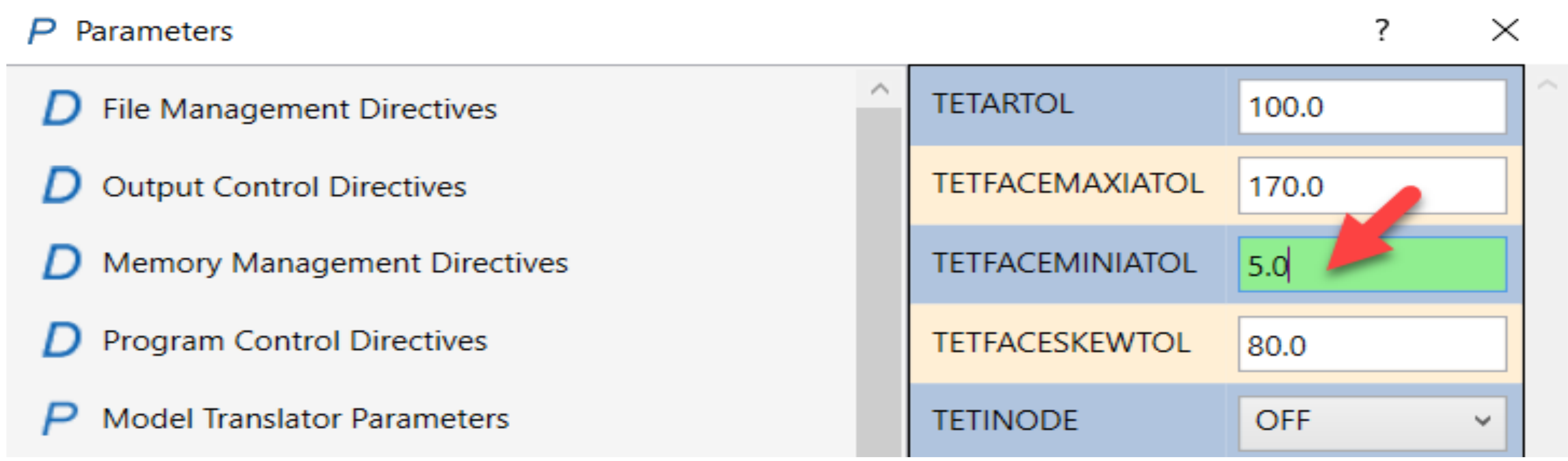

## WARNING



# Exercise 1 – Parameters

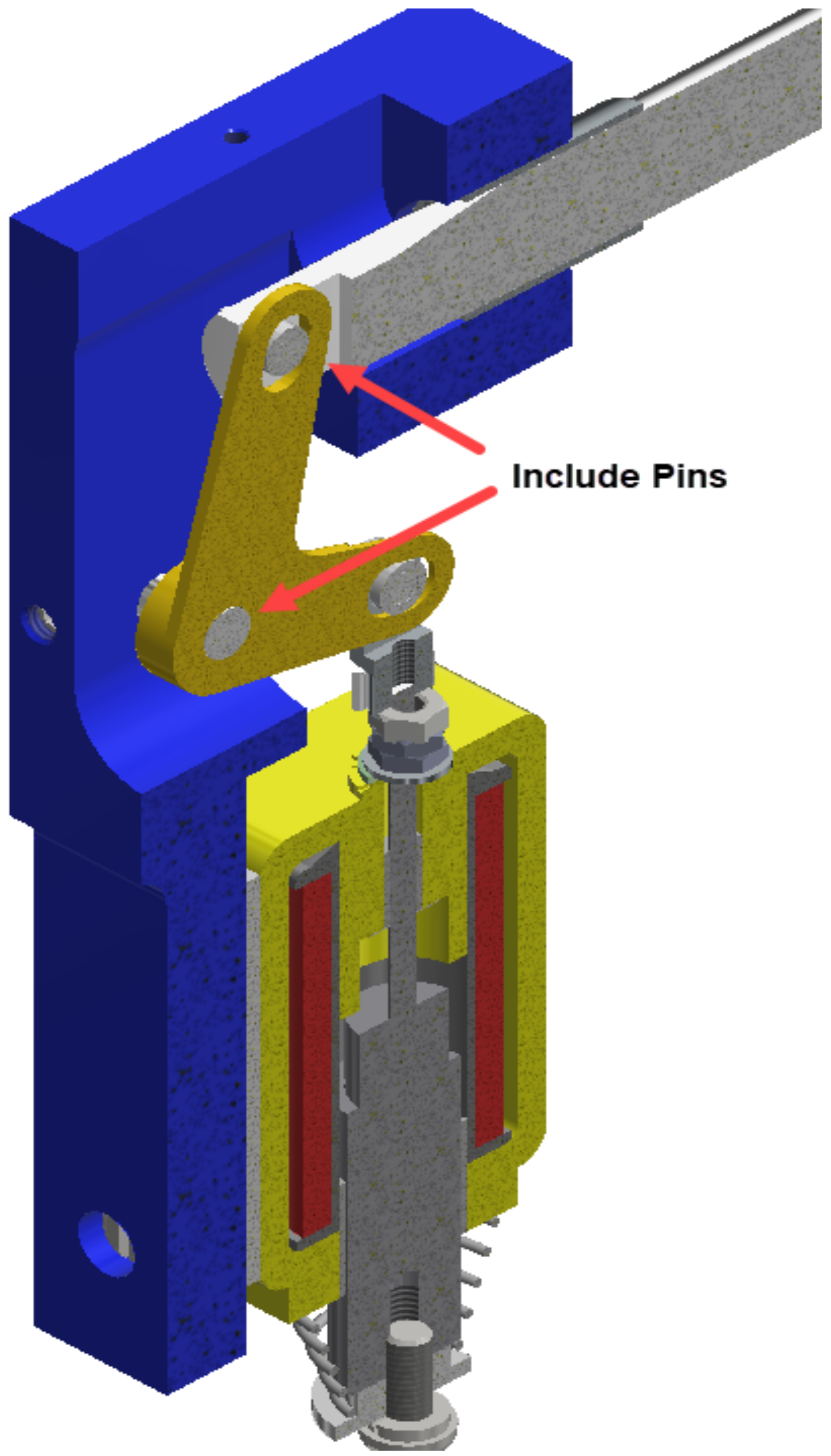
TETFACEMINIATOL

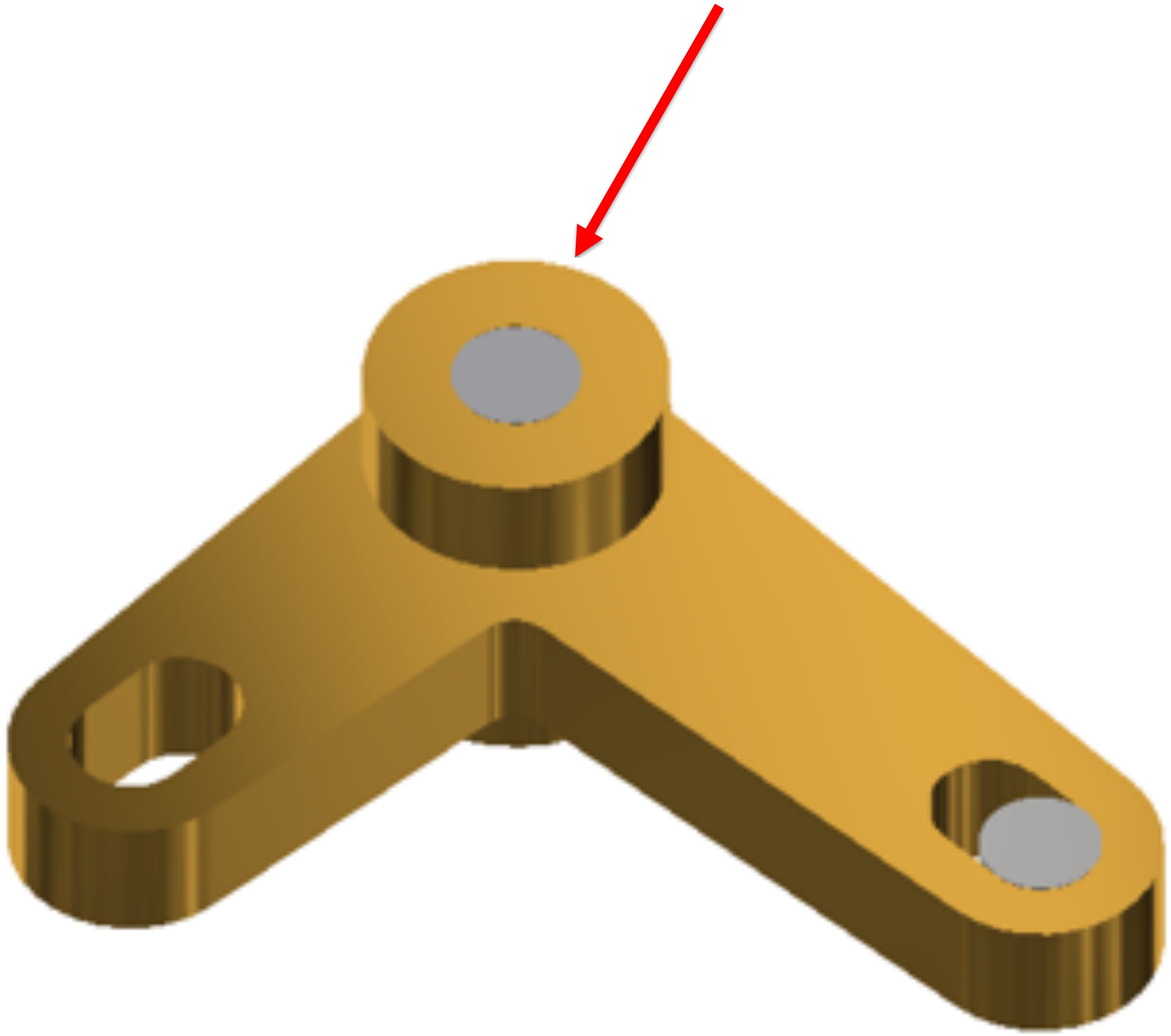
```
GENERATING RESULTS NEUTRAL FILE
PERCENT COMPLETE:   100

DELETING FILE:   dfdbybvw4.ECD

MODEL ANALYSIS TIME SUMMARY

TOTAL CPU TIME = 12.7 SECONDS
WALLCLOCK TIME = 12.9 SECONDS

EXECUTION TERMINATED NORMALLY

TOTAL WARNINGS      = 26
TOTAL FATAL ERRORS  = 0
```




```
DELETING FILE:   dfdbybvw4.NDB

GENERATING RESULTS NEUTRAL FILE
PERCENT COMPLETE:   100

DELETING FILE:   dfdbybvw4.ECD

MODEL ANALYSIS TIME SUMMARY

TOTAL CPU TIME = 13.8 SECONDS
WALLCLOCK TIME = 14.1 SECONDS

EXECUTION TERMINATED NORMALLY

TOTAL WARNINGS      = 0
TOTAL FATAL ERRORS  = 0
```

