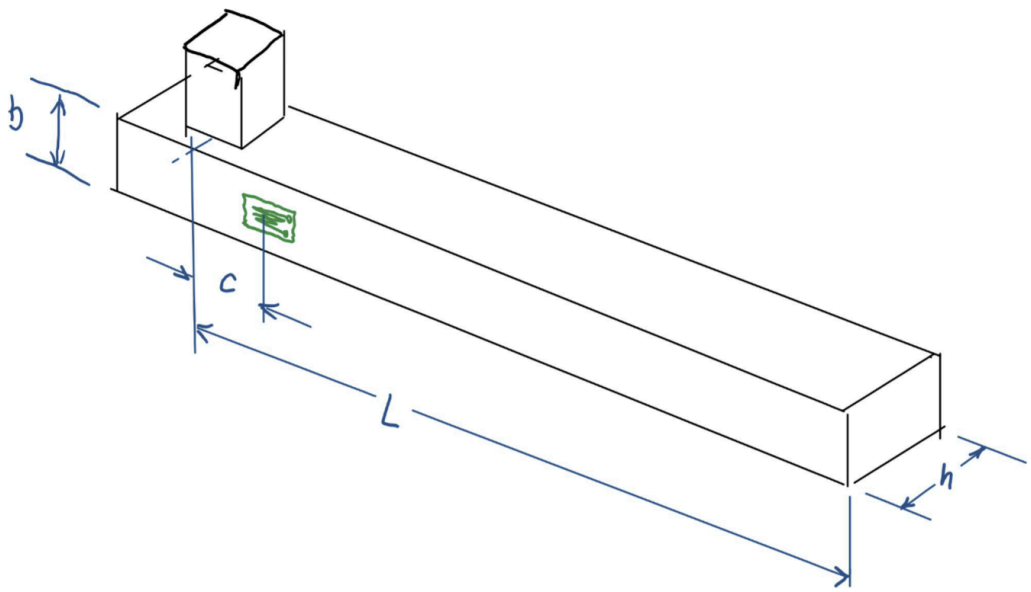
MAE 3270

Fall 2025
Final Homework Torque Wrench Design

By:
Samantha Pochet (sep244)

1. Image(s) of CAD model. Must show all key dimensions.



Maintained dimensions of original wrench geometry.

In inches:
L = 16; length from drive to where load applied
h = 0.75; width
b = 0.5; thickness
c = 1.0; distance from center of the drive to center of the strain gauge

2. Describe material used and its relevant mechanical properties.

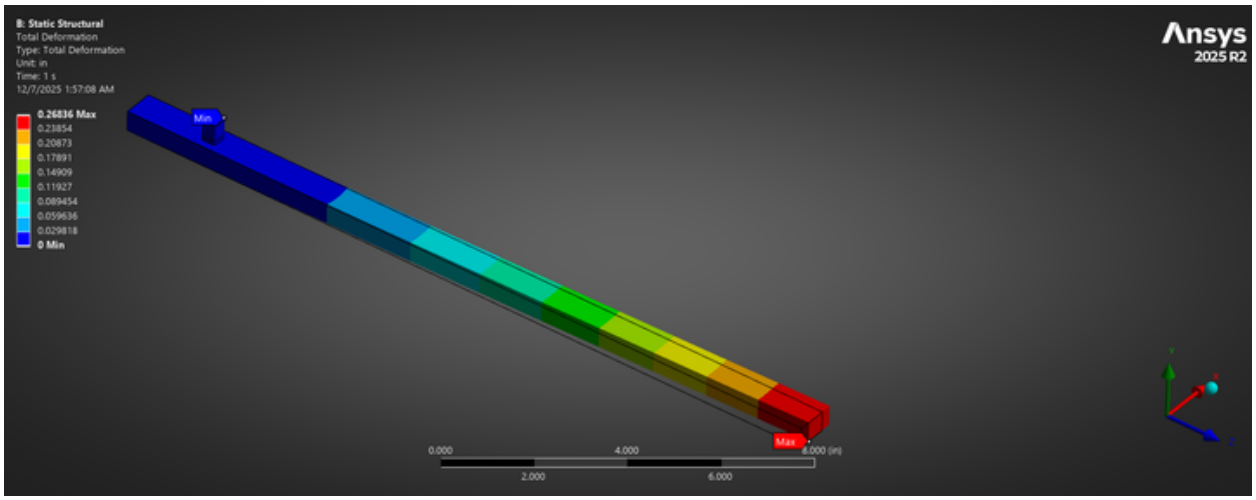
Note: values were chosen to be within the range of values provided by the Granta database.

