# Matt Pianka, MPP72, Final HW Part 2, 12/8/25

Monday, December 8, 2025 6:07 PM

5.1.1

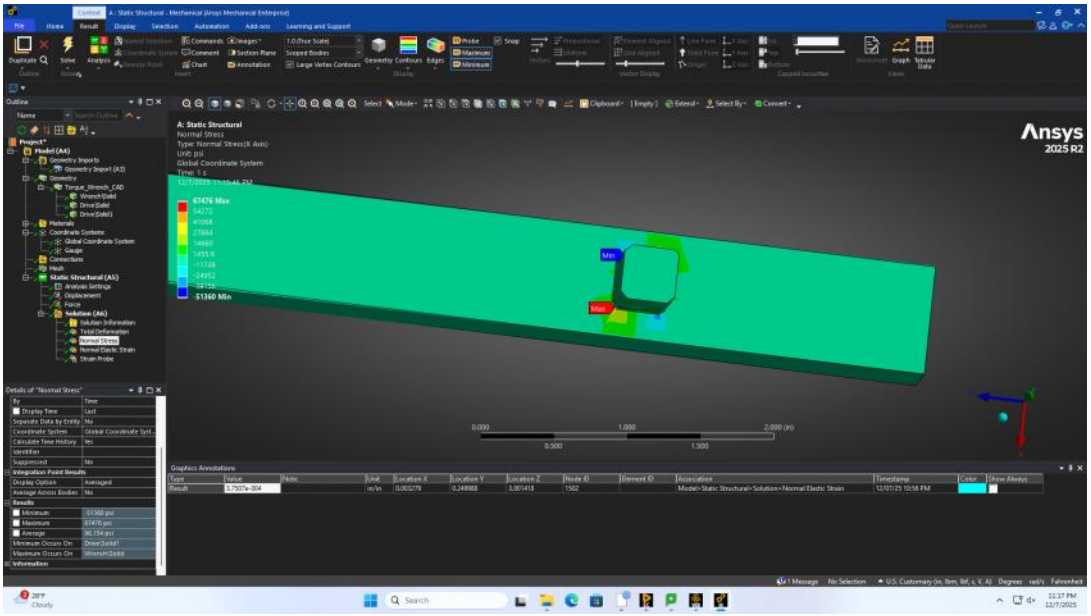
1)

```
M  = 600;        % max torque (in-lbf)
L  = 16;         % length from drive to where load applied (in)
h  = 0.75;       % width (in)
b  = 0.5;        % thickness (in)
c  = 1.0;        % distance from center of drive to center of strain gauge (in)
E  = 32e6;       % Young's Modulus (psi)
nu = 0.29;       % Poisson's ratio
su = 370e3;      % yield or ultimate strength (psi)
KIC = 15e3;      % fracture toughness (psi*sqrt(in))
sfatigue = 115e3; % fatigue strength at 1e6 cycles
name = 'M42 Steel';

a0 = 0.04;       % initial crack depth for fracture safety (in)

I = (h^3 * b)/12;      % moment of inertia (in^4)
y = h/2;               % outer fiber distance (in)
F = M / L;             % force at end (lbf)
delta = F*L^3 / (3*E*I); % end deflection:

sigma_max = M * y / I;     % psi

Mgauge = F * (L-c);            % bending moment at gauge
sigma_gauge = Mgauge * y / I;
eps_gauge = sigma_gauge / E;      % strain at gauge

X_strength = su / sigma_max;

Y = 1.12;
K = Y * sigma_max * sqrt(pi*a0);
X_crack = KIC / K;

X_fatigue = sfatigue / sigma_max;
Vout_mV_per_V = eps_gauge * 1000;    % mV/V

fprintf("Load-point deflection:       %.4f in\n", delta)
fprintf("Max normal stress:           %.2f ksi\n", sigma_max/1000)
fprintf("Strength X:                  %.2f\n", X_strength)
fprintf("Crack-growth X:              %.2f\n", X_crack)
fprintf("Fatigue X:                   %.2f\n", X_fatigue)
fprintf("Strain at gauge:             %.1f microstrain\n", eps_gauge*1e6)
fprintf("Output:                      %.2f mV/V\n", Vout_mV_per_V)
```

