Optimization of Violin Sound Quality

Phase 1

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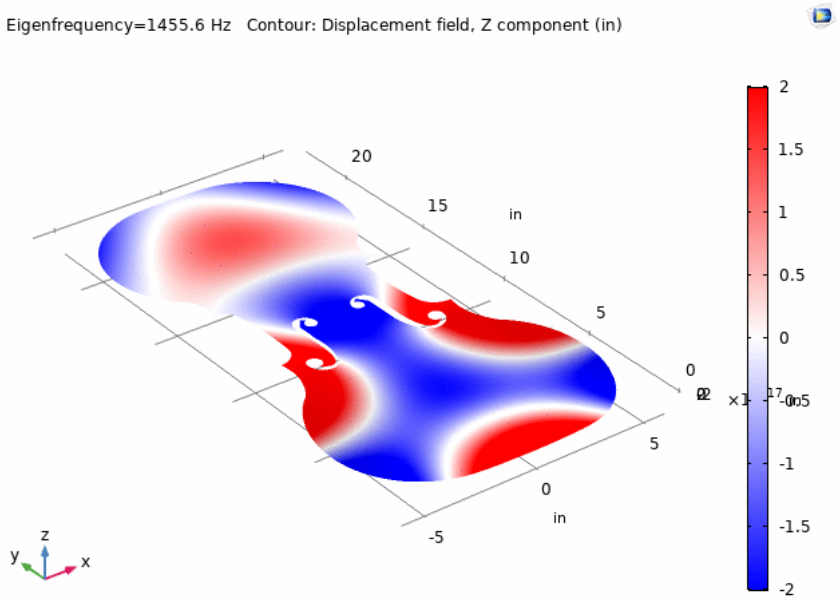


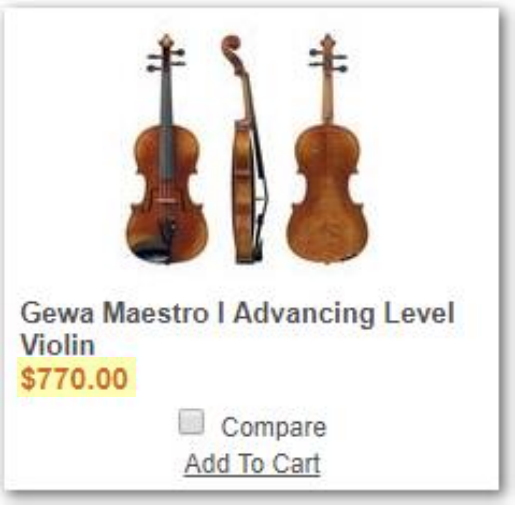
Buying a Violin

Luthier

Online

Buying a Violin - Luthier

AUDUBON STRINGS
Repairs
Rentals • Sales
Consignments



Clark Instruments
Quality Craftsmanship and Service
for the String-Instrument Community --- Tom Clark

Violins
2014 Juzek student violin, 4/4 to 1/10, Strad model with ebony fittings, Prelude strings. Includes case and bow, $350

Buying a Violin - Online

Glarry Full Size 4/4 Matte Violin for Beginners Christmas gift,Carrying Voilin Case,Bow,Shoulder Rests,Four-hole tuner,extra...

2.5 out of 5 stars ˅ 4

$33.99

FREE Shipping

Teekland New 4/4 Acoustic Violin & Case & Bow & Rosin for Violin Beginner (Green)

3.5 out of 5 stars ˅ 8

$38.86

FREE Shipping

ViolinSmart Full Size 4/4 Violin

3 out of 5 stars ˅ 135

$38.99

FREE Shipping

Buying a Violin

Chladni Patterns

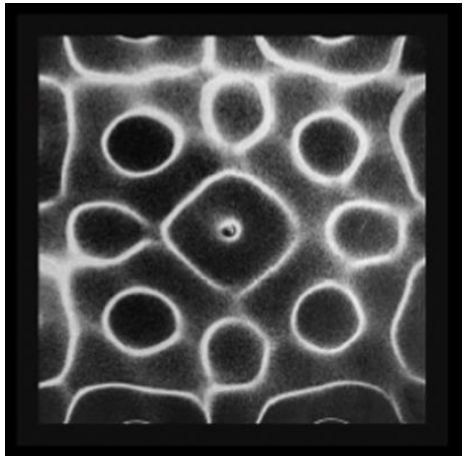
Used to visualize the effects of vibration of mechanical systems

- This helps study the impact of various alterations
- Study the impact of violin geometry and material on the resonances of a violin

Chladni Patterns

Requirements:

- Constrained at the center
- No initial velocity
- No initial displacement

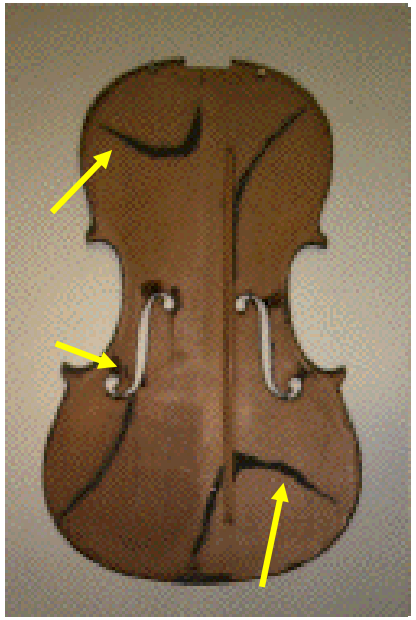


Chladni Patterns

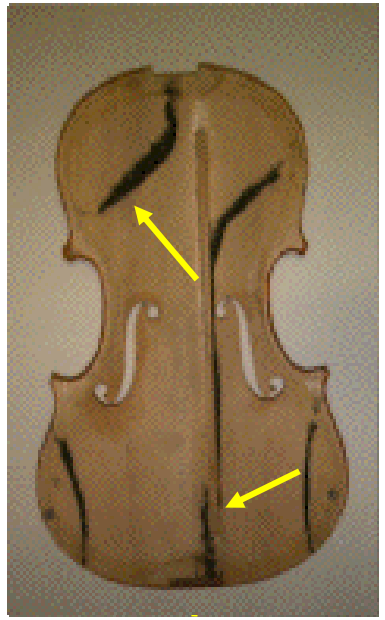
Used to visualize the effects of vibration of mechanical systems