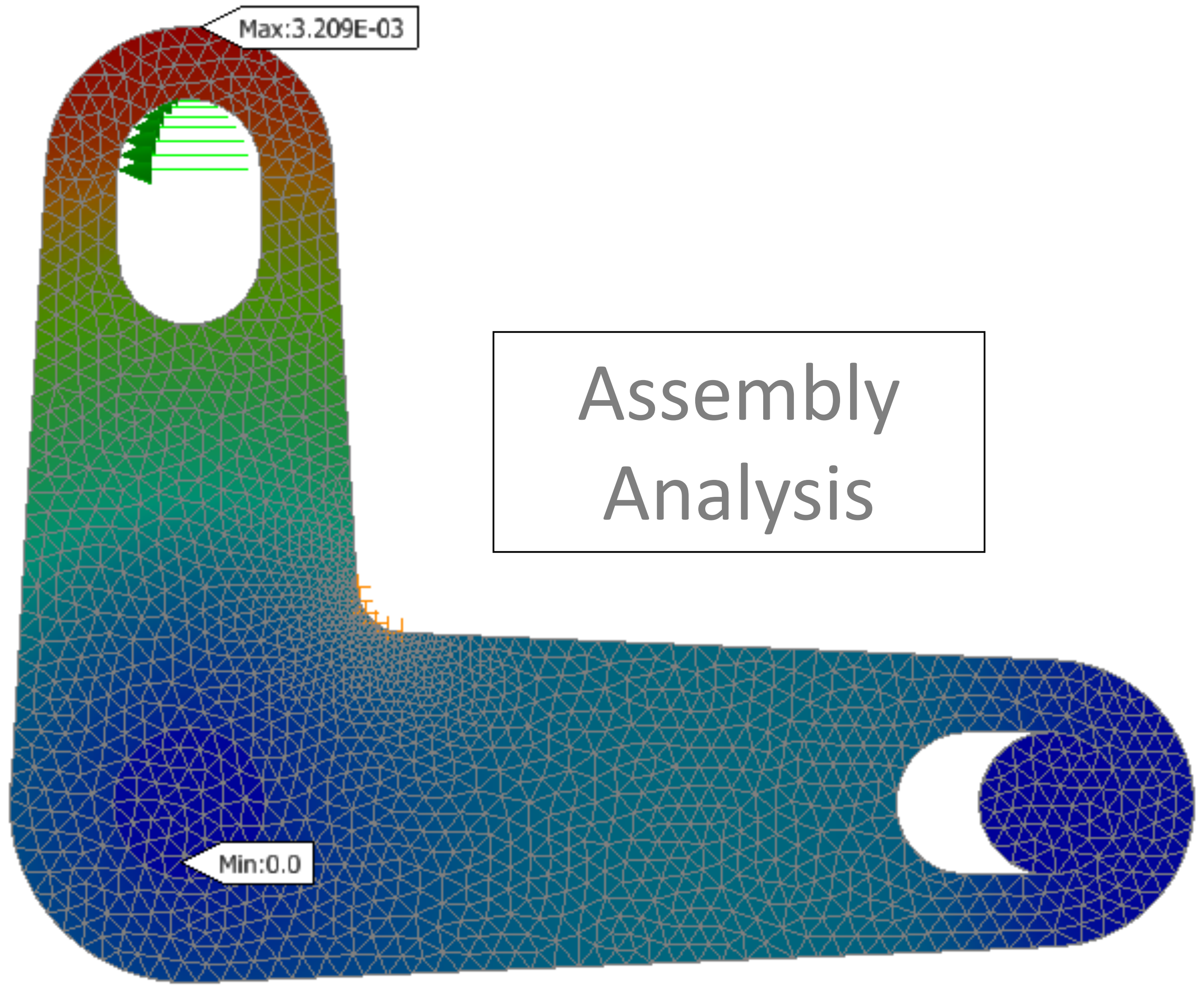
# Exercise 2 – Assembly Analysis



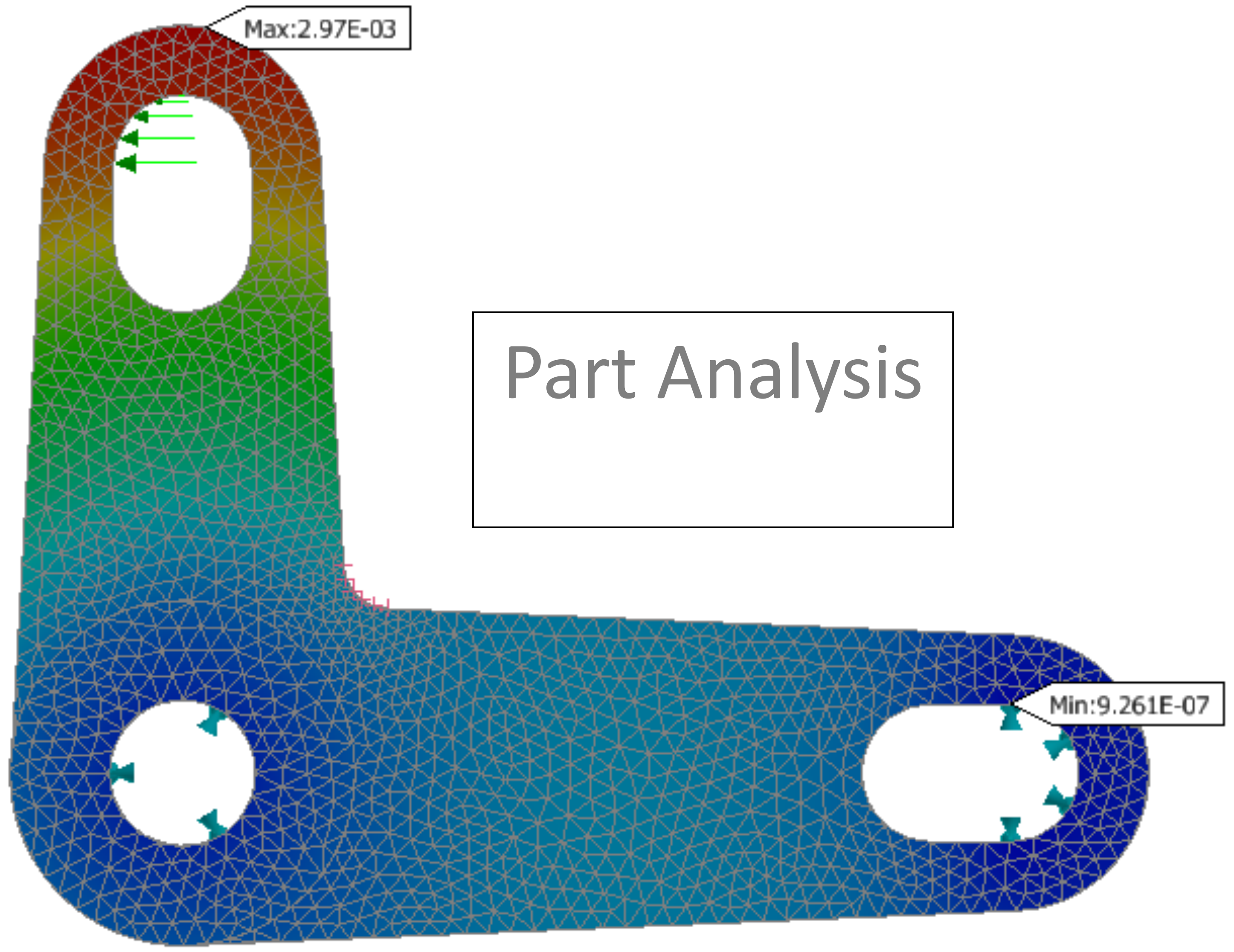



# Hands on Session 2 – Lets Continue

# Exercise 2 – Displacement Results




Assembly Analysis



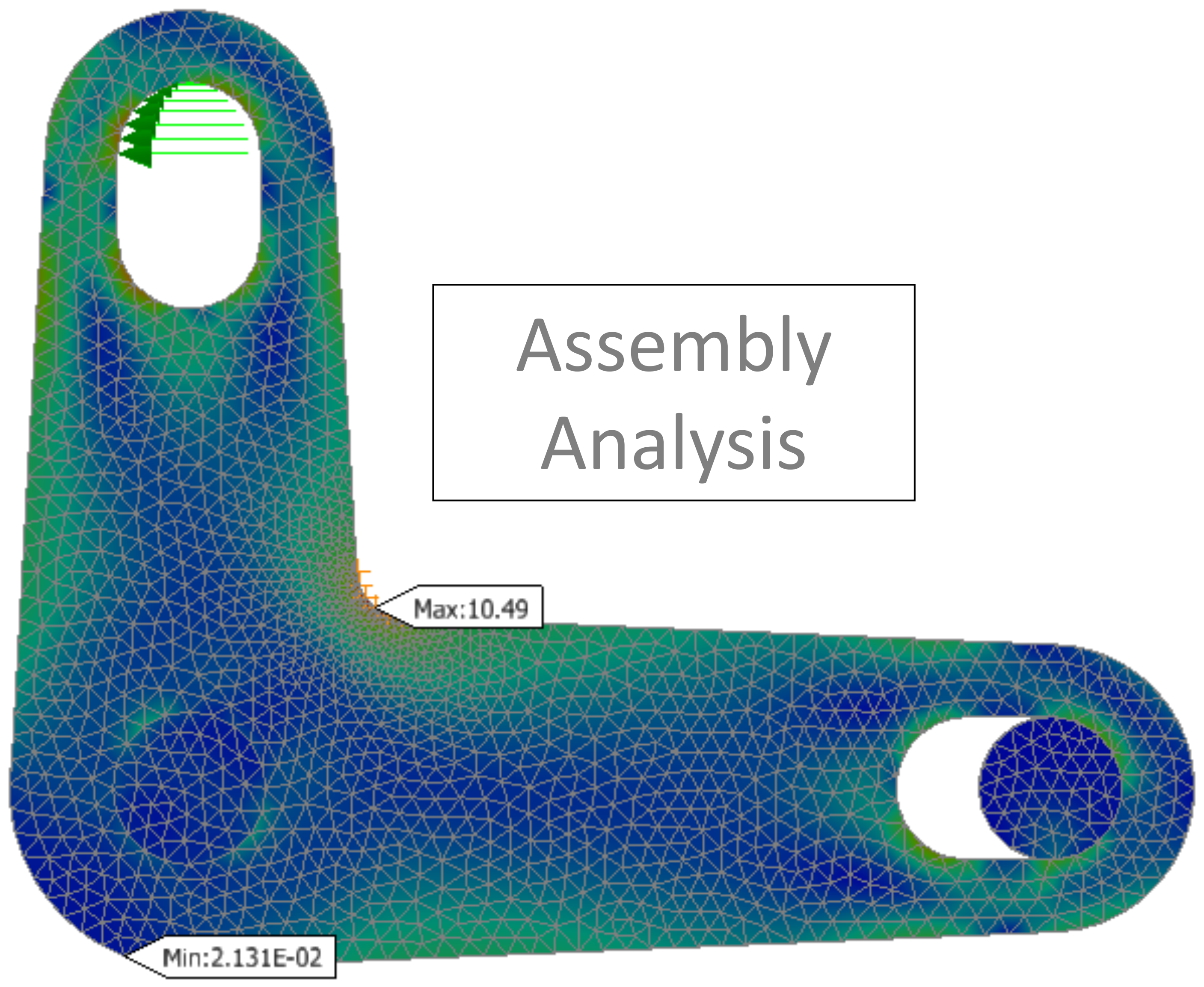

Part Analysis

0.0032mm

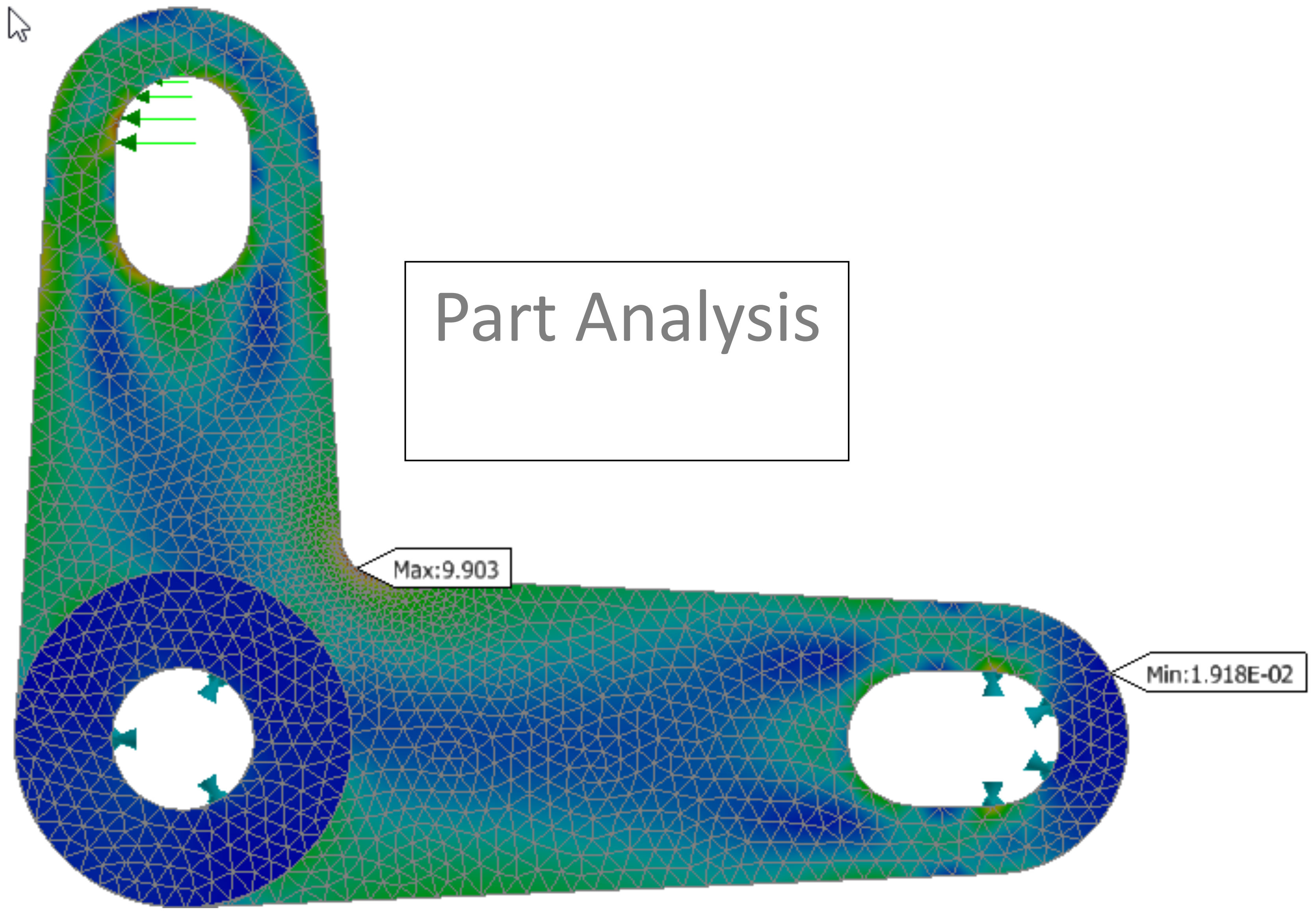
