Project 2 Report

MECHENG 5139: Applied Finite Element Method

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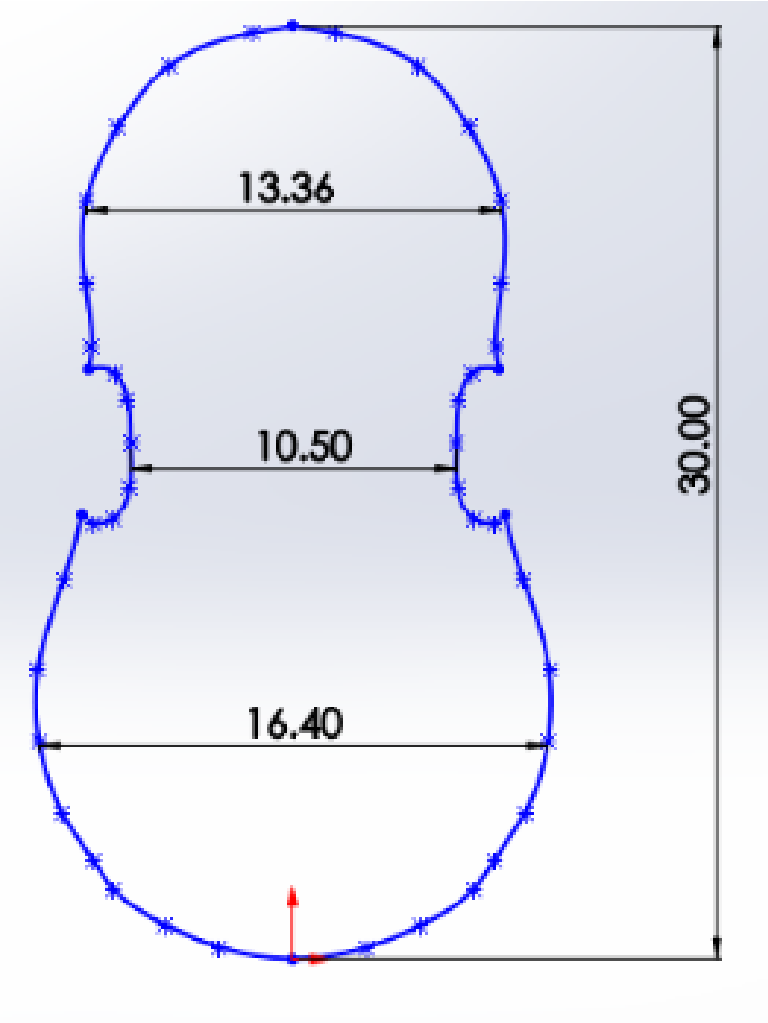
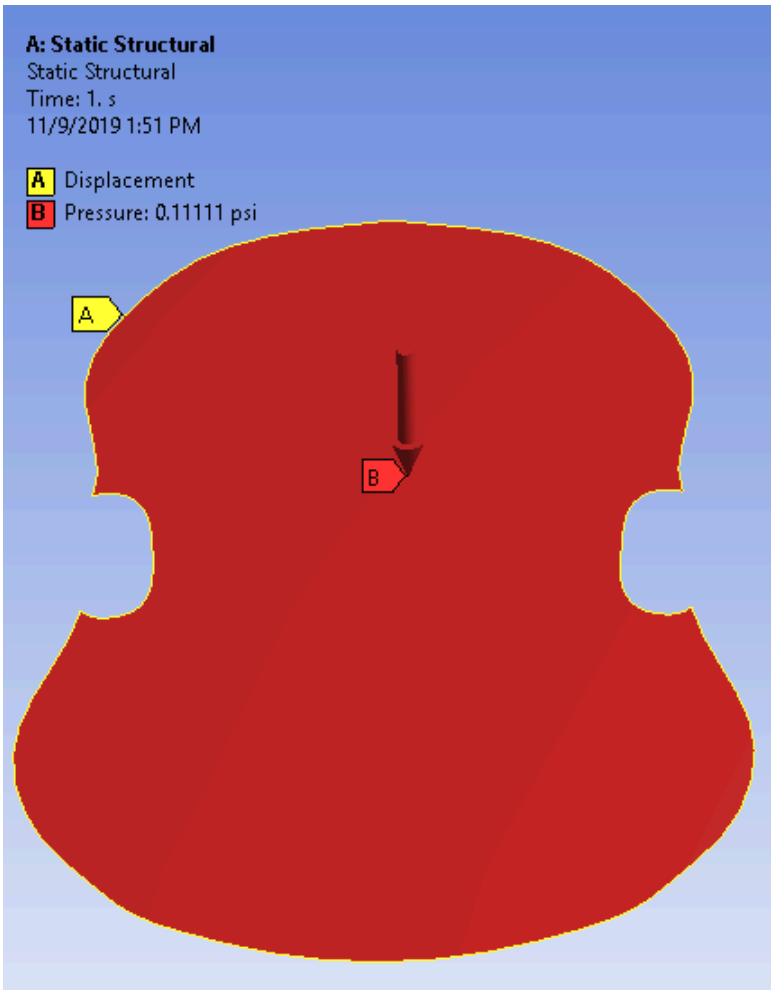
Overview