- Luthiers use Chaldni patterns to improve resonance and sound quality in hand-made instruments
- If the geometry of a mass-produced violin is improved, sound quality of the instrument can go up

Luthier-Made



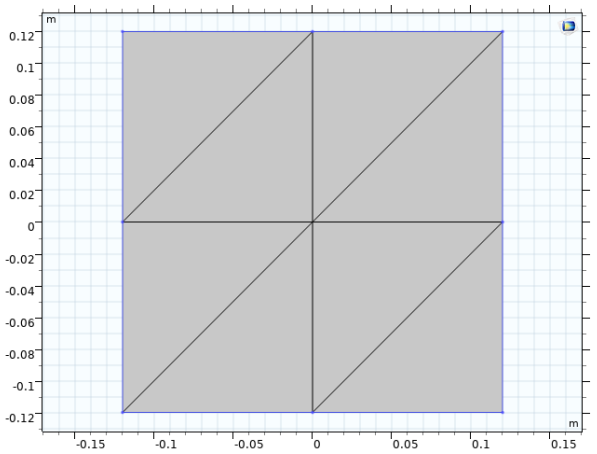
Mass-Produced

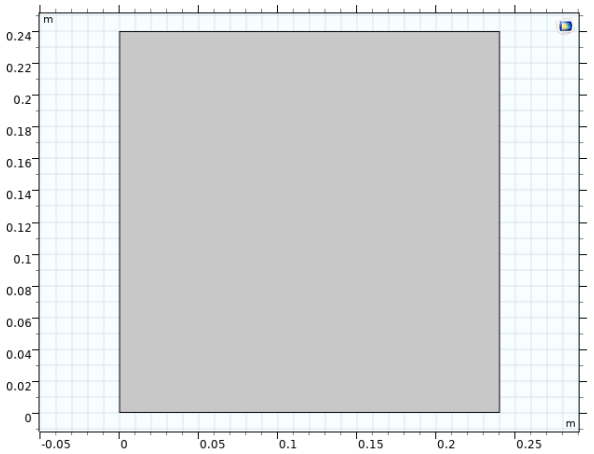


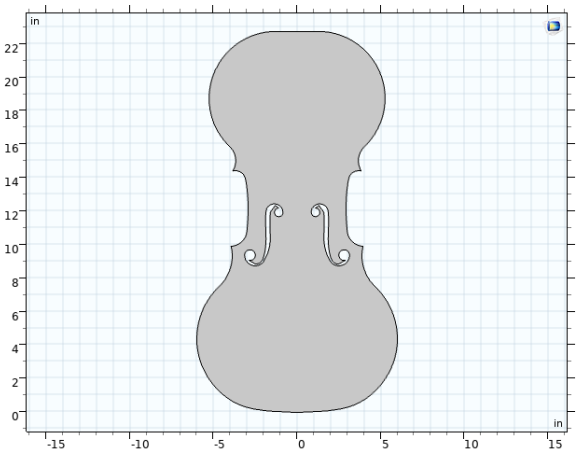
COMSOL Specifics

- Physics
  - Structural Mechanics – Plate Module
- Boundary Conditions
  - Constrained at the center of the body
  - Unconstrained edges with no loads
- Frequency Range
  - 175 Hz - 2700 Hz, a range chosen based on the pitch range of the violin, i.e. G3 = 196 Hz through ~E7 = 2637 Hz.
- Geometry
  - Thickness = 10mm