0.00297mm

8%

# Exercise 2 – Stress Results Comparison




Assembly Analysis



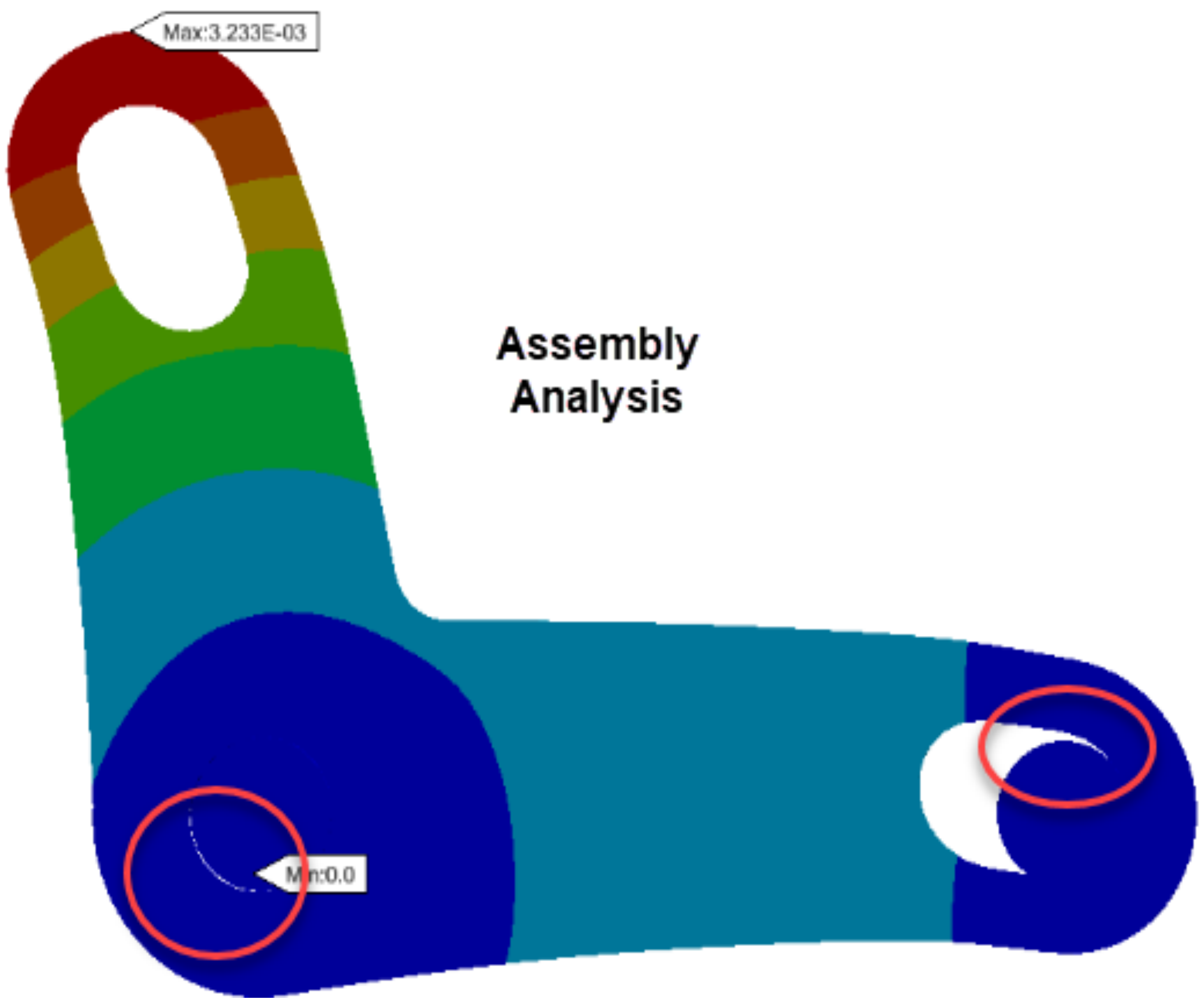

Part Analysis

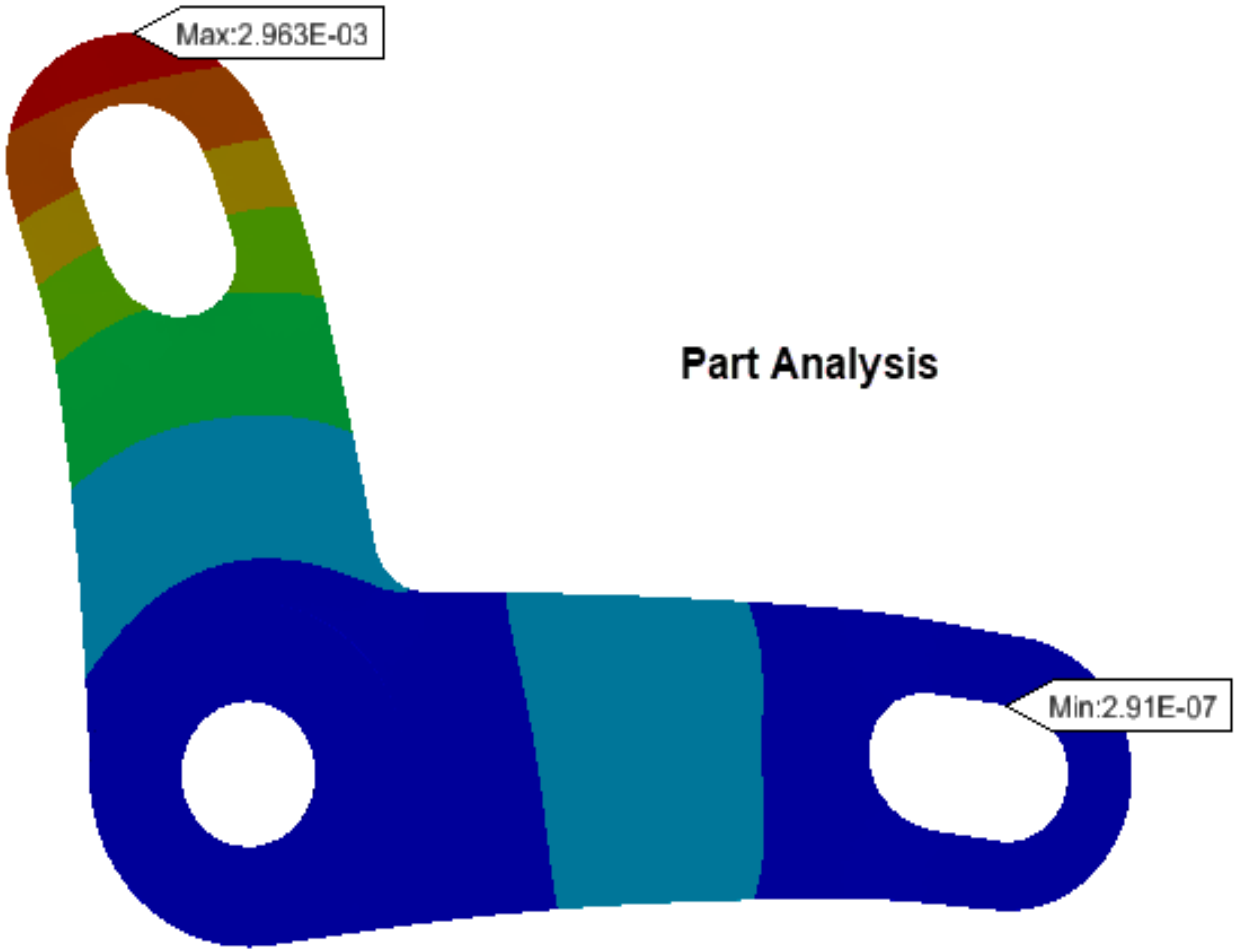
10.49MPa

9.903MPa

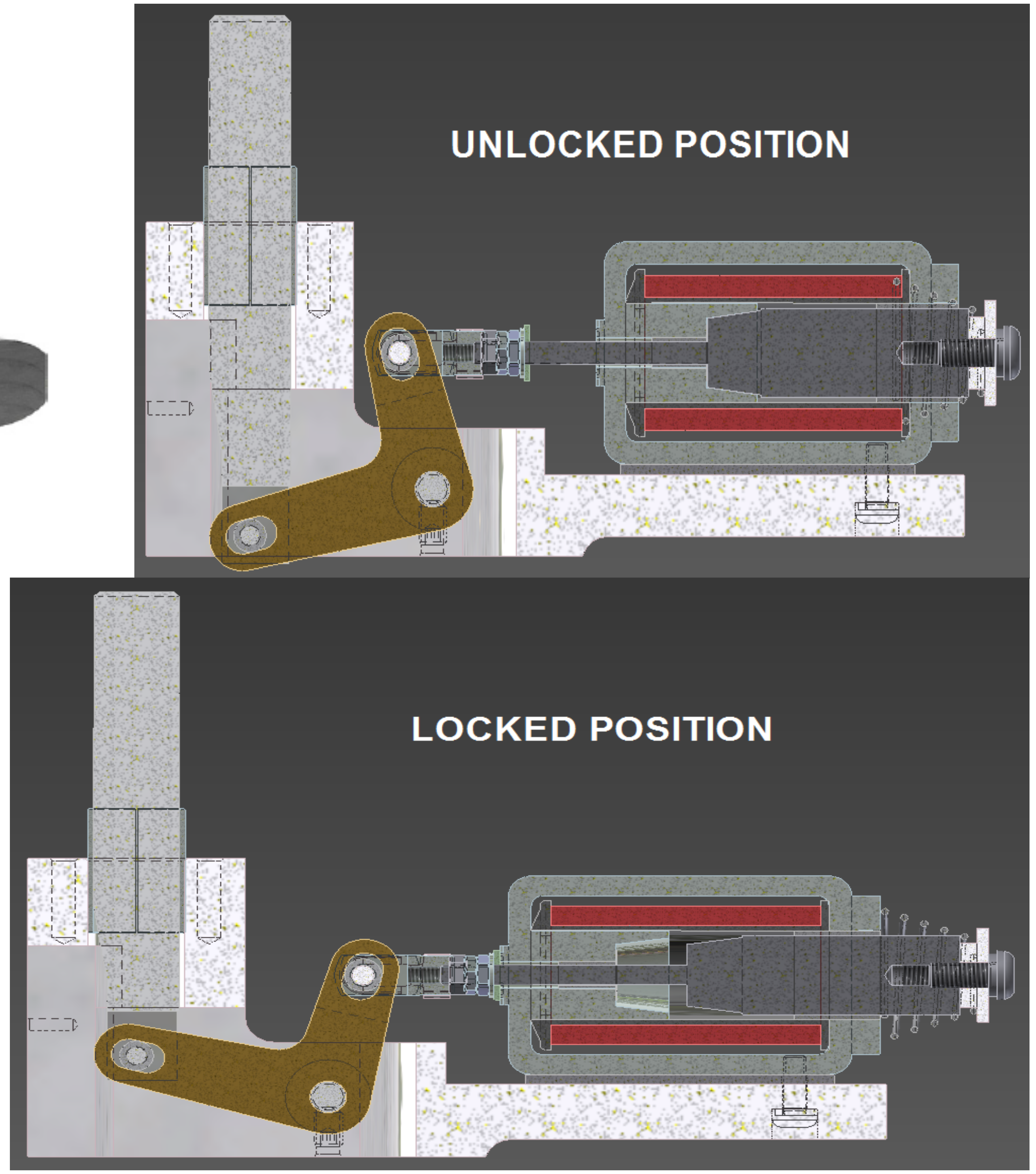
5.9%

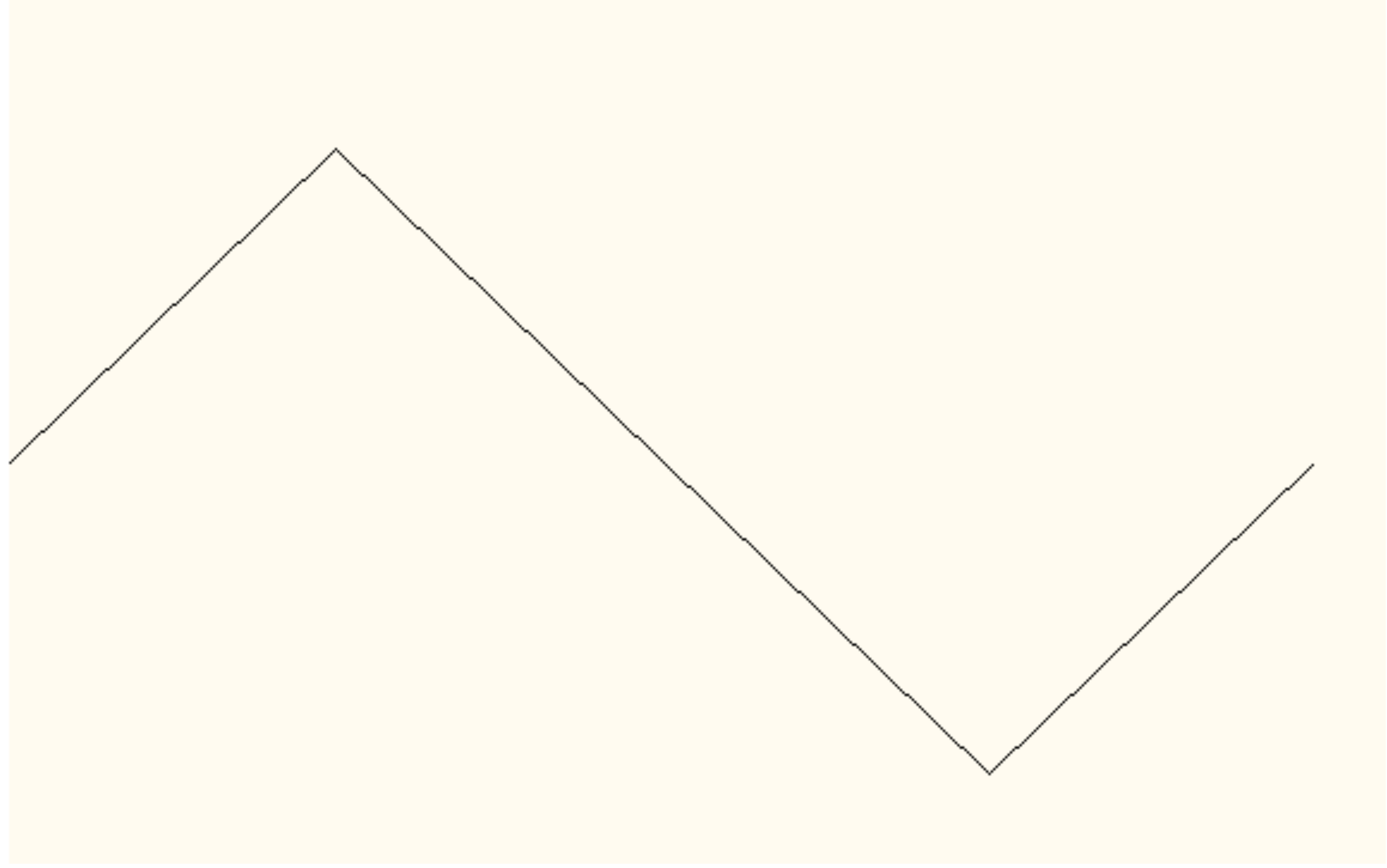
# Exercise 2 – Why is there a difference