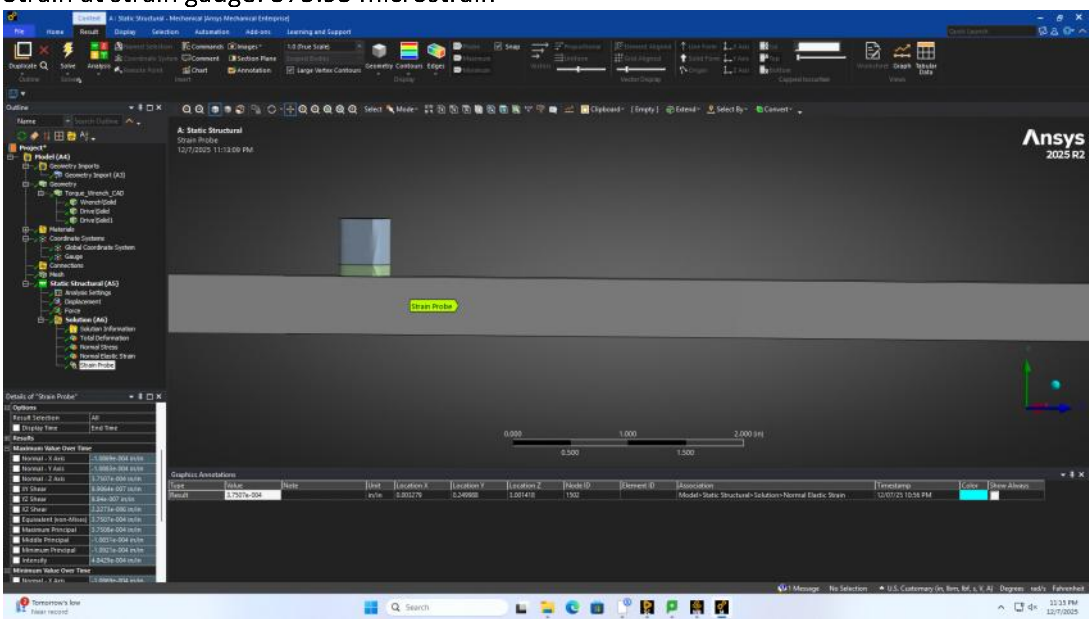
2)

```
>> MAE_3270_Final_Hw
Load-point deflection:       0.0910 in
Max normal stress:           12.80 ksi
Strength X:                  28.91
Crack-growth X:              2.95
Fatigue X:                   8.98
Strain at gauge:             375.0 microstrain
Output:                      0.38 mV/V
```

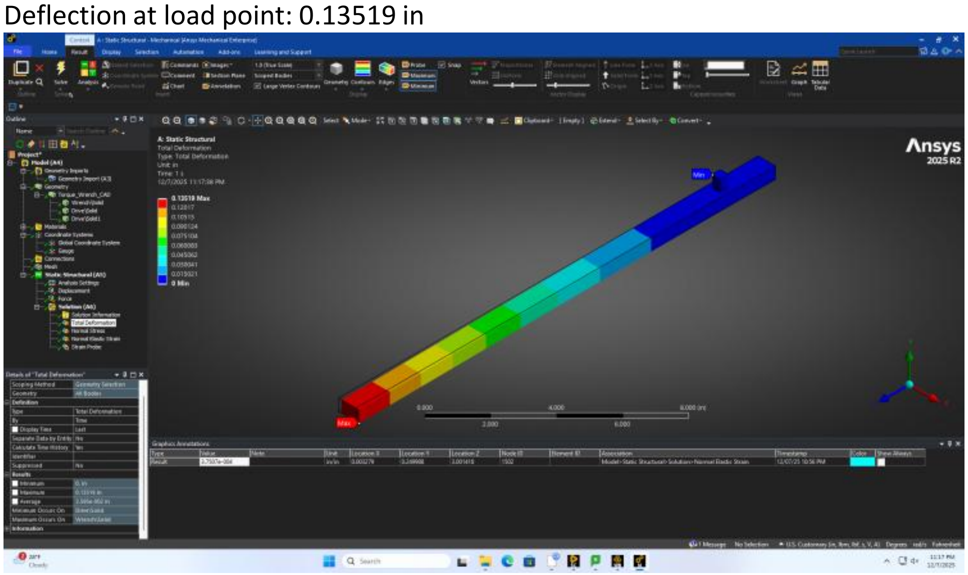
3) Max normal stress: 67476 psi=67.476 ksi