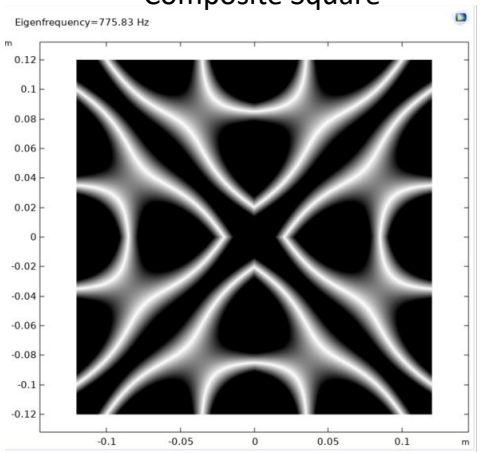
Getting to a Violin



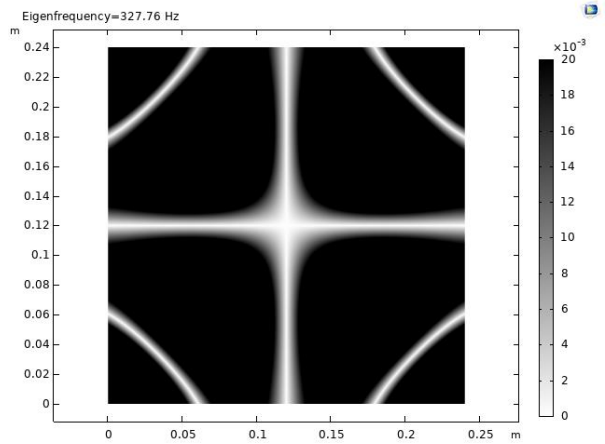




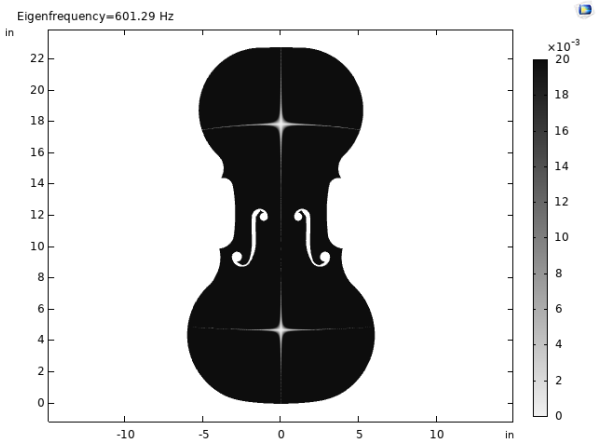
Composite Square



Full Square

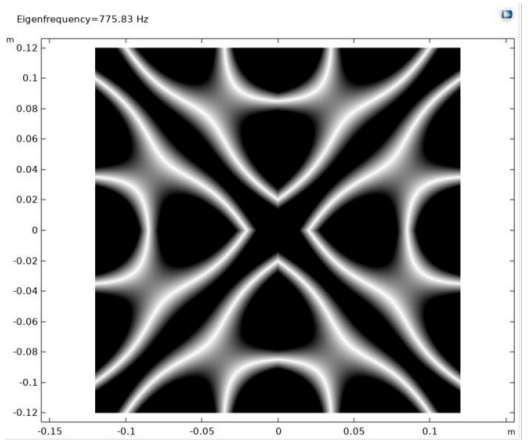


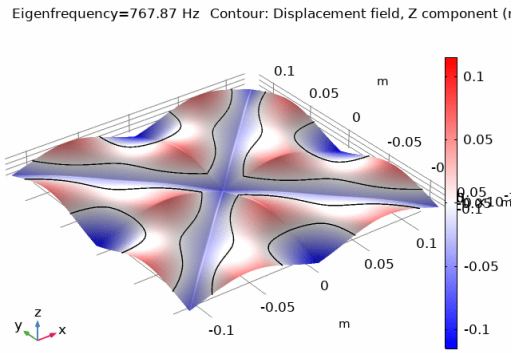
Violin



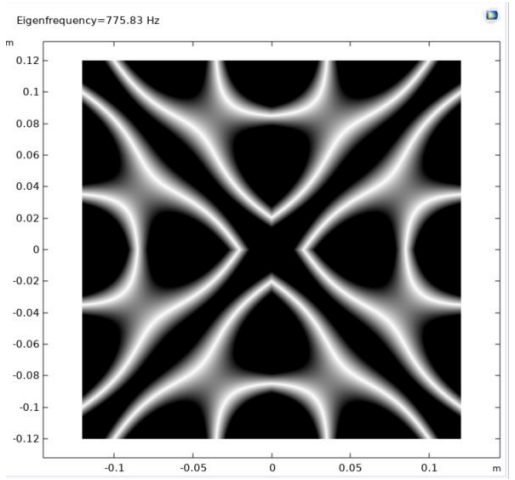
Composite Square

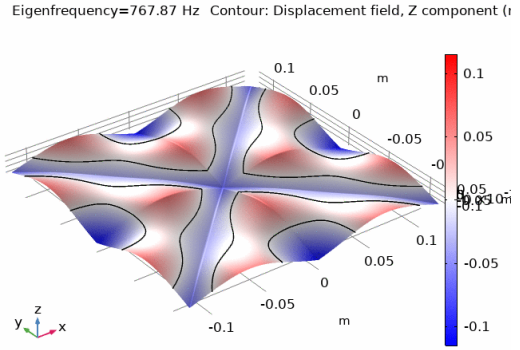
COMSOL Model:



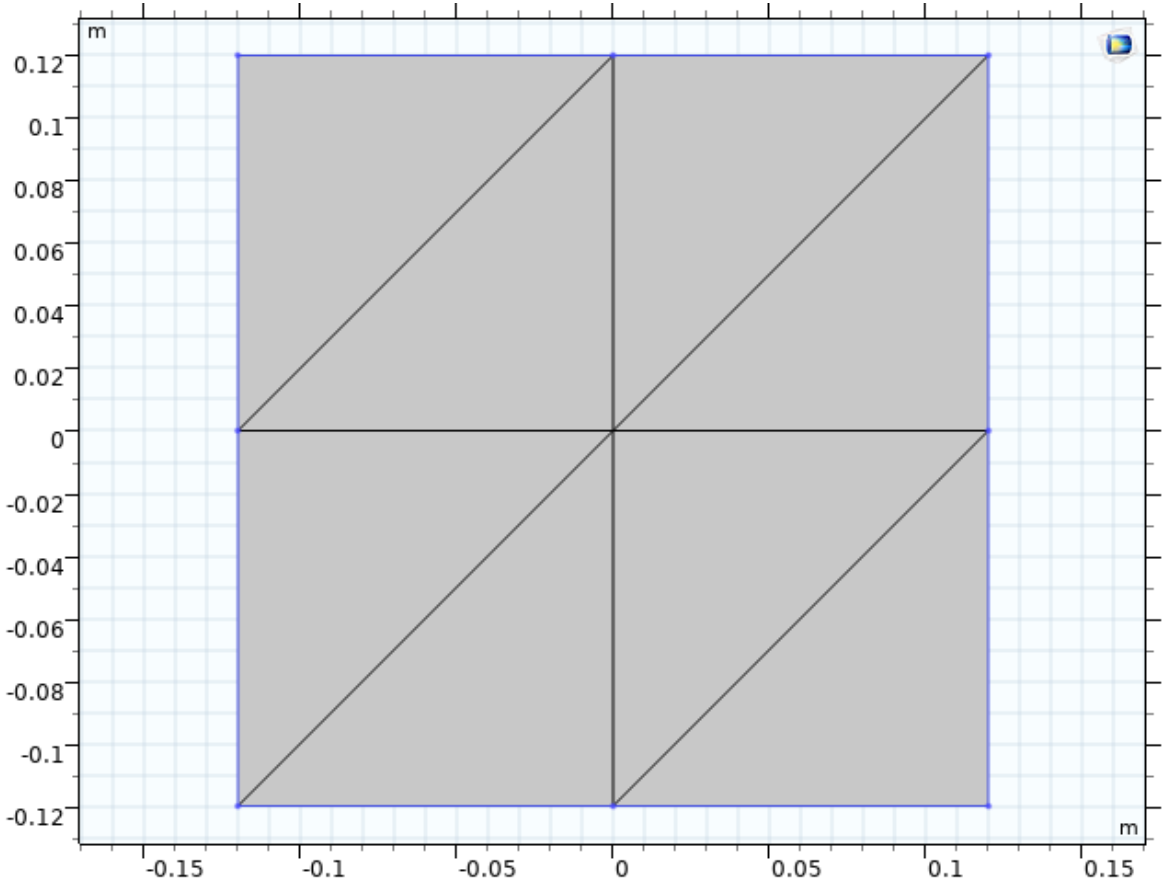


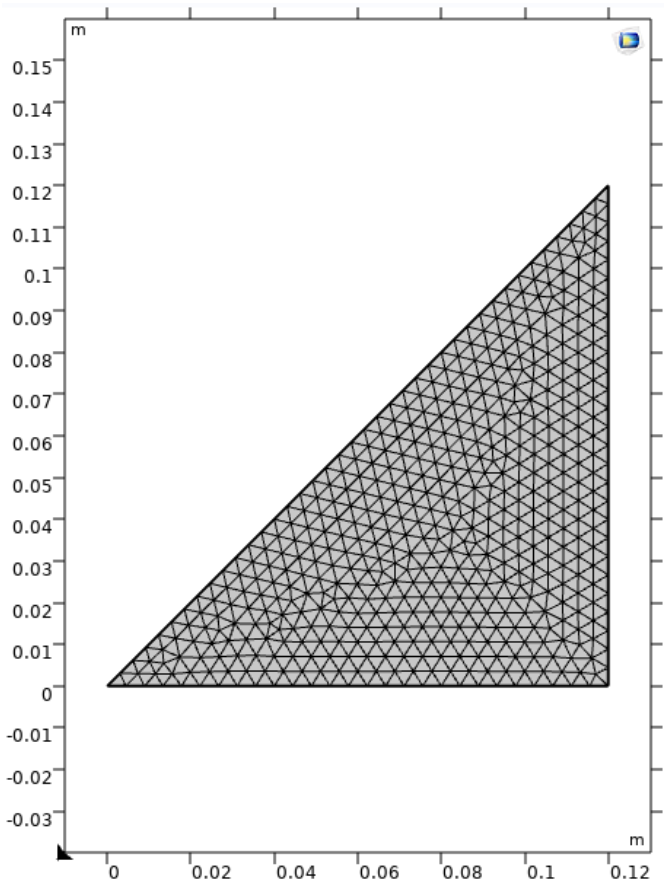
Rebuilt Validation Model:





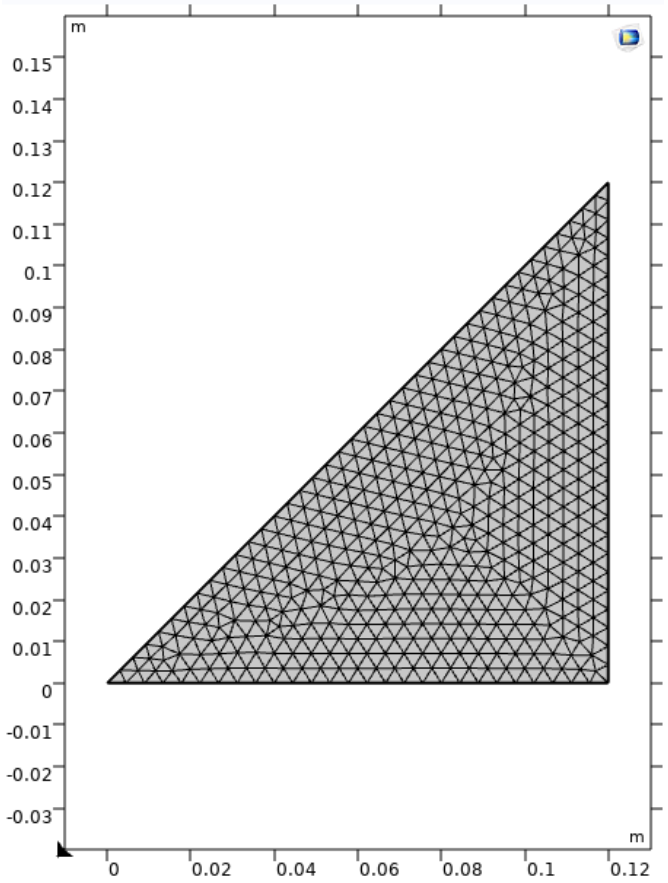
Composite Square



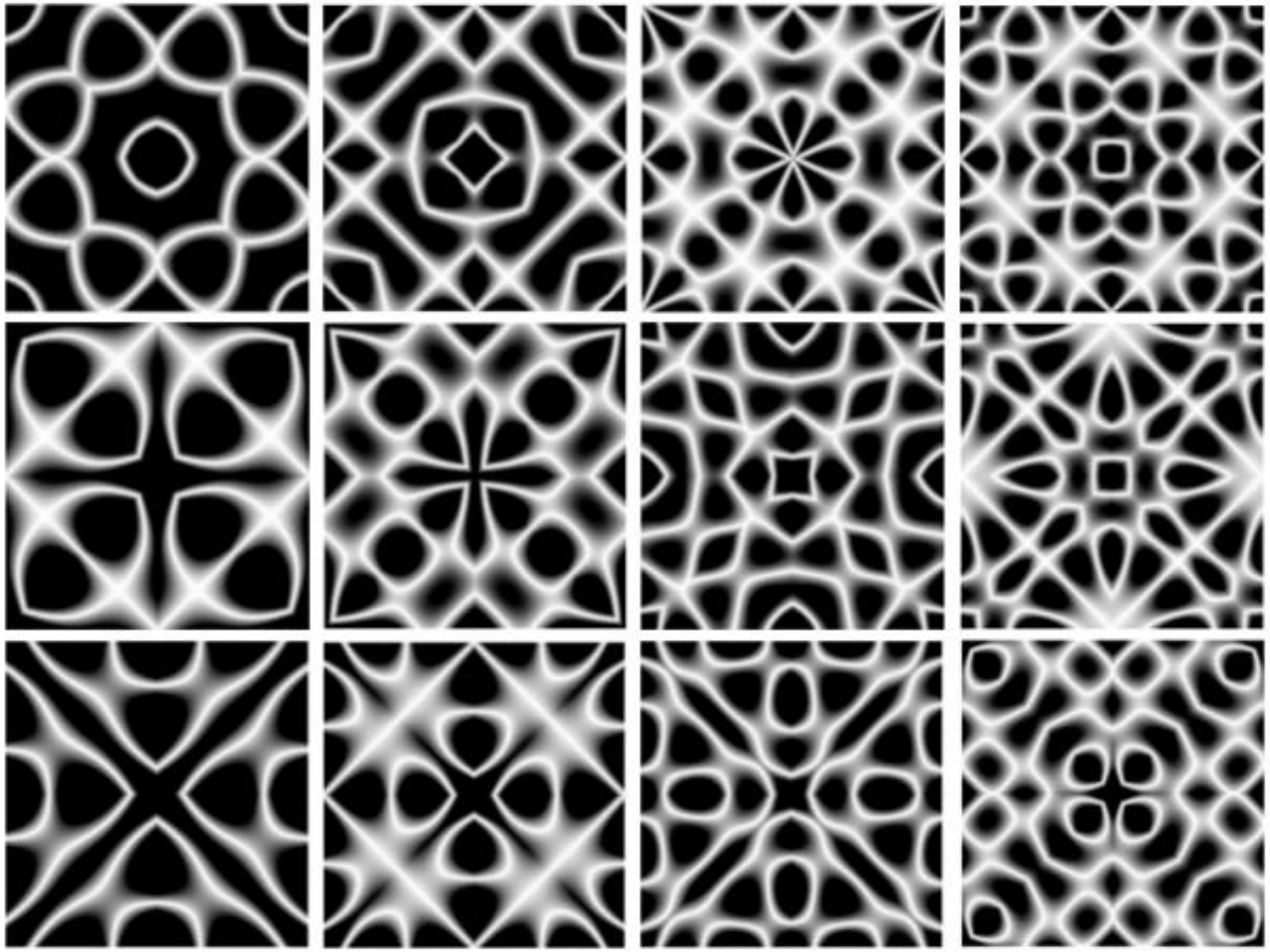


Composite Square

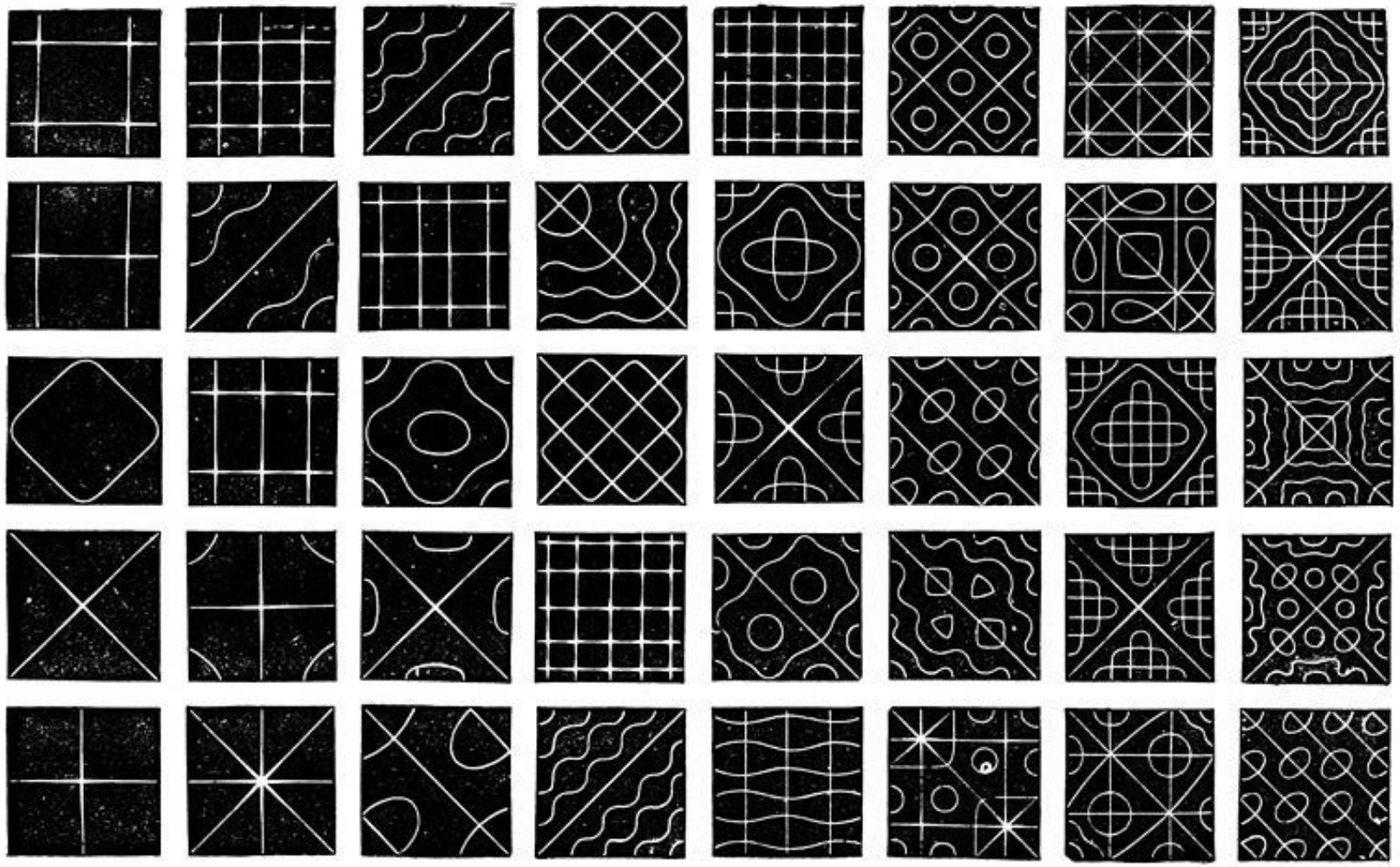
- Mesh:
  - Triangular Elements
  - Physics-Controlled
    - Finer
  - Elements: 1043
  - Average Quality: 0.98
- Material: AISI Steel 4340