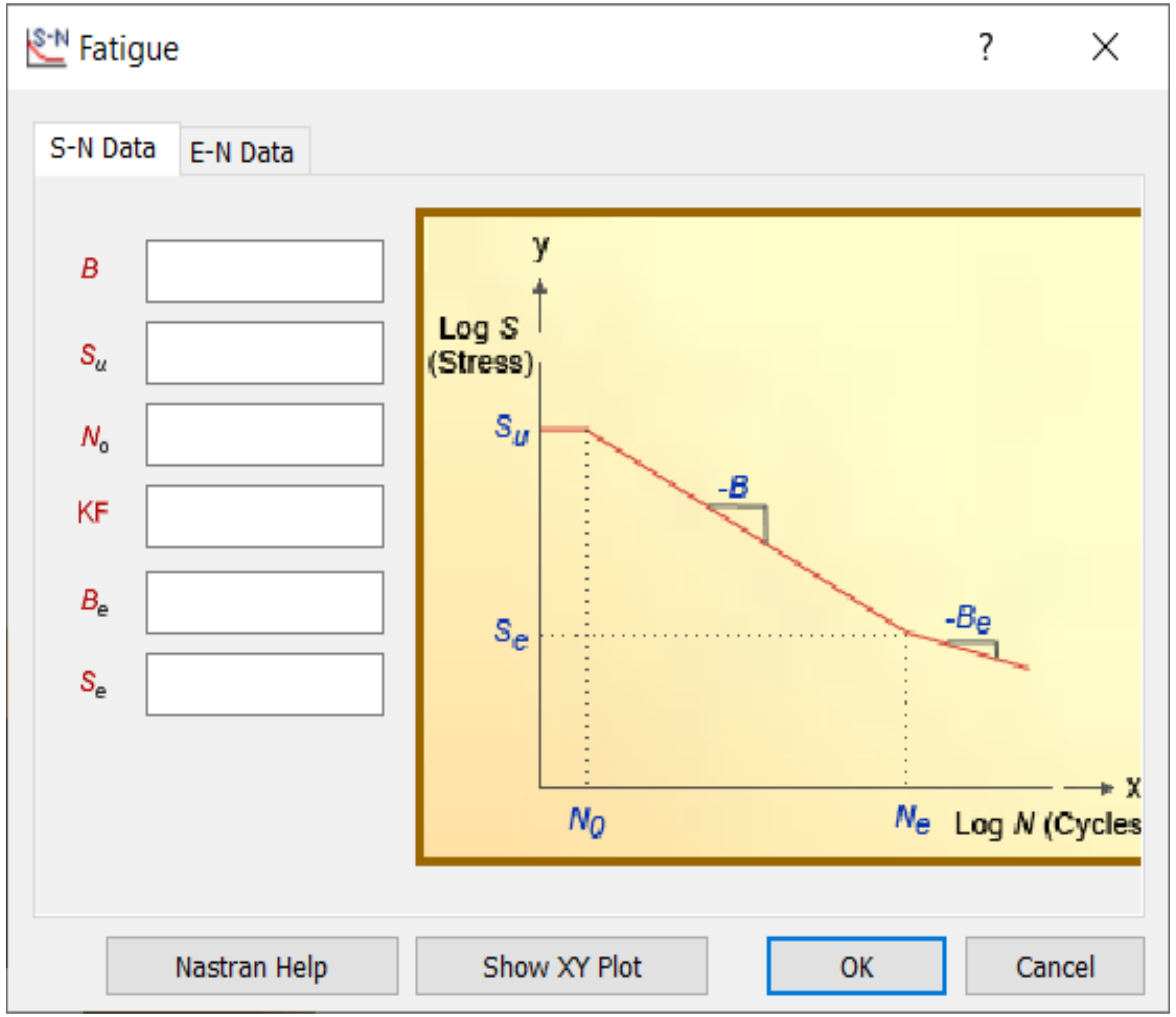
# Exercise 3 – Fatigue Analysis

Assuming fully reverse loading

# Exercise 3 – Fatigue Analysis




**Typically we only need to specify the following values.**

**B** – Gradient of the curve in the high cycle region.

**$S_e$** – Endurance limit.

**$S_u$** – UTS value of material (Need to specify **$S_f$**)

**$N_o$** – Beginning of high cycle fatigue

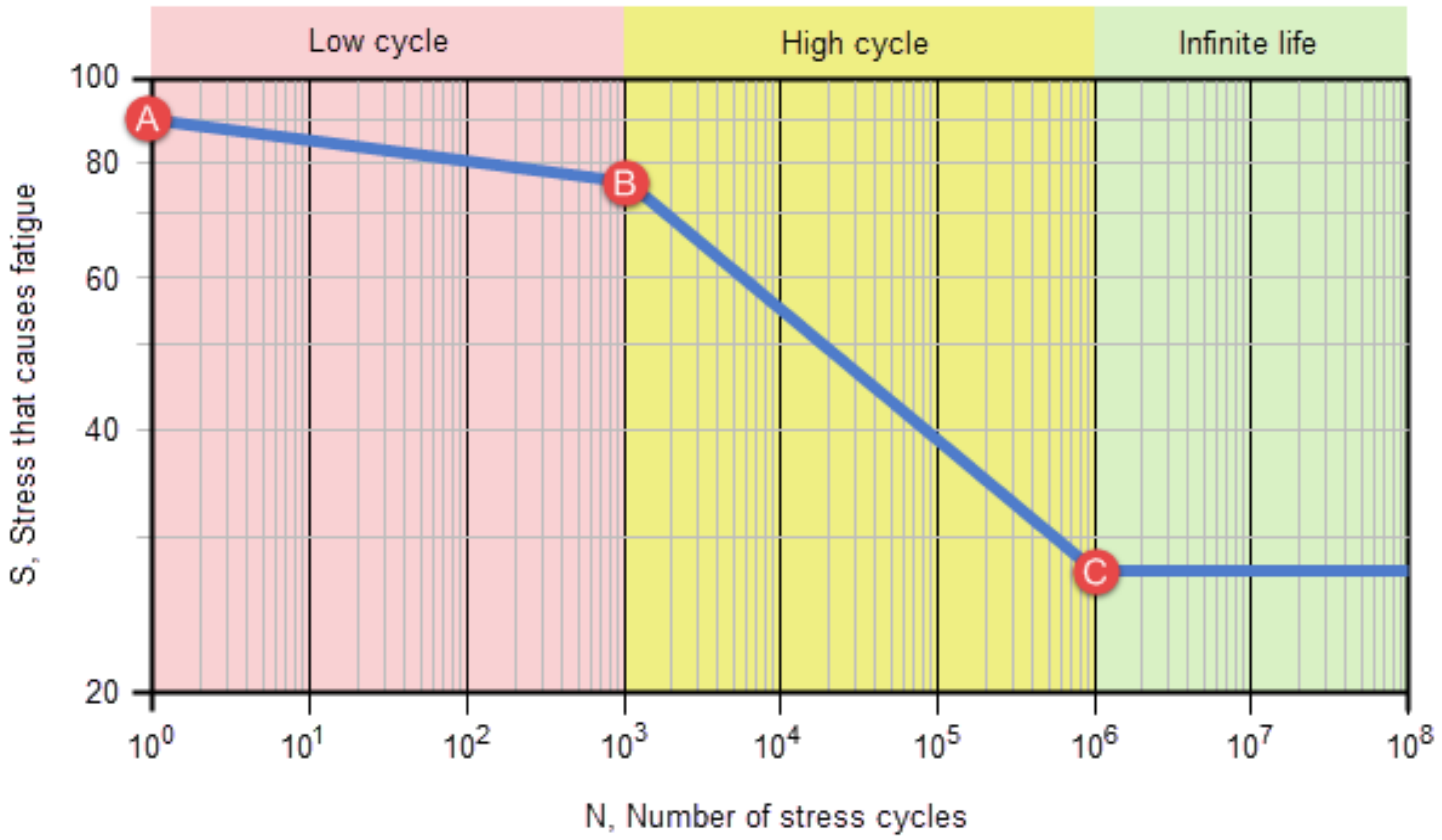
# Exercise 3 – Fatigue Analysis

Lets first have a look at **$N_o$**

**$N_o$** – Is the number of cycles at the beginning of High Cycle Fatigue region.

And typically is 1000 cycles

**$N_o$** – 1000



# Exercise 3 – Fatigue Analysis

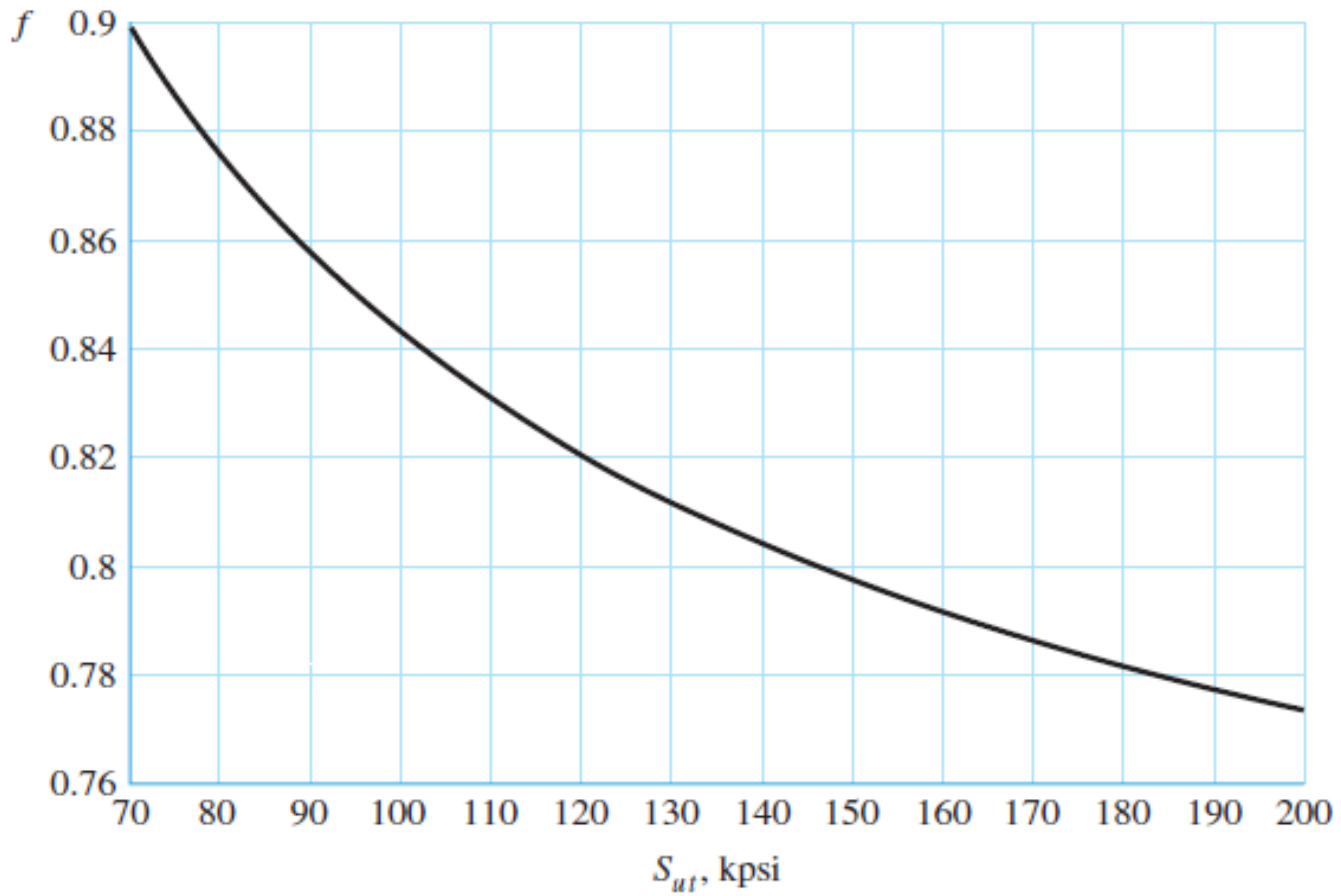
UTS information is widely available.

$S_u$ – 340

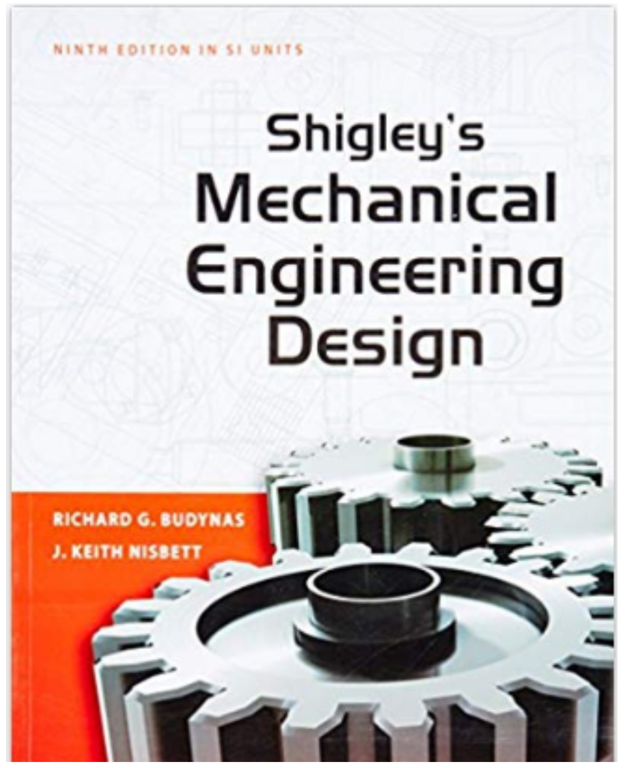
$S_u$ @ 1000 Cycles is defined as

$S_f = S_u \times f$

$S_f$ – 340 x 0.9 = 306




70 kpsi = 482MPa & 200 kpsi = 1379MPa



# Exercise 3 – Fatigue Analysis

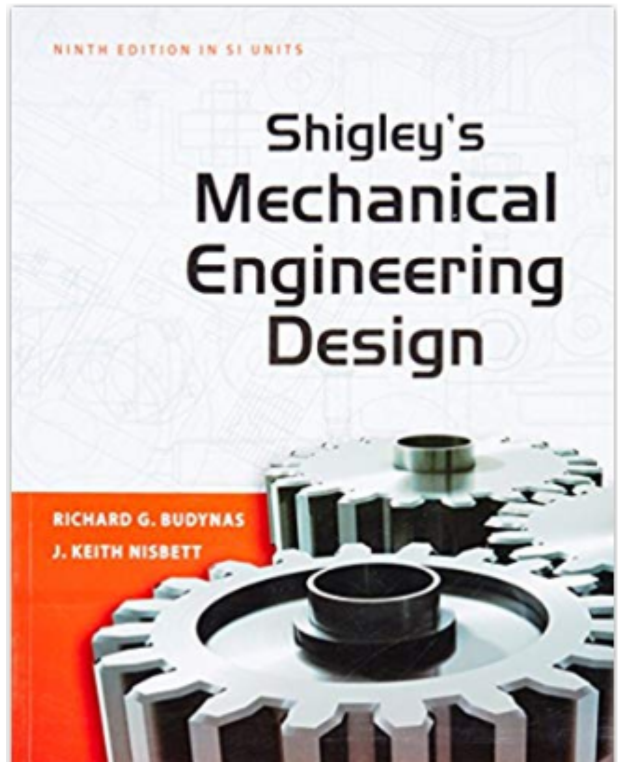
Now Endurance limit is not so obvious

$S_e$ $=k_a k_b k_c k_d k_e k_f S'_e$

Typically for Steel component

$S'_e = 0.5S_u$

- $S'_e$ is endurance limit of a test specimen
- $k_a$ is a surface factor that accounts for the finish (ground, machined, forged, and so on).