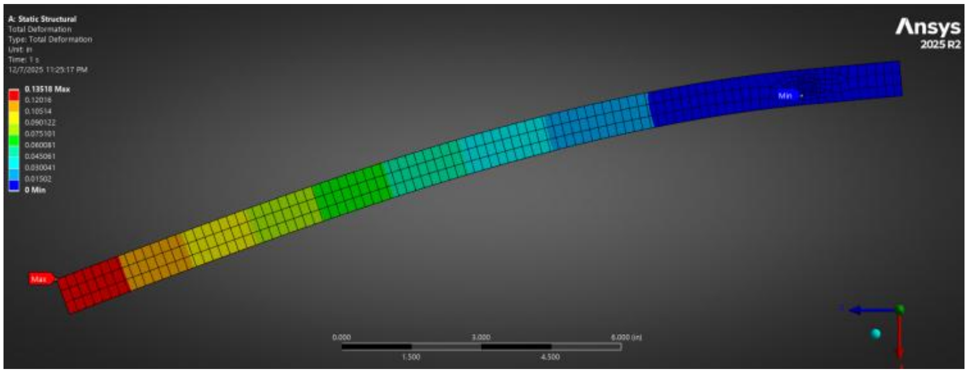

Strain at strain gauge: 375.95 microstrain




Deflection at load point: 0.13519 in




5.1.2

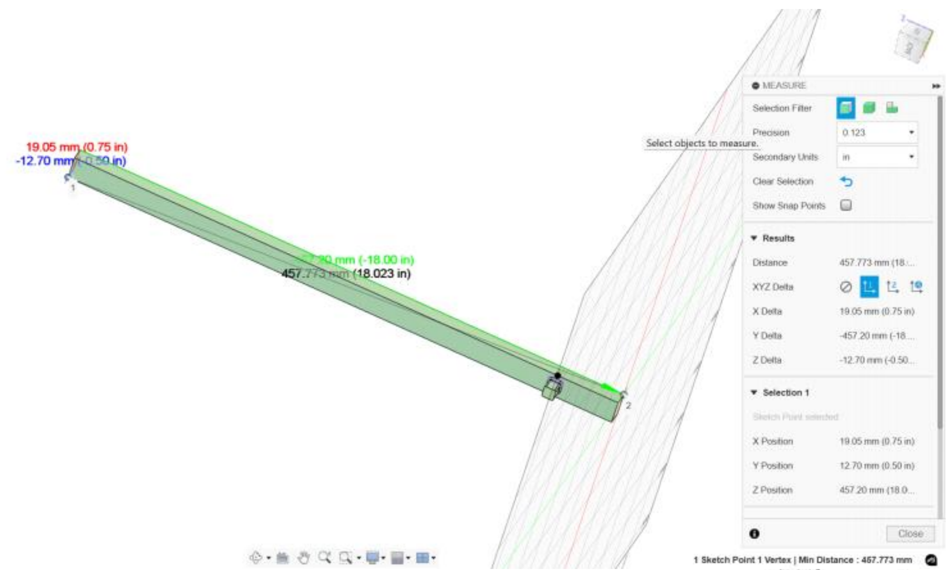
1) 