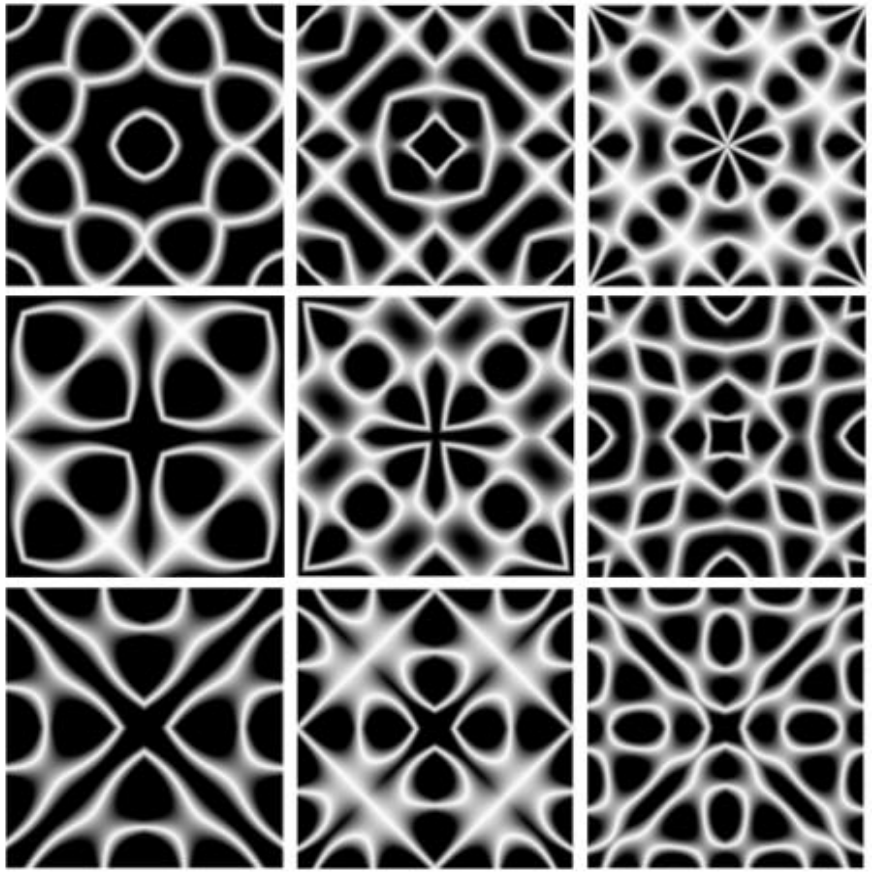
Composite Square Results



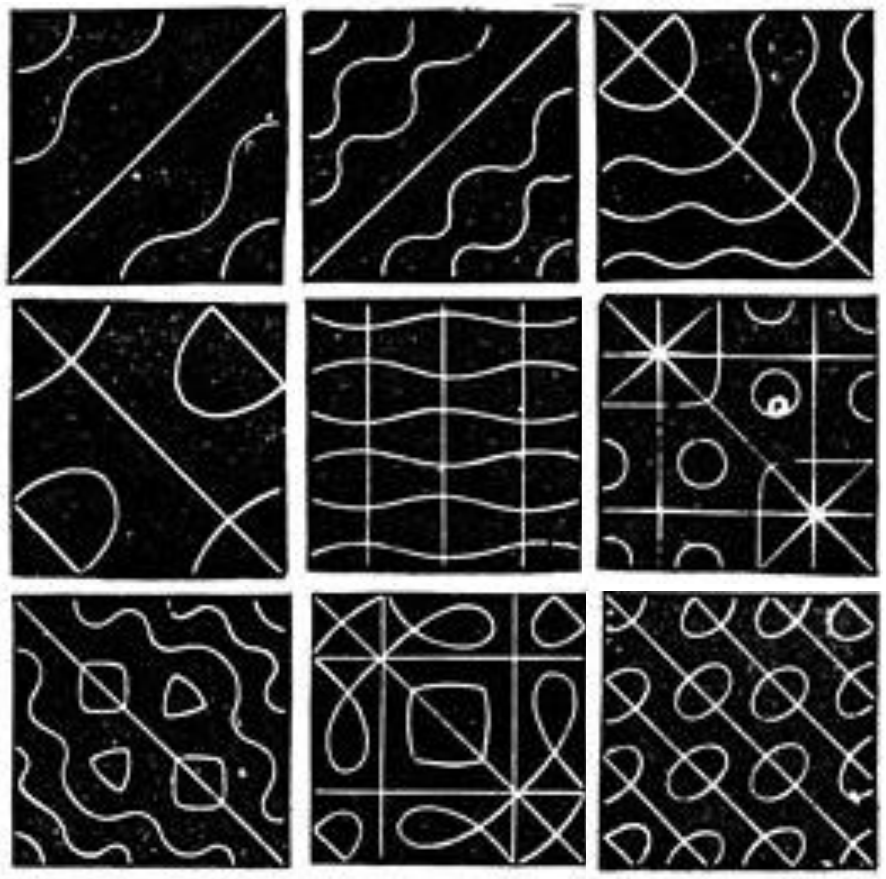
Composite Square Results



Composite Square Results

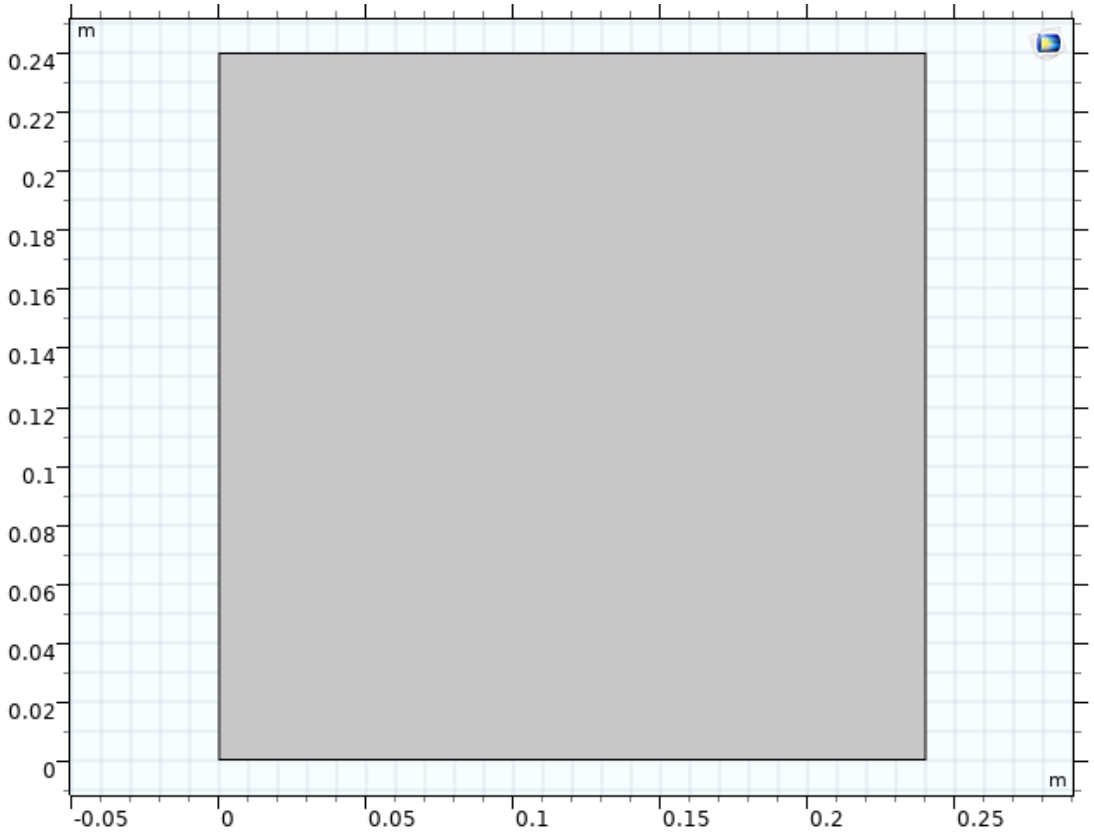


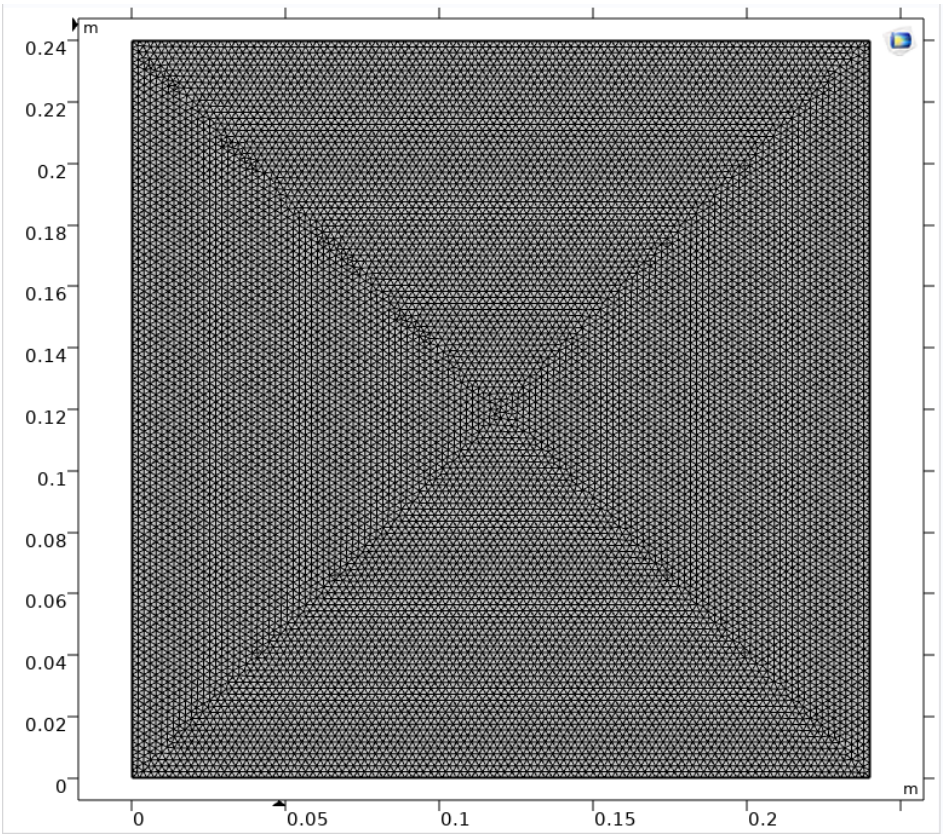