- $k_b$ is a size factor that accounts for the size of the part.
- $k_c$ is a loading factor that accounts for different types of loading (bending, axial, torsion).
- $k_d$ is a temperature factor.
- $k_e$ is a reliability factor to account for scatter in the test results from one specimen to another.
- $k_f$ is a miscellaneous factor to account for everything else (residual stress, directional characteristics, corrosion, electrolytic plating, and so on).



# Exercise 3 – Fatigue Analysis

In this example we are going to assume all k values as 1 except $k_a$

$k_a = aS_u^b$
$k_a = 4.51 \times 340^{-0.265}$
$k_a = 4.51 \times 0.2134 = 0.962$

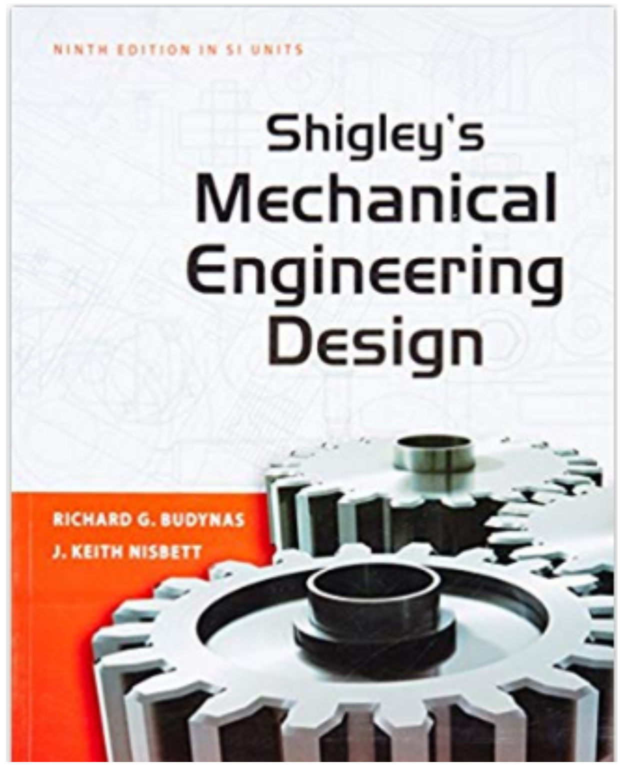
So

$S_e = 0.962 \times 0.5S_u$

$S_e = \mathbf{0.962 \times 0.5 \times 340}$

$\mathbf{S_e = 163.54}$

| Surface Finish | Factor a (MPa) | Exponent b |
|---|---|---|
| Ground | 1.58 | -0.085 |
| Machined or cold-drawn | 4.51 | -0.265 |
| Hot-rolled | 57.7 | -0.718 |
| As-forged | 272 | -0.995 |



# Exercise 3 – Fatigue Analysis

We now have all the information required to calculate B from the following equation.

The slope of the S-N curve is

$$B = \frac{\log(S_u) - \log(S_e)}{\log(N_e) - \log(N_0)}$$

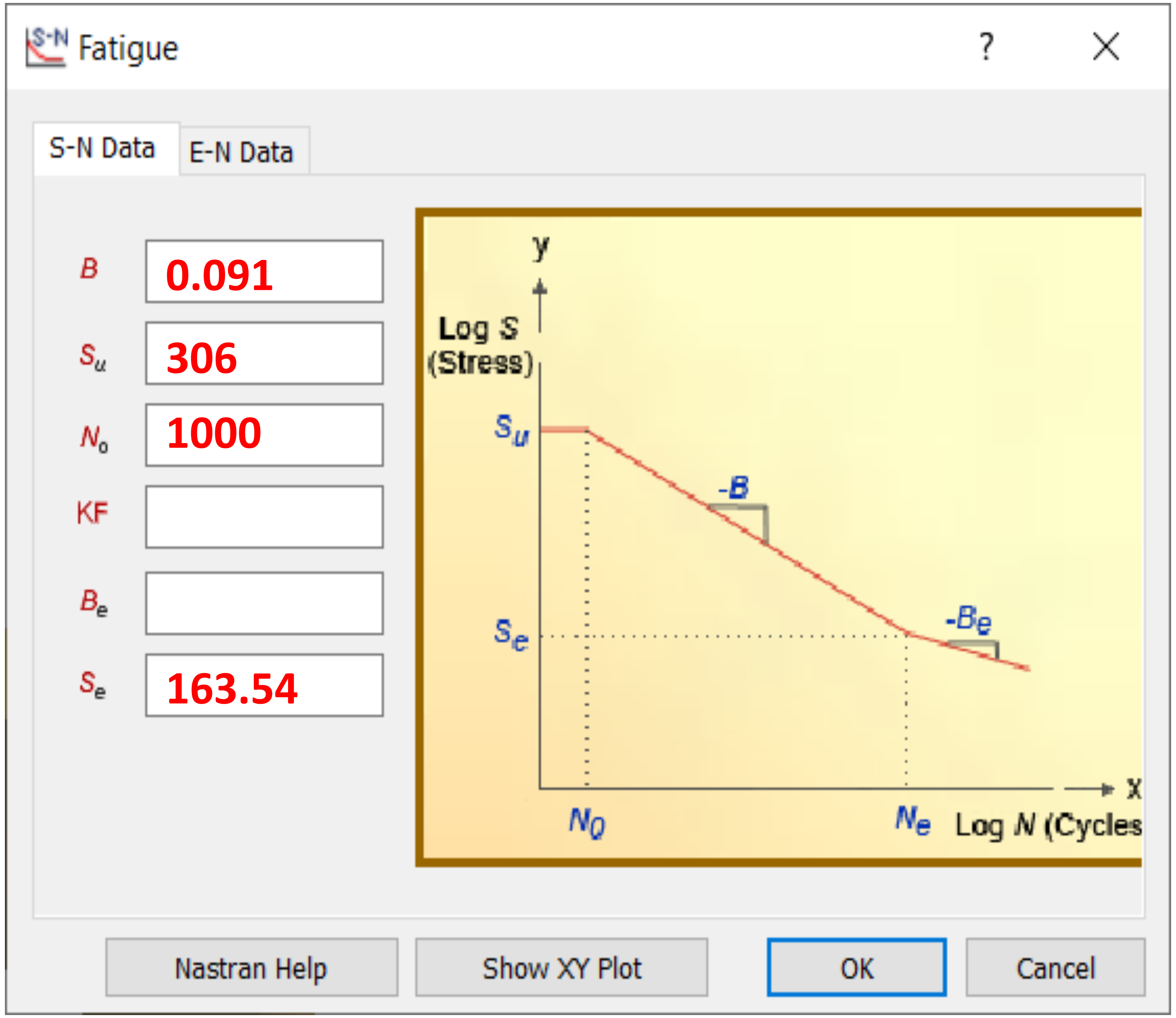
Where Ne is usually 1 million cycles.