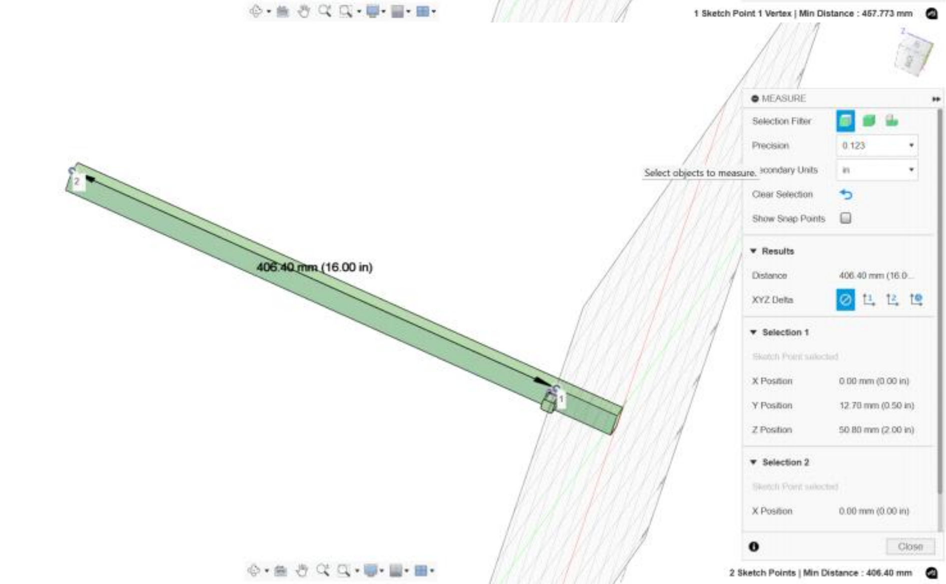

Yes, because the lines across the length of the handle remain straight lines.

2) The FEM max normal stress is significantly larger than the hand calculated max normal stress by about a factor of 5. These are so drastically different because the hand calculations make a lot of simplifications because it uses beam theory. However, the FEM analysis does not make these assumptions and accounts for the drive and the stress concentrations around it, which the hand calculations do not do.

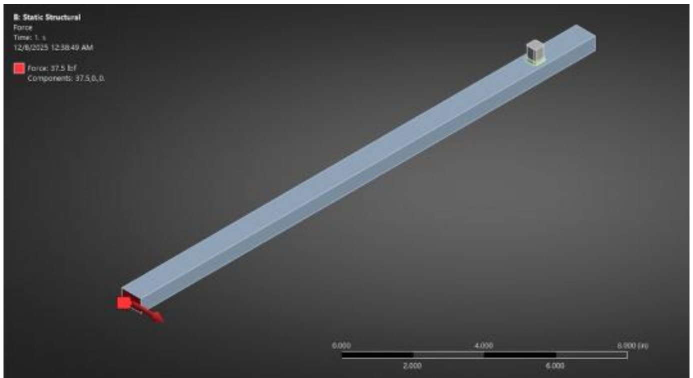
3) The FEM displacement is larger than the hand calculated displacement by about a factor of 1.5. This differs because the hand calcs. treat it like a cantilever beam, which simplifies the geometry. In the FEM analysis, it takes the full geometry of the wrench, including the effect of the deformation of the drive.

