Phase 4 - Design Validation

Group 8 - Colin Baker, Kory Pringle

Validation Results

Based on the results from our FEA simulation in Solidworks, our design is a valid femoral fracture plate as it only slightly fails when the femoral head is instantaneously loaded with 800N of force downward. In the FEA, failure was predicted on the front of the plate around the central screw hole, as well as on the back of the plate, mainly in the upper left portion. It was originally predicted that failure would occur near the central screw hole, because of the lack of support and surface area in that section. This result is consistent with the predictions that were made.

FEA vs. Back-of-Envelope Calculations

When comparing our FEA to the Back-of-Envelope Calculations done in Phase 3 of this design there is a major discrepancy in output values. The failure of the fracture plate occurs at the same position on the plate however the maximum shear stress is much higher than our calculations done by hand. The maximum shear stress calculated in the Solidworks is 5502.24 MPa greater than the maximum shear stress found by hand. Based on the FEA calculations done in Solidworks we can determine that there was a mistake in the calculations done by hand causing the value of maximum stress to be much lower than it actually is. Since the Back-of-Envelope Calculations are much different we feel as if we should trust the Solidworks FEA over them. With this being said we are also not 100% confident that there was not an error in the Solidworks FEA.

Design Validation Table - FEA Values (Taken for 800N)

Measurement	Min Value	Max Value
Stress (Von Mises)	0 MPa	5616 MPa
Displacement in Y	-3.030 mm	1.571 mm
Strain	0	3.658e-03
F.O.S	5.034e-02	3

Path Forward

Overall, our design had a majority of successful results from our FEA, as well as Back-of-Envelope Calculations. In terms of the actual design itself, it included multiple holes and scallops, as well a long axis channel, therefore creating a small contact area, while also keeping the strength of the plate. During the FEA,

the large majority of plate failure occurred around the front central screw hole, and the back upper left side. This could be due to plate error, however this could also be an error in the program in which the plate may not have been placed in an optimal testing area. Going forward, the amount of screw holes and scallops would likely be kept, as well as the channel down the middle. Future improvements would be as follows:

- Possible new orientation of scallops with screw holes
- Make a design that is more fit to a specific femur
- Threading through screw holes for alignment and more security of plate

To summarize, the design did not have many flaws, and most changes would be made simply if given a specific femur with more in depth measurements to design around.

Appendix C: FEA Report

Simulation of Femur-Plate Assembly

Date: Sunday, April 26, 2020
Designer: Solidworks
Study name: Static
Analysis type: Static

Table of Contents

Description

No Data

Model Information

Model name: Femur-Plate Assembly
Current Configuration: Default

Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Fillet1 	Solid Body	Mass:0.0544994 kg Volume:6.93554e-06 m^3 Density:7,857.99 kg/m^3 Weight:0.534094 N	C:\Users\Cbake\OneDrive\Desktop\School\Sophomore\Mech of Solids\Design Project\Plate Design 2.SLDPRT Apr 3 23:12:41 2020

Study Properties

Study name	Static
Analysis type	Static
Mesh type	Mixed Mesh

Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\Cbake\OneDrive\Desktop\School\Sophomore\Mech of Solids\Design Project)

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin

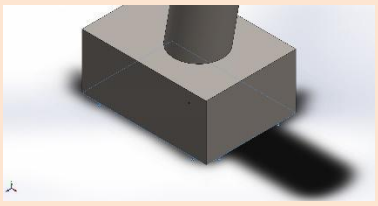
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

Model Reference	Properties		Components
	**Name:**	1023 Carbon Steel Sheet (SS)	SolidBody 1(Cut-Extrude6)(Distal Femur-1), SolidBody 1(Fillet1)(Plate Design 2-1), SolidBody 1(Cut-Extrude6)(Proximal Femur-1)
	Model type:	Linear Elastic Isotropic	
	Default failure criterion:	Unknown	
	Yield strength:	2.82685e+08 N/m^2	
	Tensile strength:	4.25e+08 N/m^2	
	Elastic modulus:	2.05e+11 N/m^2	
	Poisson's ratio:	0.29	
	Mass density:	7,858 kg/m^3	
	Shear modulus:	8e+10 N/m^2	
	Thermal expansion coefficient:	1.2e-05 /Kelvin	
Curve Data:N/A			