$$B = \frac{\log(306) - \log(163.54)}{\log(1E6) - \log(1E3)}$$

$$B = \frac{2.486 - 2.214}{6 - 3}$$

$$\boldsymbol{B} = \frac{0.272}{3} = 0.091$$

# Exercise 3 – Fatigue Analysis

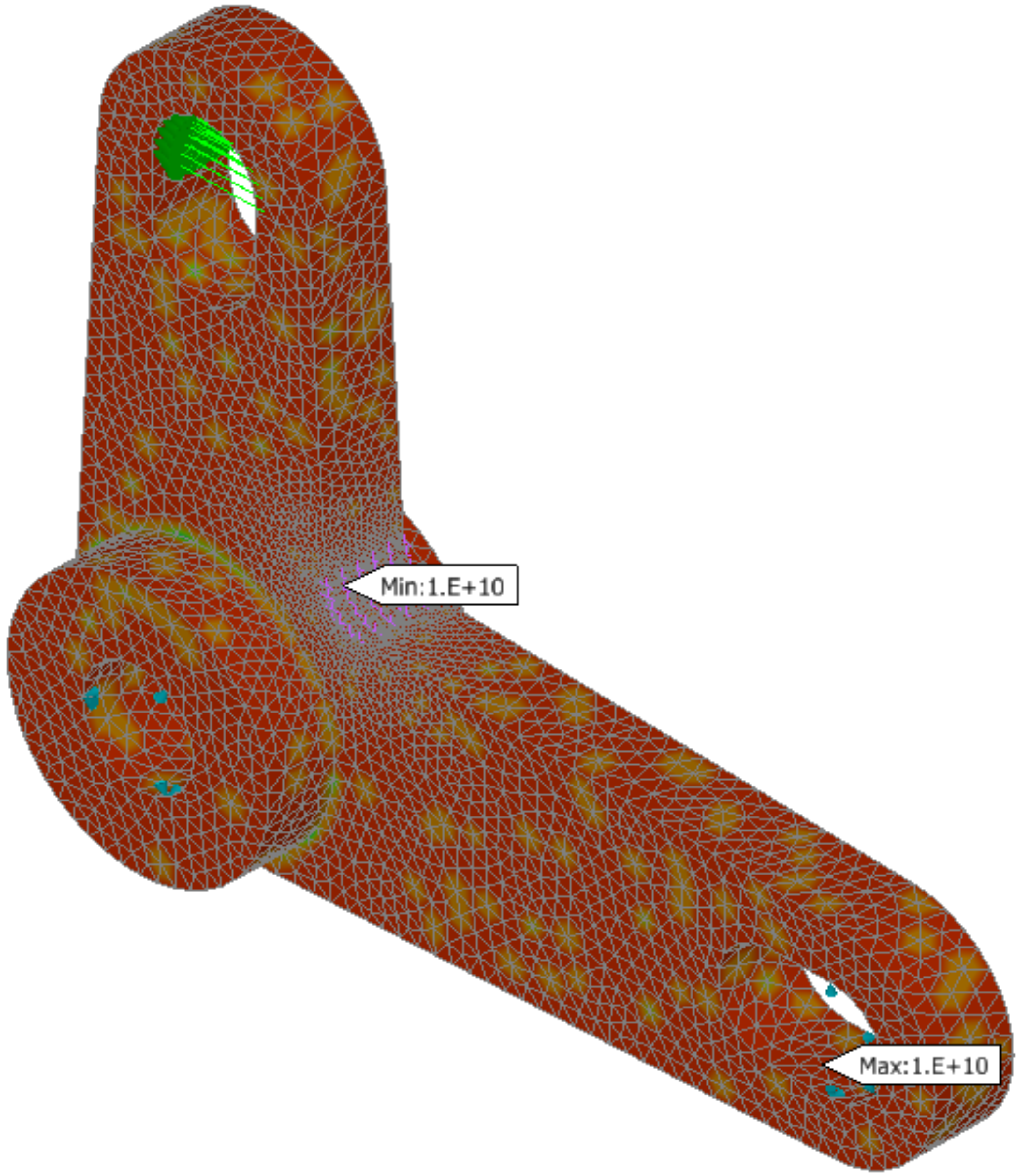


# Hands on Session 3

# Exercise 3 – Fatigue Analysis

Fatigue life is 1e10.

Because Maximum Stress value is below Endurance Limit

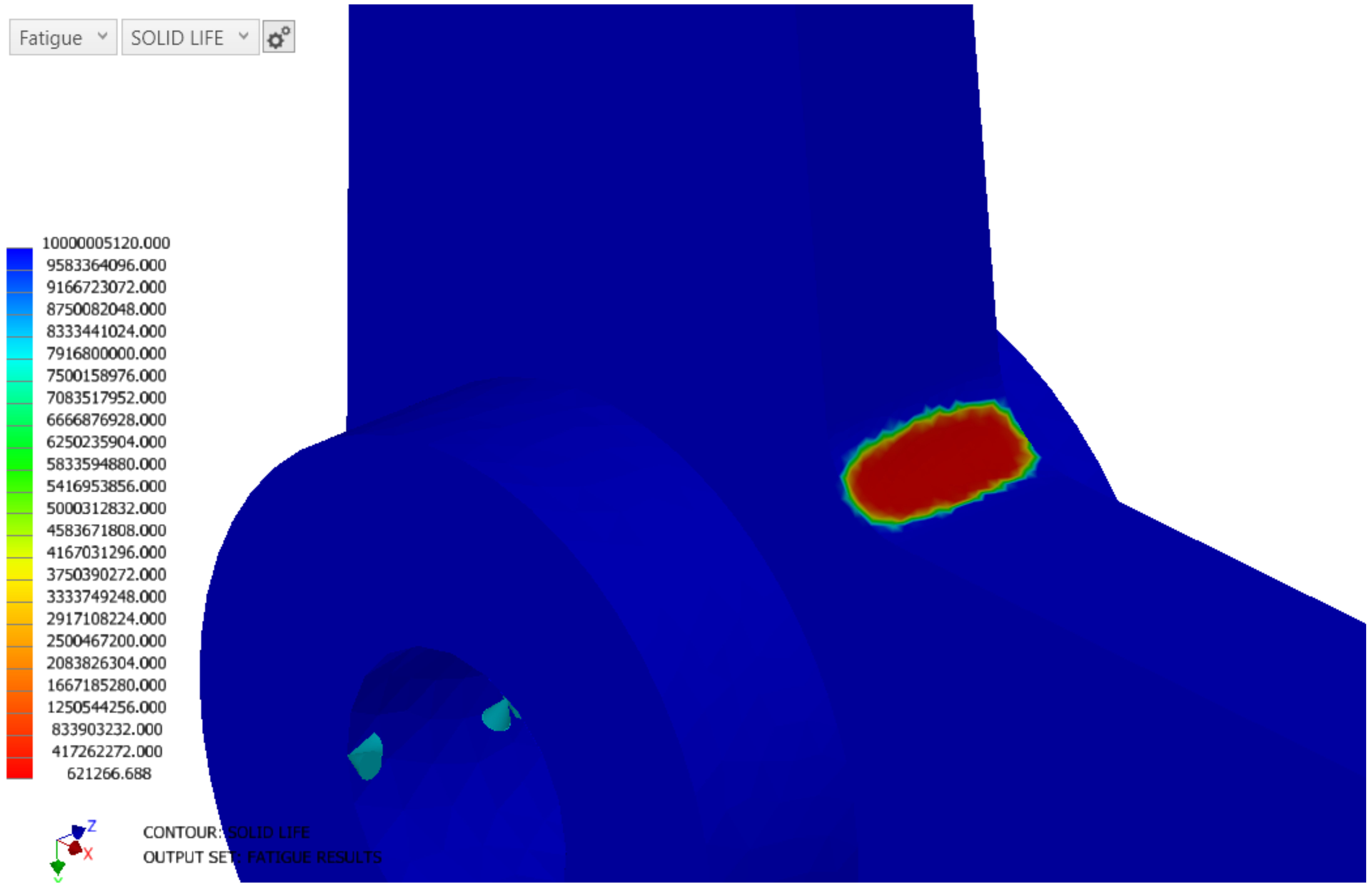


# Exercise 3 – Fatigue Analysis

Now increase load from -30N to -500N.

What is now the minimum life?