Simulation



Physical Experimentation

Improvement – Full Square

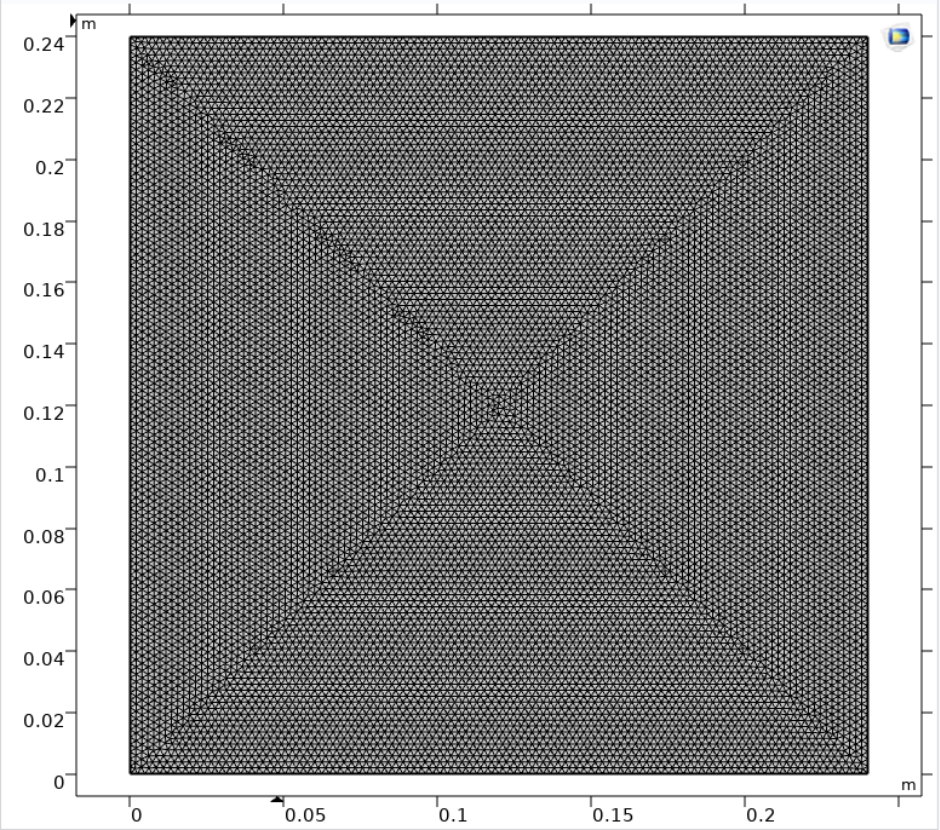




Improvement – Full Square

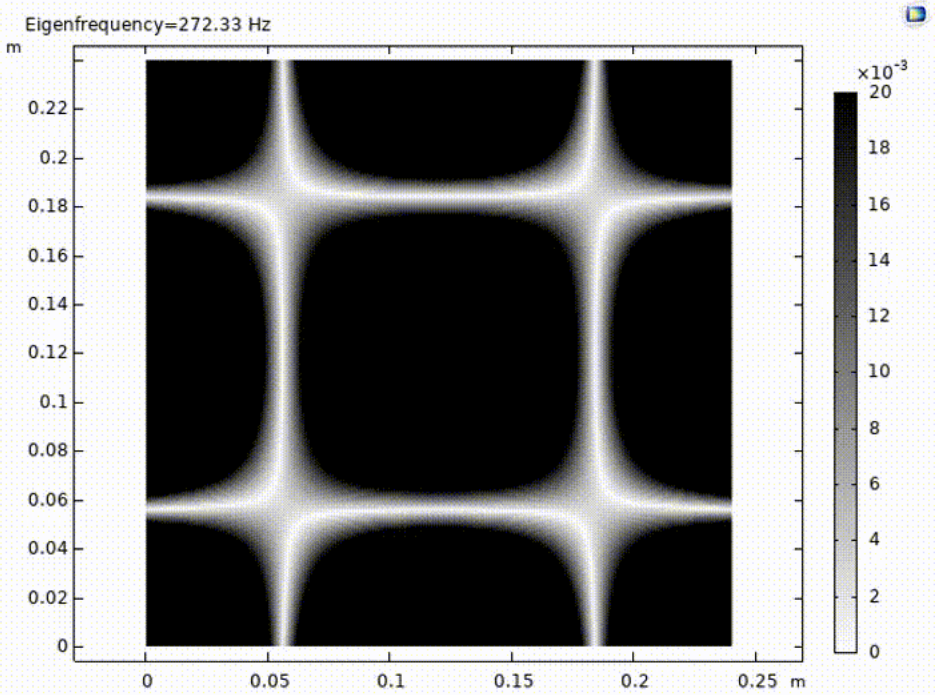
- Mesh:
  - Triangular Elements