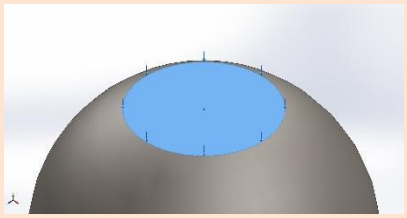
Loads and Fixtures

Fixture name	Fixture Image	Fixture Details

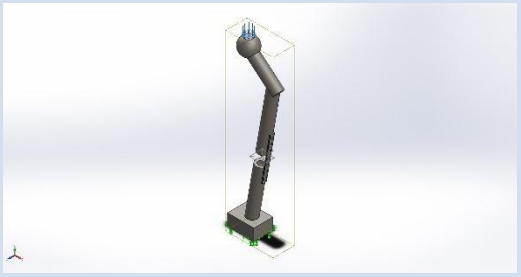
Fixed-1		**Entities:** 1 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	0	0	0	1e-33
Reaction Moment(N.m)	0	0	0	1e-33

Load name	Load Image	Load Details
Force-1		**Entities:** 1 face(s) **Type:** Apply normal force **Value:** 800 N

Contact Information

Contact	Contact Image	Contact Properties
Global Contact		**Type:** Bonded **Components:** 1 component(s) **Options:** Incompatible mesh

Mesh information

Mesh type	Mixed Mesh
Mesher Used:	Standard mesh

Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Jacobian check for shell	On
Element Size	0.268274 in
Tolerance	0.0134137 in
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	Off

Mesh information - Details

Total Nodes	12784
Total Elements	6312
Time to complete mesh(hh;mm;ss):	00:00:03
Computer name:	

Resultant Forces

Reaction forces

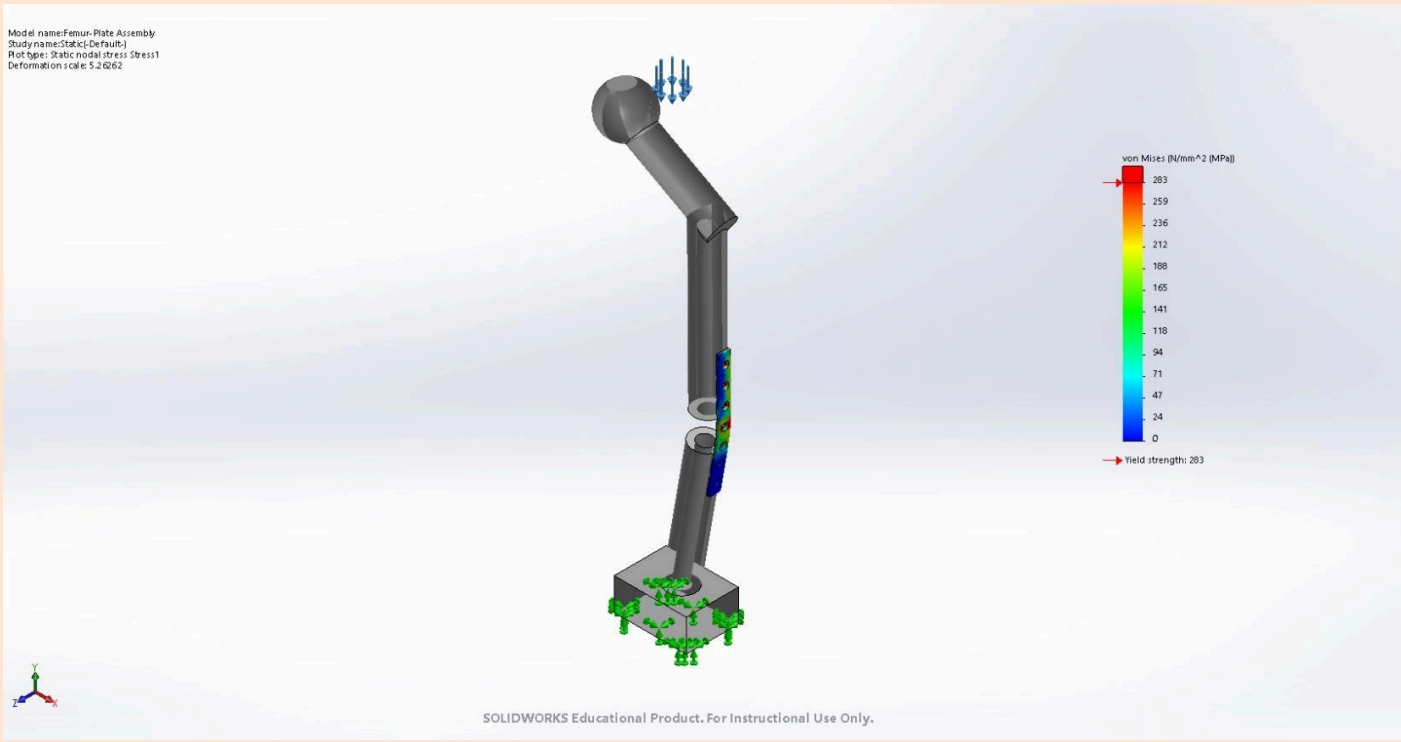
Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	-0.0112152	800.007	-0.00187302	800.07

Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	1e-33

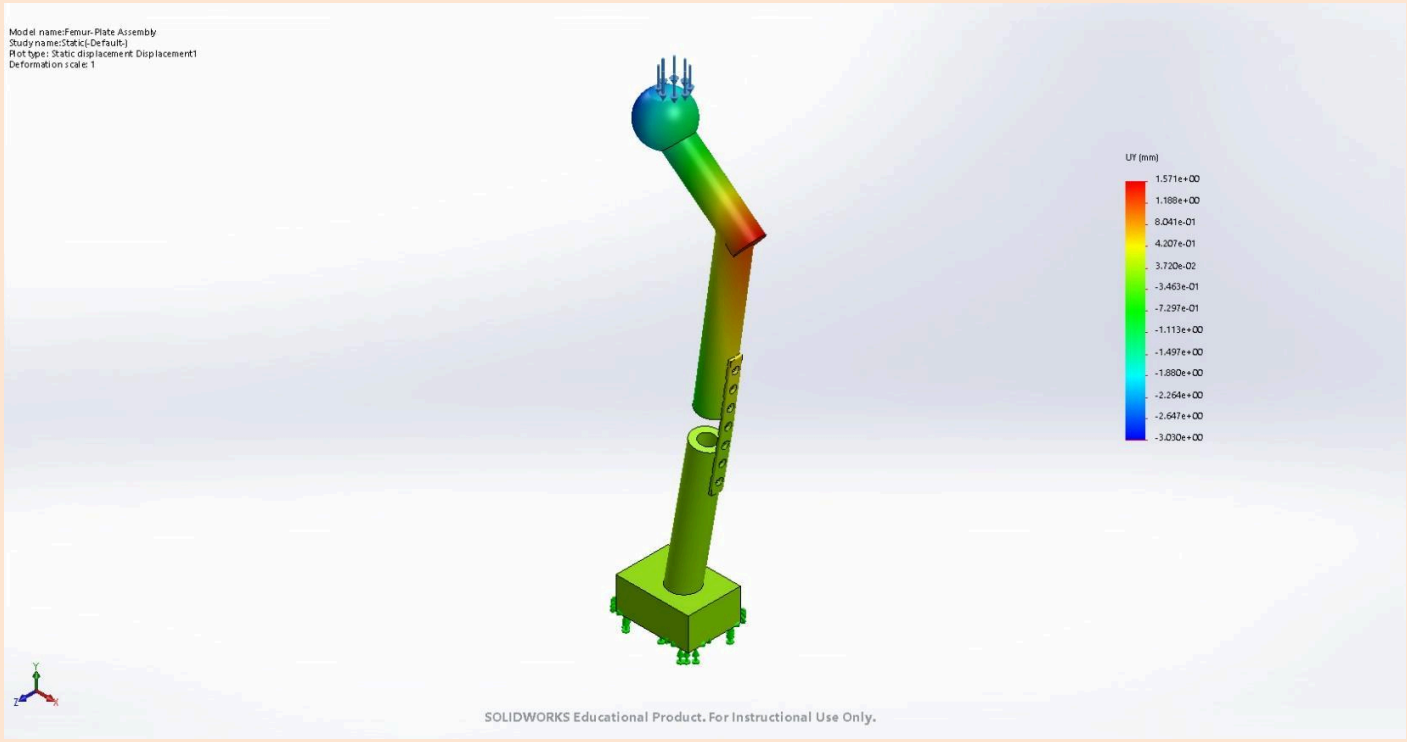
Study Results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0N/mm^2 (MPa) Node: 3177	5,616N/mm^2 (MPa) Node: 464