**621266**

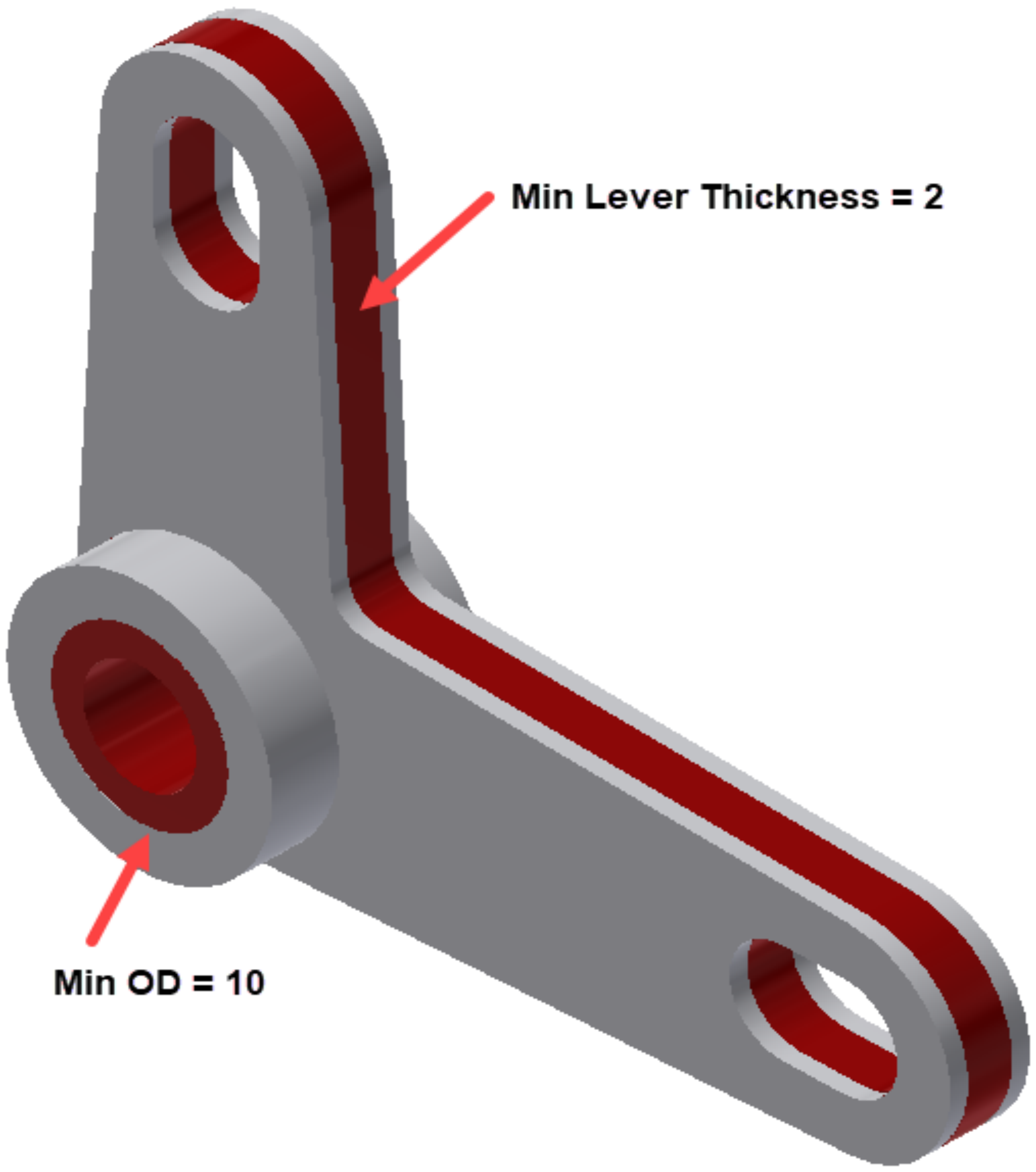


# Exercise 4 – Design Optimisation

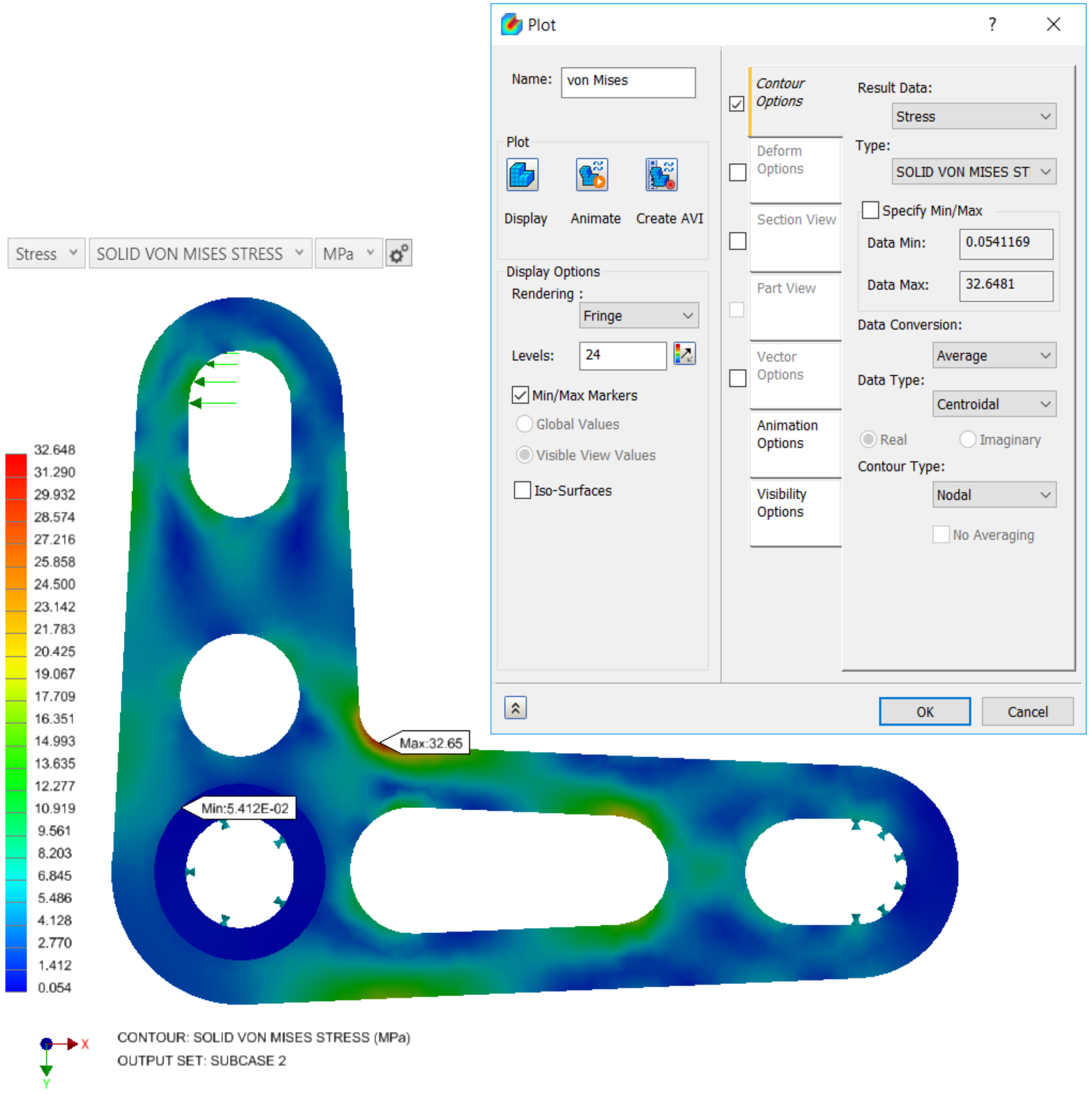
Design Restrictions

Minimum thk ≥ 2 mm
OD of circular hole ≥ 10 mm
Slot shapes cannot be altered

| Target Safety Factor is 5 |
|---|



# Exercise 4 – Design Optimisation




Maximum Stress is 32.65 MPa

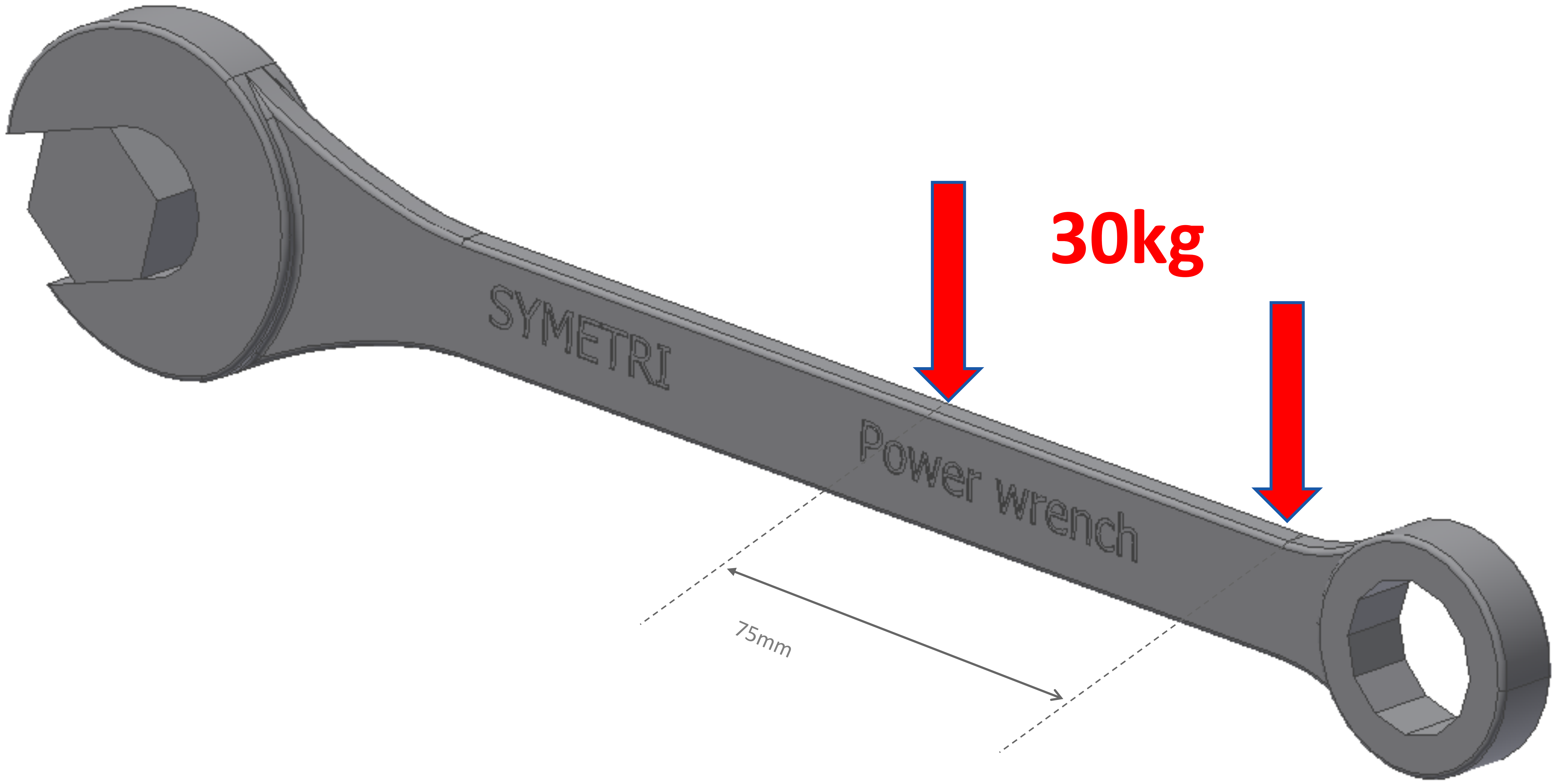
Therefore Safety Factor is

SF = 200/32.65 = 6.12

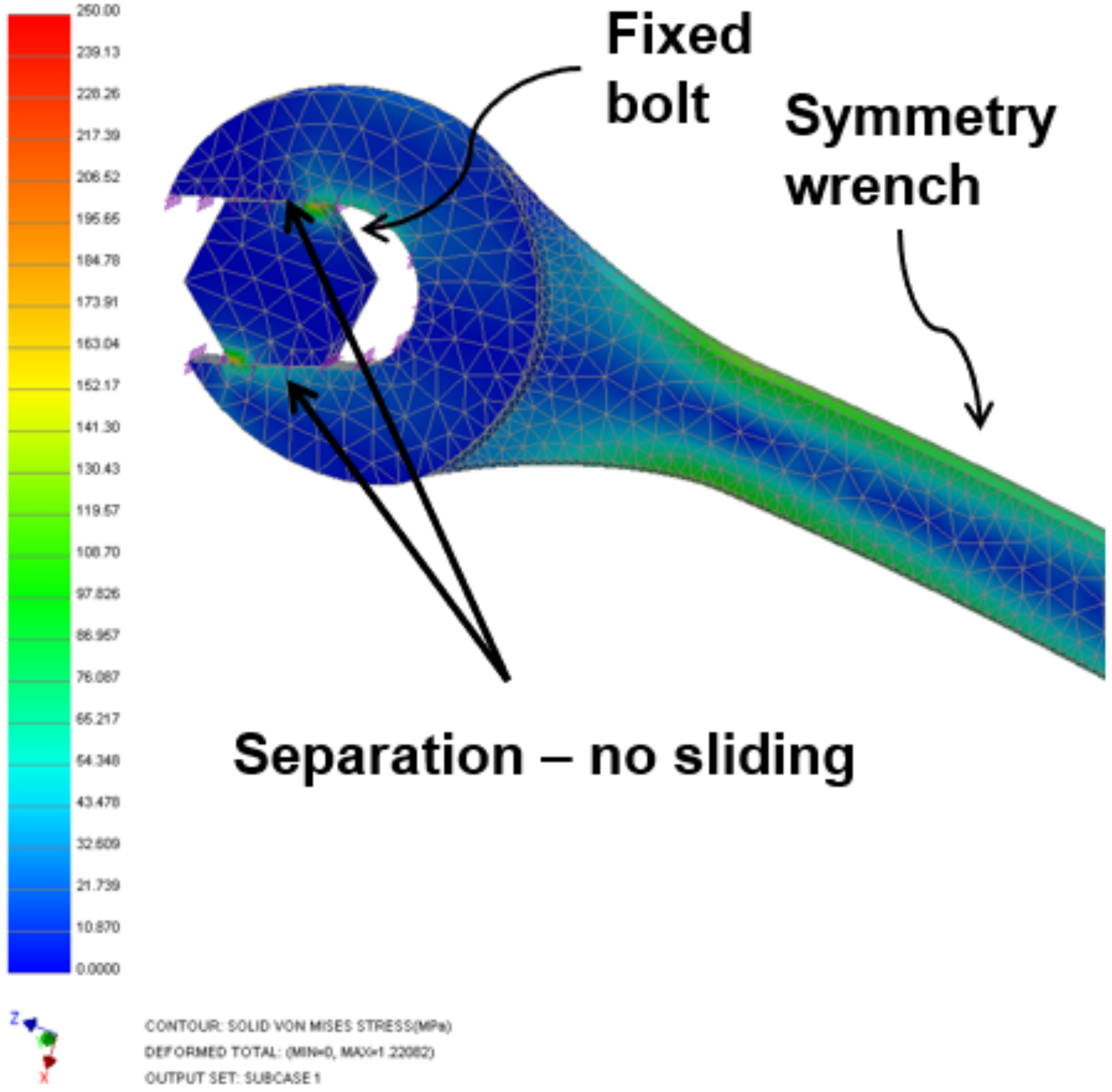
# Exercise 5 – Practice Exercise

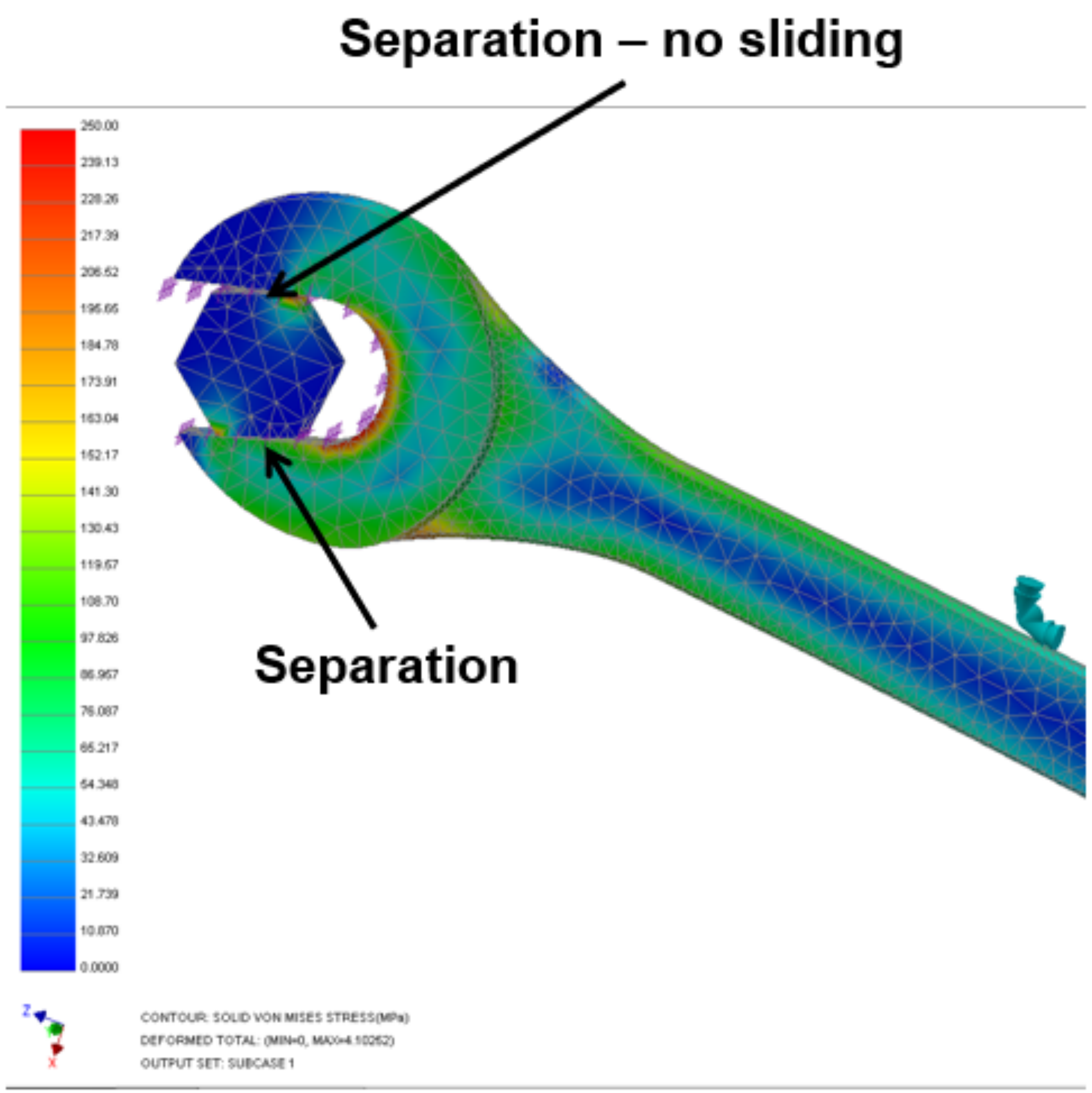