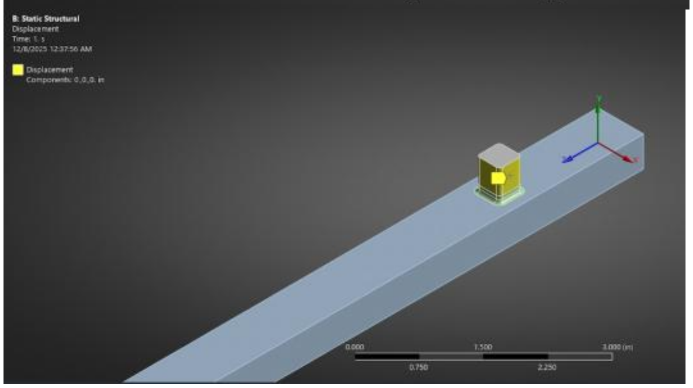
5.2.1



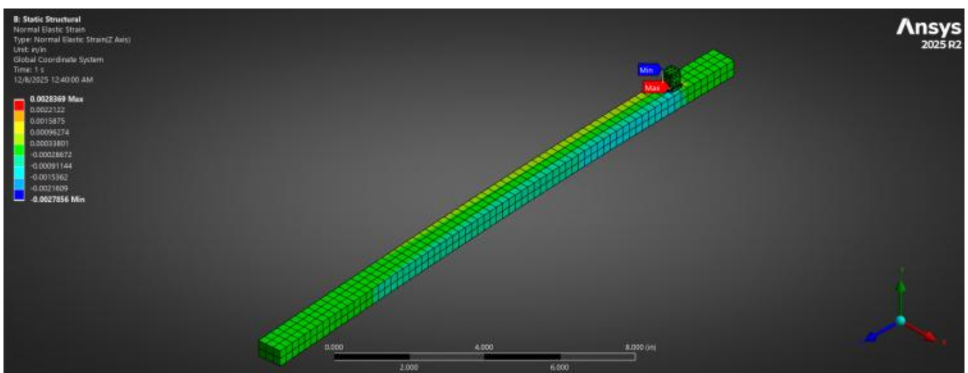



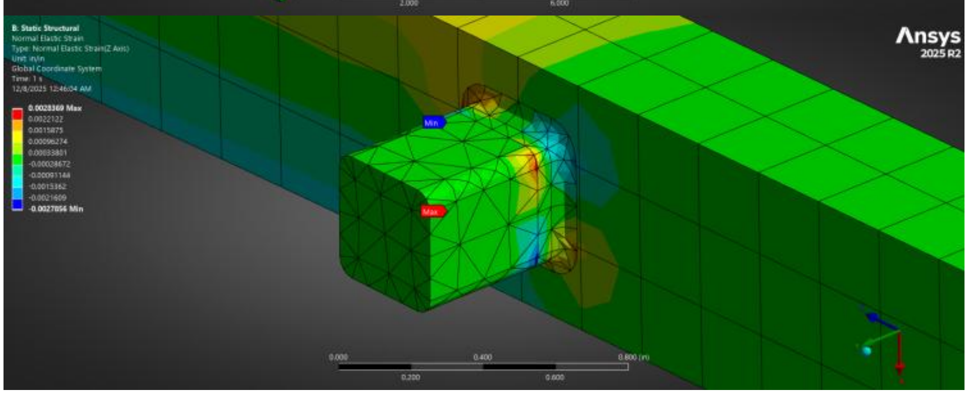
7075-T6 Aluminum Alloy
E=10.6e6
nu=0.33
Ultimate Stress = 80e3
Fracture Toughness = 24e3
Fatigue strength = 23e3

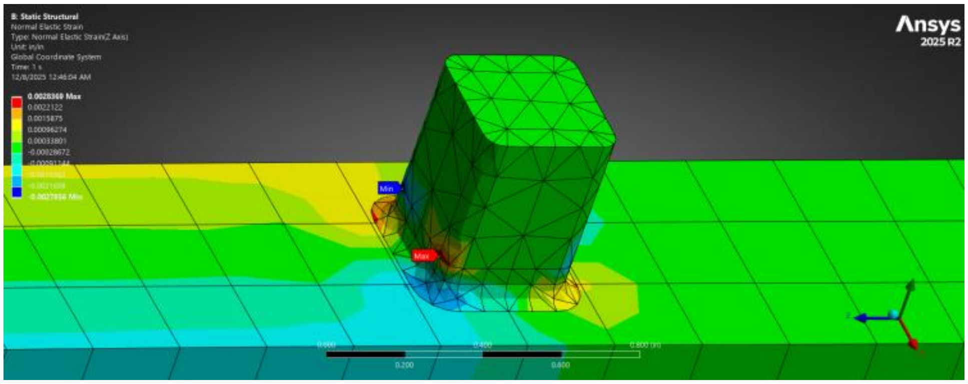


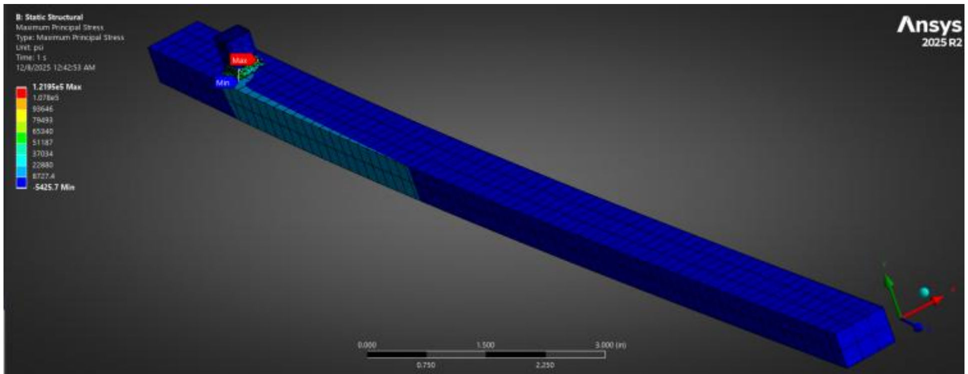

4)