Material selection: Titanium alloy, TI-6Al-4V

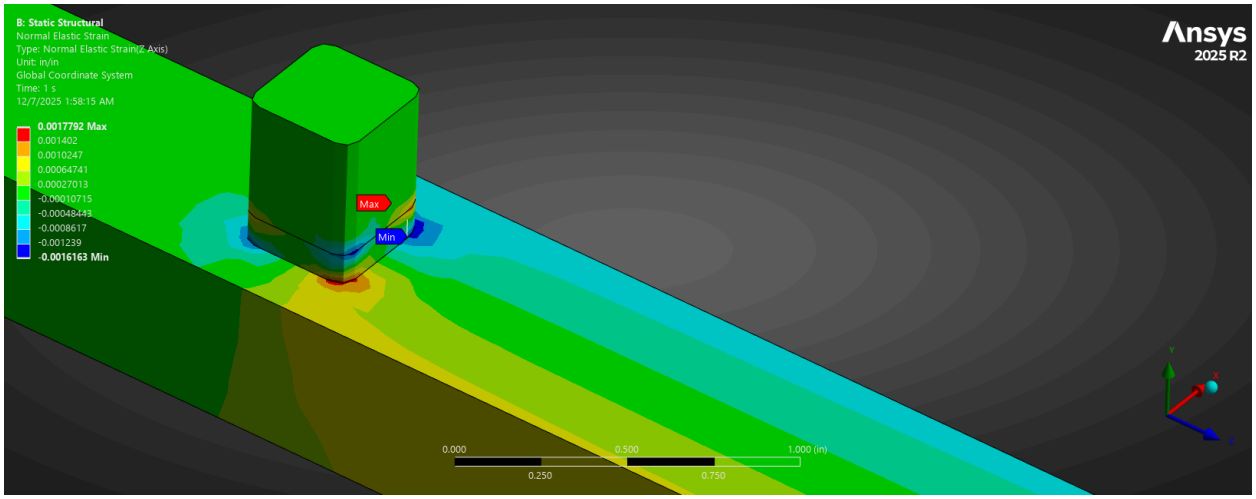
Young's modulus: 1.65e7 psi
Poisson's ratio: 0.35
Yield strength: 140e3 psi
Fracture toughness: 85e3 psi√in
Fatigue strength for 10^6 cycles: 70e3 psi

3. Diagram communicating how loads and boundary conditions were applied to your FEM model.

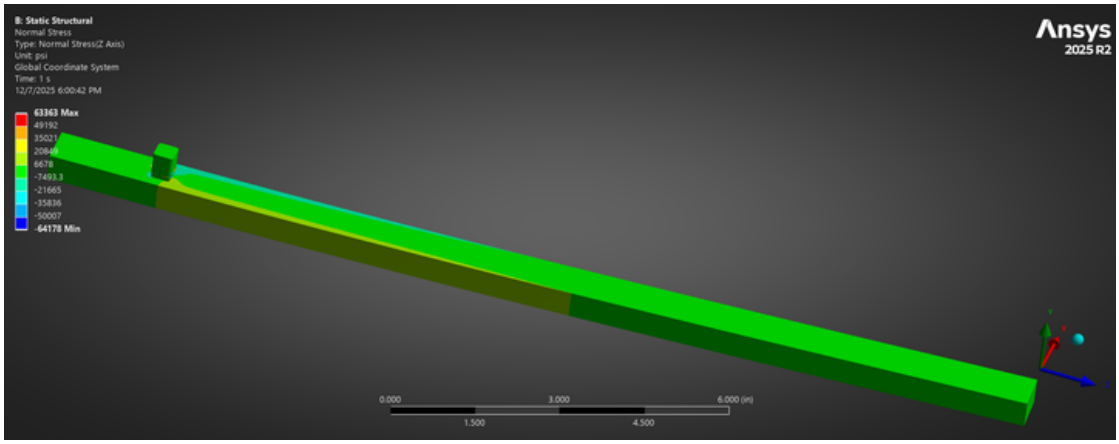
37.5lbf applied force at the end of the wrench (face) purely in the x direction
Displacement set to 0 for all components of the faces of the top component of the drive. (excluding the top face)