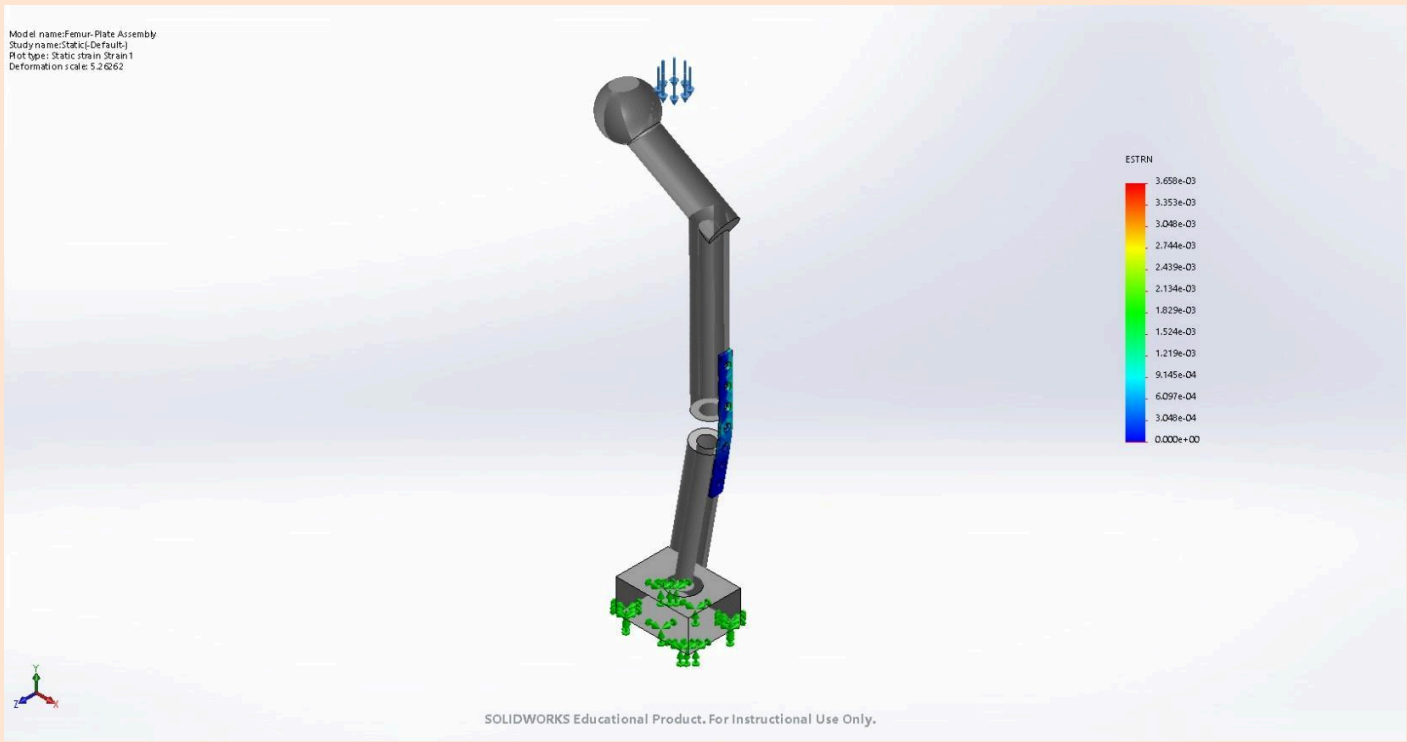
Femur-Plate Assembly-Static-Stress-Stress1