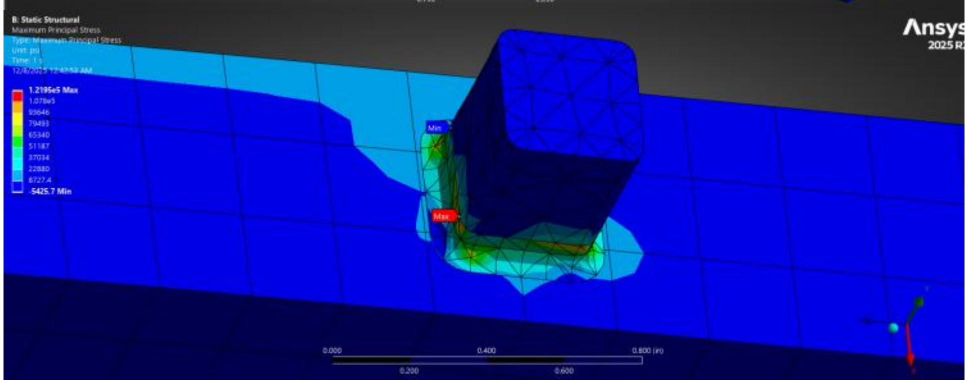


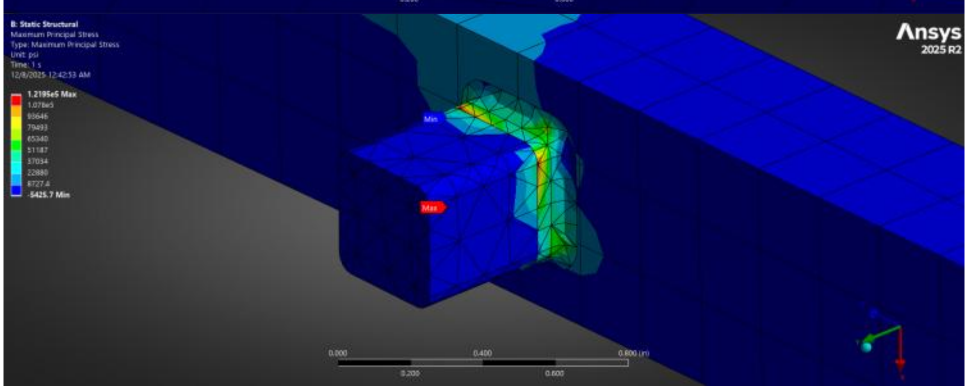





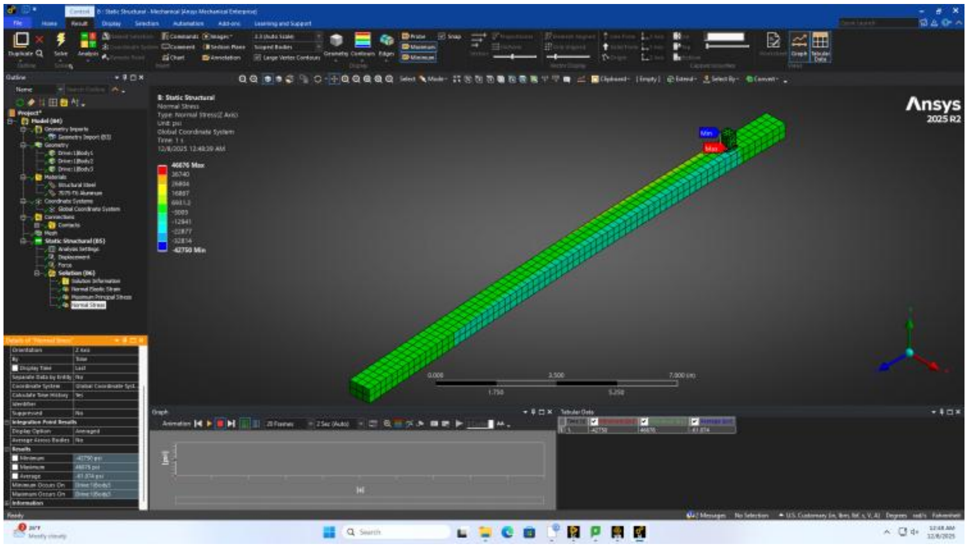

5)