When Steven Sharp Nelson performs with the Trans-Siberian Orchestra, he gets carried away: he grabs his maple cello by the base of the neck and smashes the back face flat on the ground (similar to smashing a guitar). This exerts a uniform pressure of 0.1111 psi into the face. The dimensions in inches of this ¼-inch-thick face is shown below.



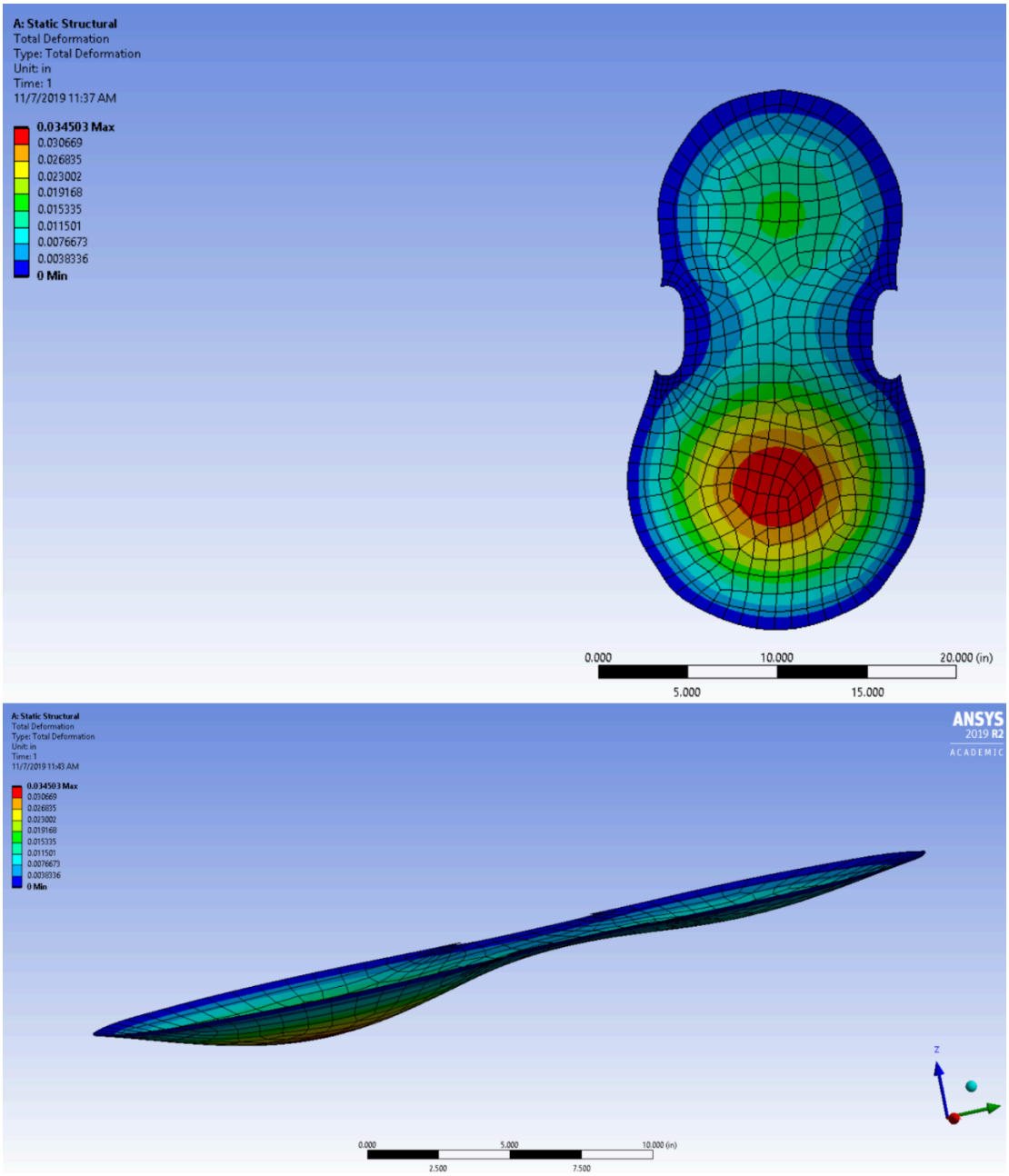
Description of FEA Model

Structural and modal analyses were done using two quadrilateral mesh densities (1-inch and 0.5-inch). All outside edges were given a zero-displacement condition in the x, y, and z directions to mimic rib support. A normal pressure of 0.1111 psi was also added into the back face.