Name	Type	Min	Max
Displacement1	UY: Y Displacement	-3.030e+00mm Node: 10665	1.571e+00 mm Node: 11648



Femur-Plate Assembly-Static-Displacement-Displacement1

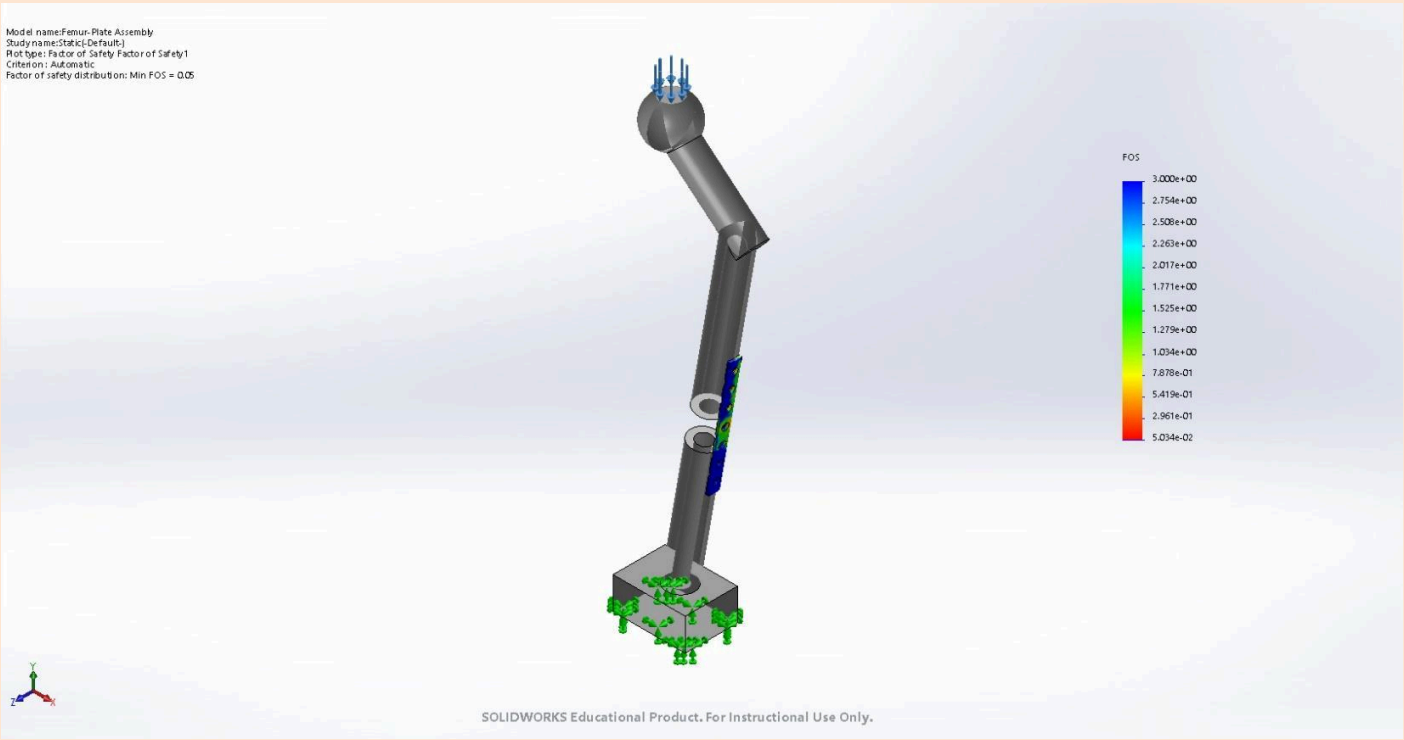
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0.000e+00 Element: 1511	3.658e-03 Element: 67



Femur-Plate Assembly-Static-Strain-Strain1

Name	Type	Min	Max
Factor of Safety1	Automatic	5.034e-02	3.000e+00

		Node: 464	Node: 1



Femur-Plate Assembly-Static-Factor of Safety-Factor of Safety1