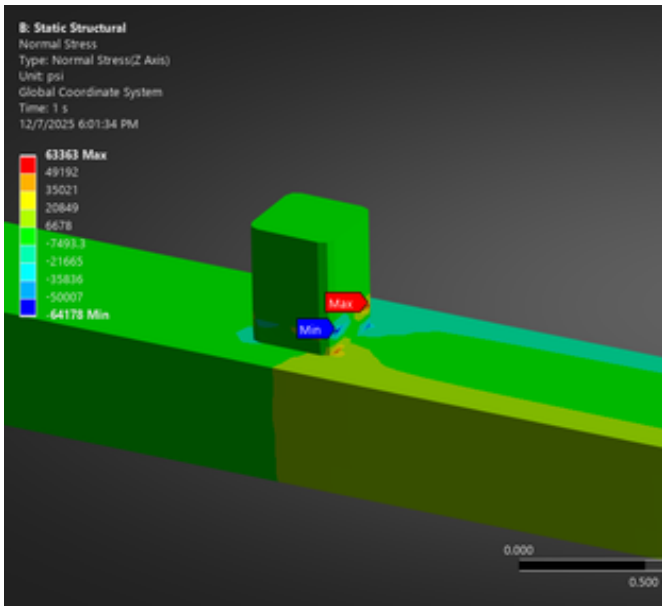


4. Normal strain contours (in the strain gauge direction) from FEM



5. Contour plot of maximum principal stress from FEM

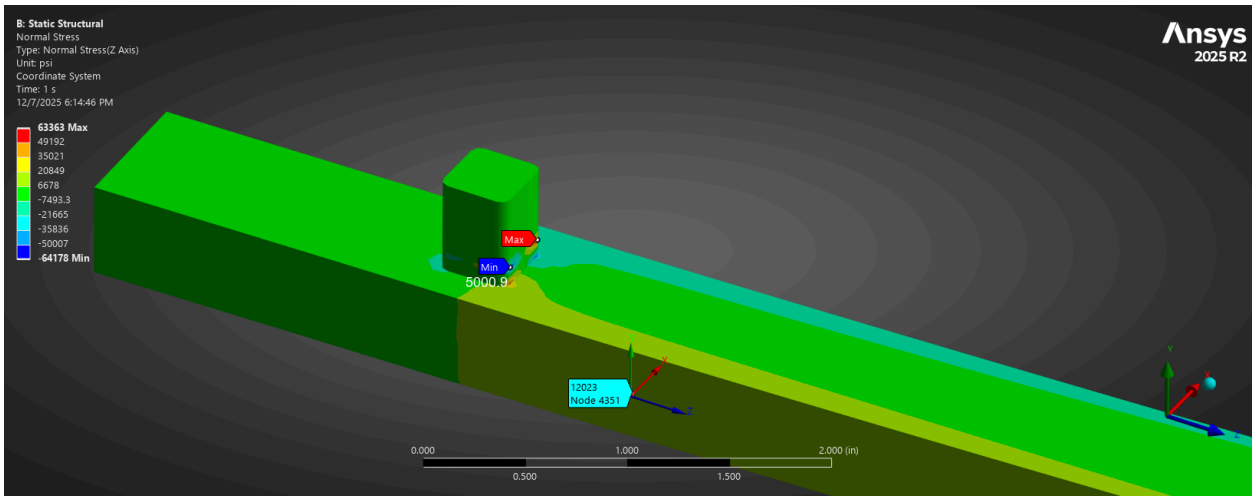




6. Summarize results from FEM calculation showing maximum normal stress (anywhere), load point deflection, strains at the strain gauge locations

Max Normal Stress:

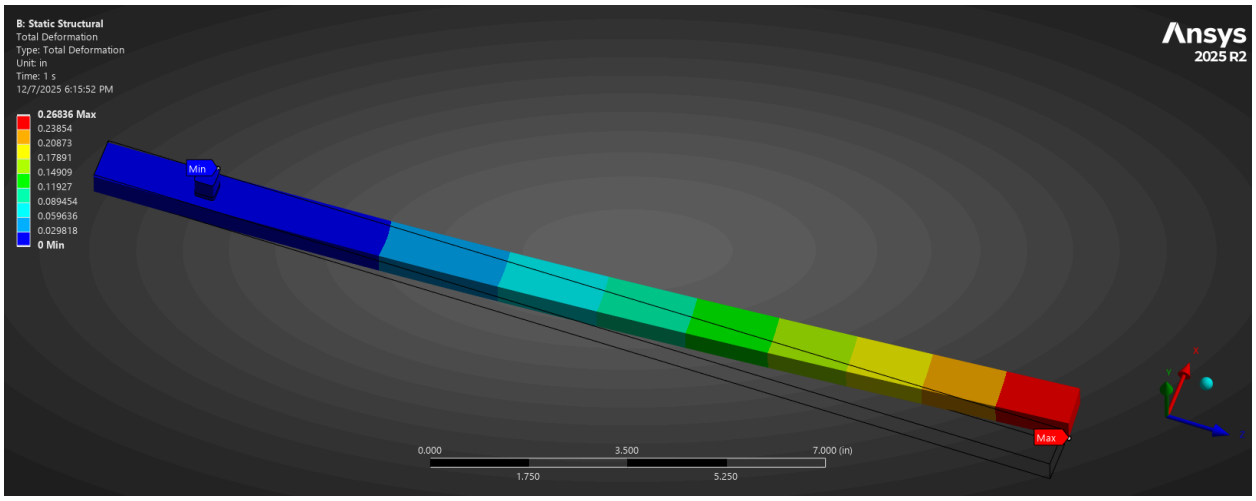
12.0 ksi at gauge location, artificial maximum value explained by stress singularity created by meshing.



Deflection at Load:

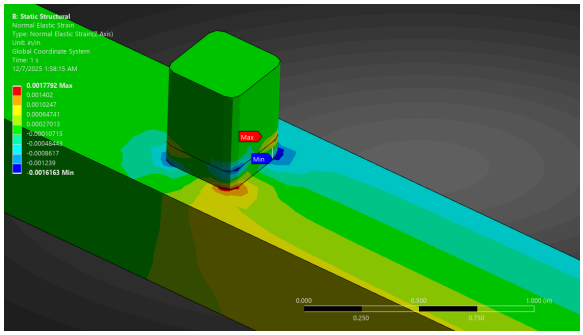
0.26 inch deflection at load

0.17 in expected from hand calculations



Strain at gauge:
New Coordinate axis created at gauge location, 15 inches from load at the end of the wrench.

Maximum Value Over Time	
Normal - X Axis	-2.5442e-004 in/in
Normal - Y Axis	-2.548e-004 in/in
Normal - Z Axis	7.2783e-004 in/in
XY Shear	6.1413e-007 in/in
YZ Shear	-8.2244e-007 in/in
XZ Shear	1.9035e-006 in/in
Equivalent (von-Mises)	7.2773e-004 in/in
Maximum Principal	7.2783e-004 in/in
Middle Principal	-2.5425e-004 in/in
Minimum Principal	-2.5497e-004 in/in
Intensity	9.828e-004 in/in
Minimum Value Over Time	



7. Torque wrench sensitivity in mV/V using strains from the FEM analysis

$\varepsilon_{FEM} = 7.27 \times 10^{-4}$

Using a full-bridge Wheatstone circuit with GF = 2:

$mV/V = GF \cdot \varepsilon_{FEM} \cdot 1000$

$mV/V = 2 \times 7.27 \times 10^{-4} \times 1000$

$mV/V_{FEM} \approx 1.45$ mV/V

8. Strain gauge selected (give type and dimensions). Note that design must physically have enough space to bond the gauges.

Chosen gauge:

Micro-Measurements CEA-06-125UW-350

Nominal resistance: 350 Ω
Gauge factor: ≈ 2.0
Active grid length: 0.125 in (3.18 mm)
Active grid width: 0.120 in (3.05 mm)
Overall backing length: ~0.22 in
Overall backing width: ~0.16 in

The wrench cross-section at the gauge location is 0.75 in × 0.50 in, providing ample flat area to bond four such gauges in a full-bridge configuration while maintaining adequate edge margin.

Hand Calculations for Titanium Wrench:

From MatLab:

```
sigma (psi)=

      12800

Deflection (in) =

   0.1765

Factors of Safety:

SF_strength =

  10.9375

sf_crack =

  16.7258

SF_fatigue =

   5.4679


Strain at gauge:

epsilon_1 =

  7.2727e-04
```