Analyze this wrench and determine the highest von Mises stress.
Can we do any simplifications? How should we apply the contact?

Material: Steel
Load: 30kg



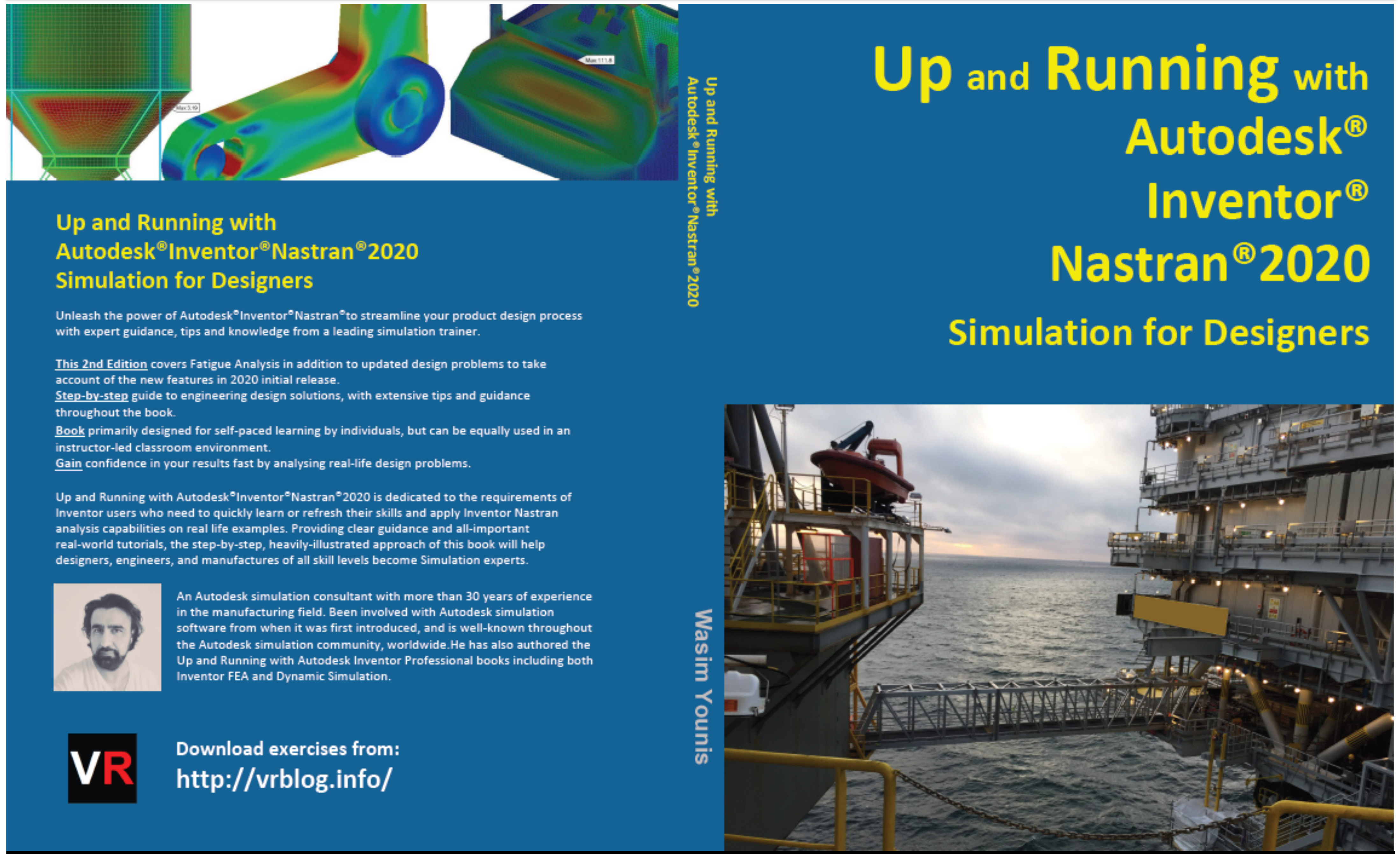
# Exercise 5 – Practice Exercise



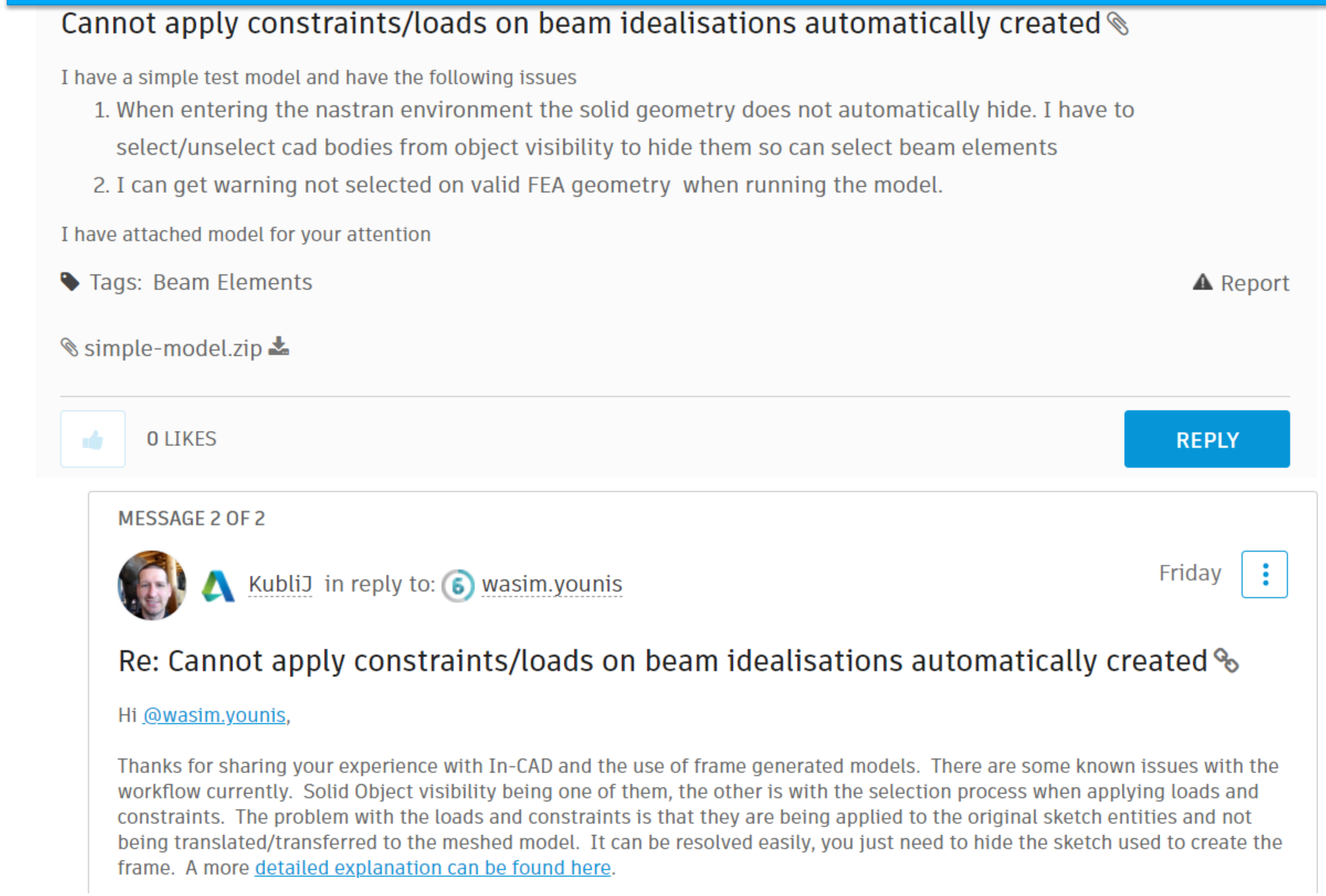
# Resources to help you accelerate learning…

Available on Amazon worldwide




Self –paced learning with real world examples.

https://forums.autodesk.com/t5/nastran-in-cad-forum/bd-p/75




Nastran In-CAD Forum - Excellent resource for any questions you may have

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