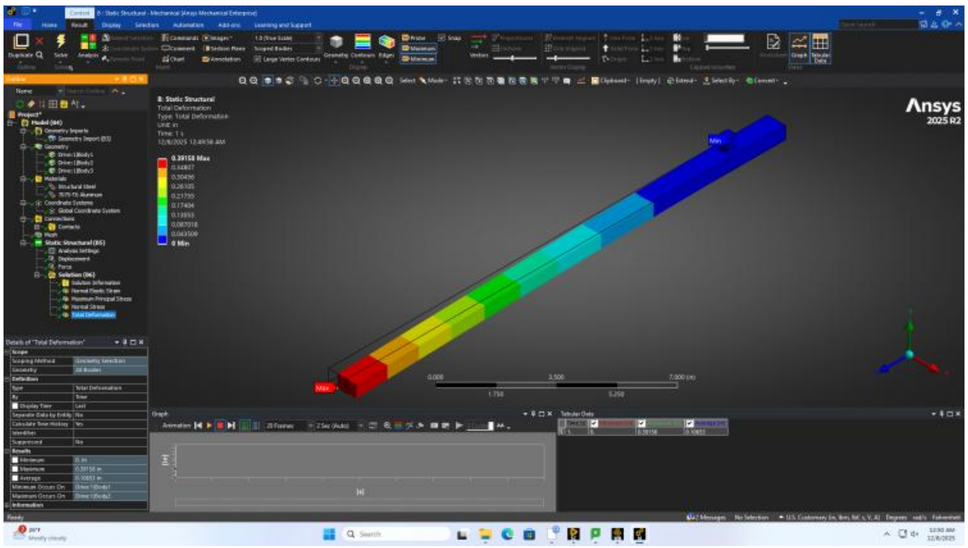



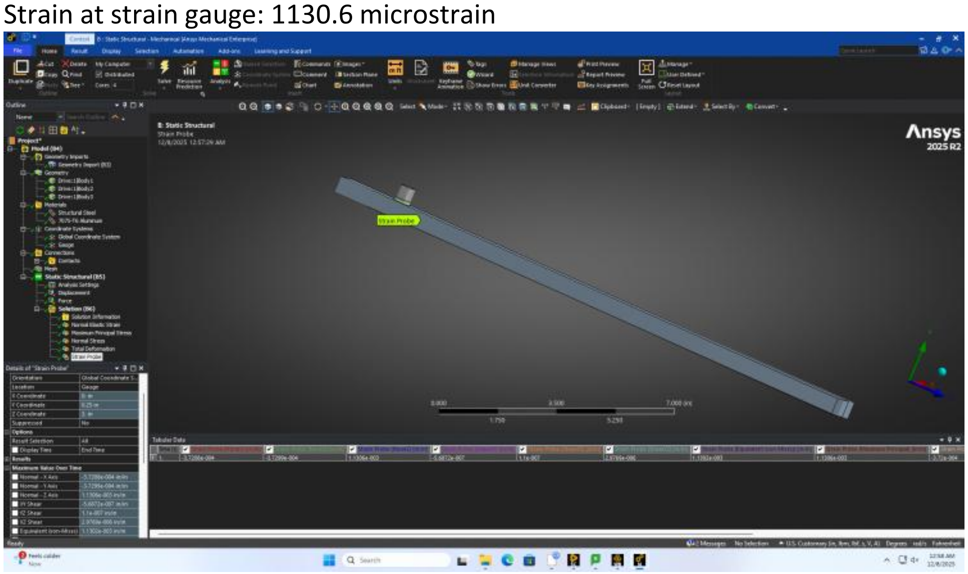

6) Max Normal Stress: 46676 psi = 46.676 ksi




Load Point Deflection: 0.39158 in




Strain at strain gauge: 1130.6 microstrain




7) 1.1302e-3 * 1000 = 1.1302 mV/V
8) Half bridge, c (distance from center of drive to center of strain gauge) = 1.0 in