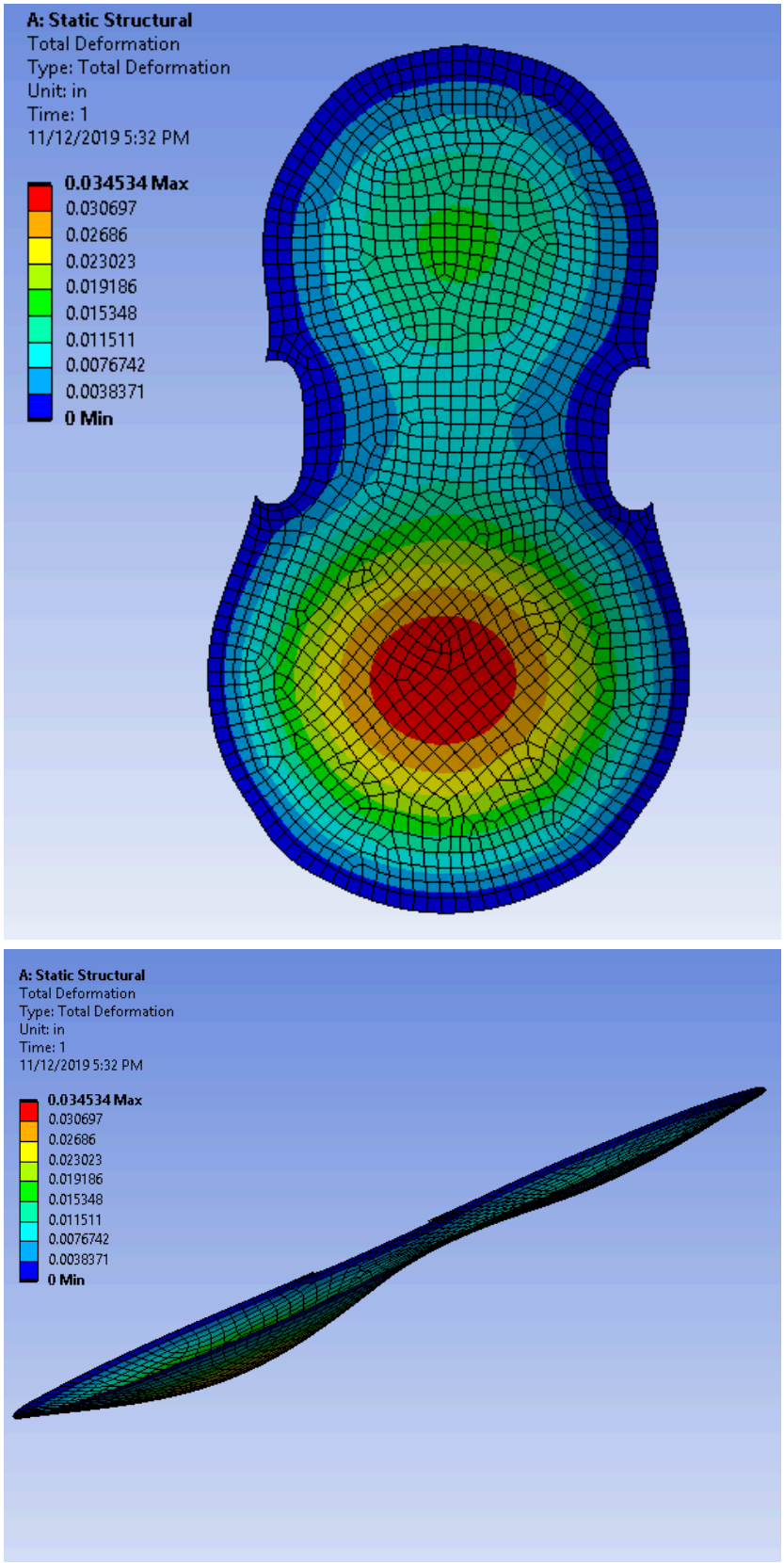


Results

Mesh Size	Total Deformation
1-inch quadratic	0.034503 in
0.5-inch quadratic	0.034534 in



1-inch quadratic mesh



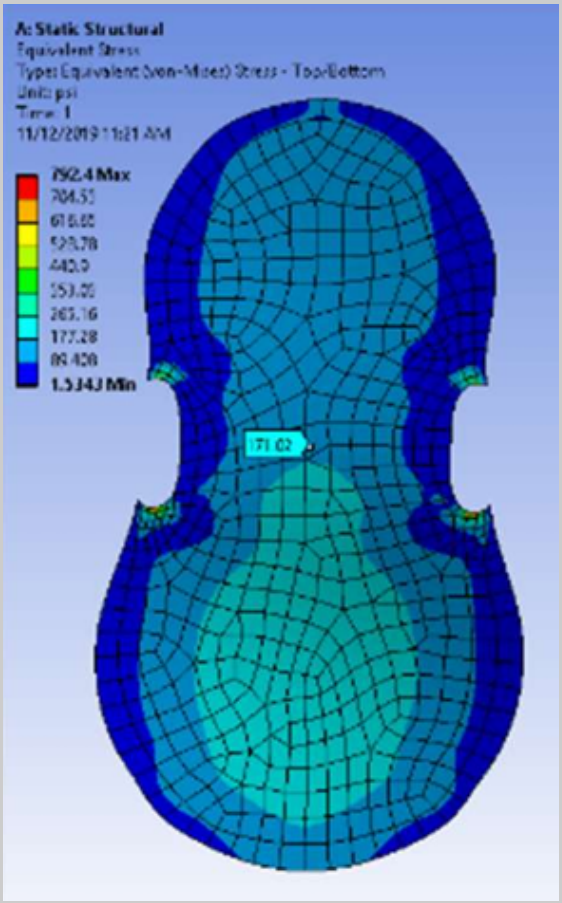
0.5-inch quadratic mesh

Verification

The cello can be approximated as a rectangle of length a = 15 in, height b = 30 in, and thickness h = 0.25 in. The case of clamped edges and uniform pressure loading was used for the following calculations. To verify the accuracy of the structural analysis, the stress and deflection at the center of the cello were checked.

$$\sigma_{maple} = \frac{p\,a^2}{2t^2\left[0.623\left(\frac{a}{b}\right)^6+1\right]} = \frac{\left(0.1111\frac{lb}{in^2}\right)(15in)^2}{2\,(0.25in)^2\left[0.623\left(\frac{15in}{30in}\right)^6+1\right]} = 198.0445\ psi$$

NOTE: This is close to the probed value of **171.02 psi**!



$$\delta_{lower,\ maple} = \frac{0.0284\, p\, a^4}{Et^3\left[1.056\left(\frac{a}{b}\right)^5+1\right]} = \frac{0.0284\left(0.1111\frac{lb}{in^2}\right)(15in)^4}{\left(1.62*10^6\frac{lb}{in^2}\right)(0.25in)^3\left[1.056\left(\frac{15in}{30in}\right)^5+1\right]} = 0.0061\ in$$

$$\delta_{upper,\ maple} = \frac{0.0284\, p\, a^4}{Et^3\left[1.056\left(\frac{a}{b}\right)^5+1\right]} = \frac{0.0284\left(0.1111\frac{lb}{in^2}\right)(15in)^4}{\left(1.08*10^5\frac{lb}{in^2}\right)(0.25in)^3\left[1.056\left(\frac{15in}{30in}\right)^5+1\right]} = 0.0916\ in$$

NOTE: These values correctly surround the probed value of **0.00923 in**!