  - Physics-Controlled
    - Extremely Fine
  - Elements: 25316
  - Average Quality: 0.99

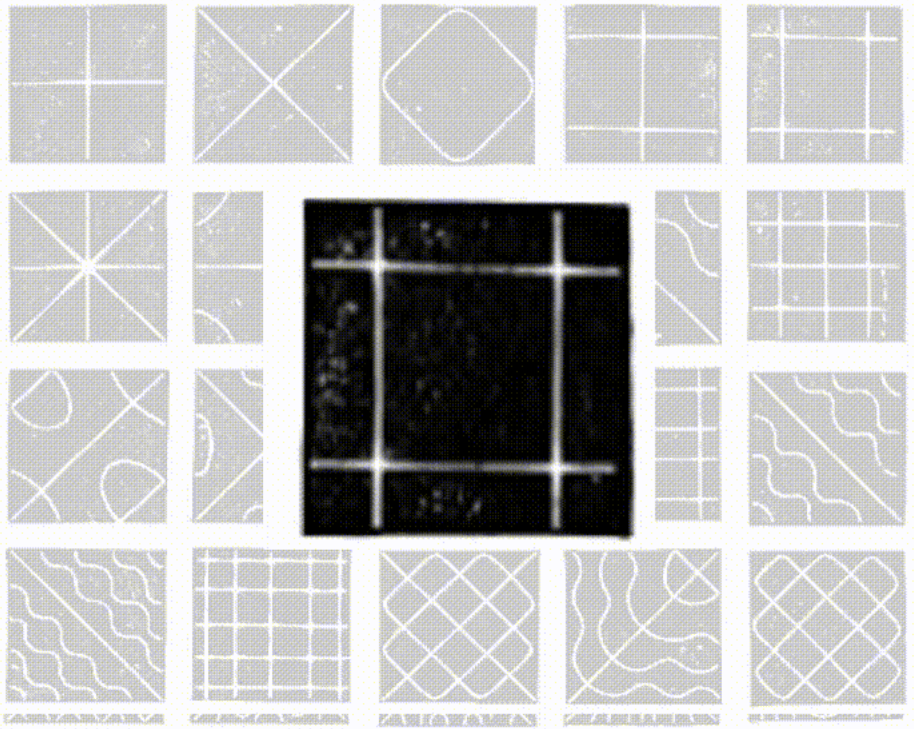
- Material: AISI Steel 4340



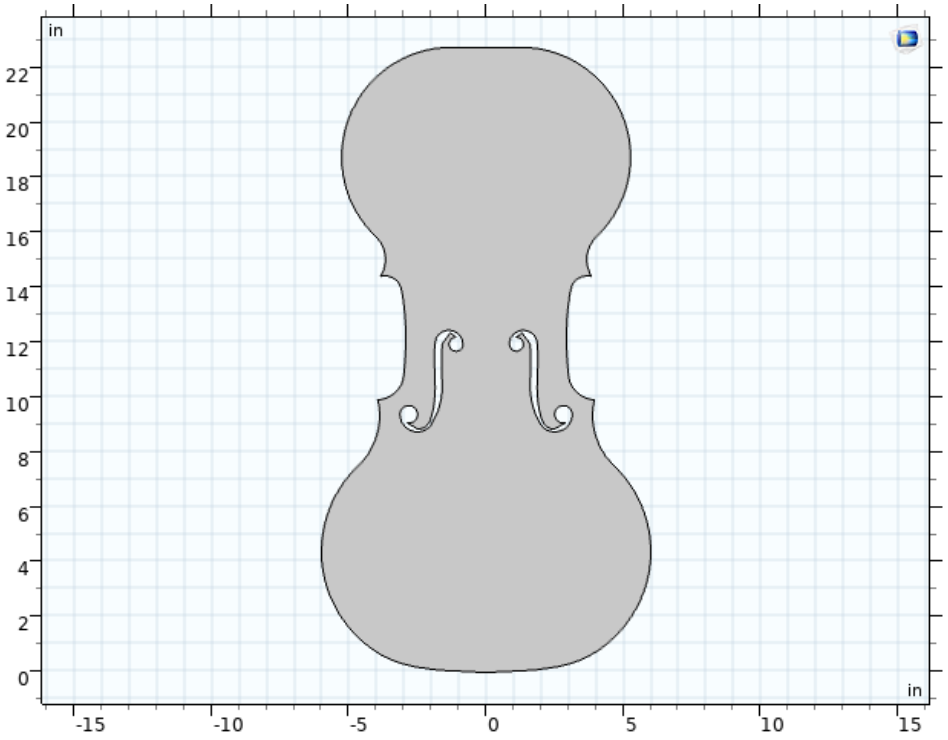
Improvement – Full Square

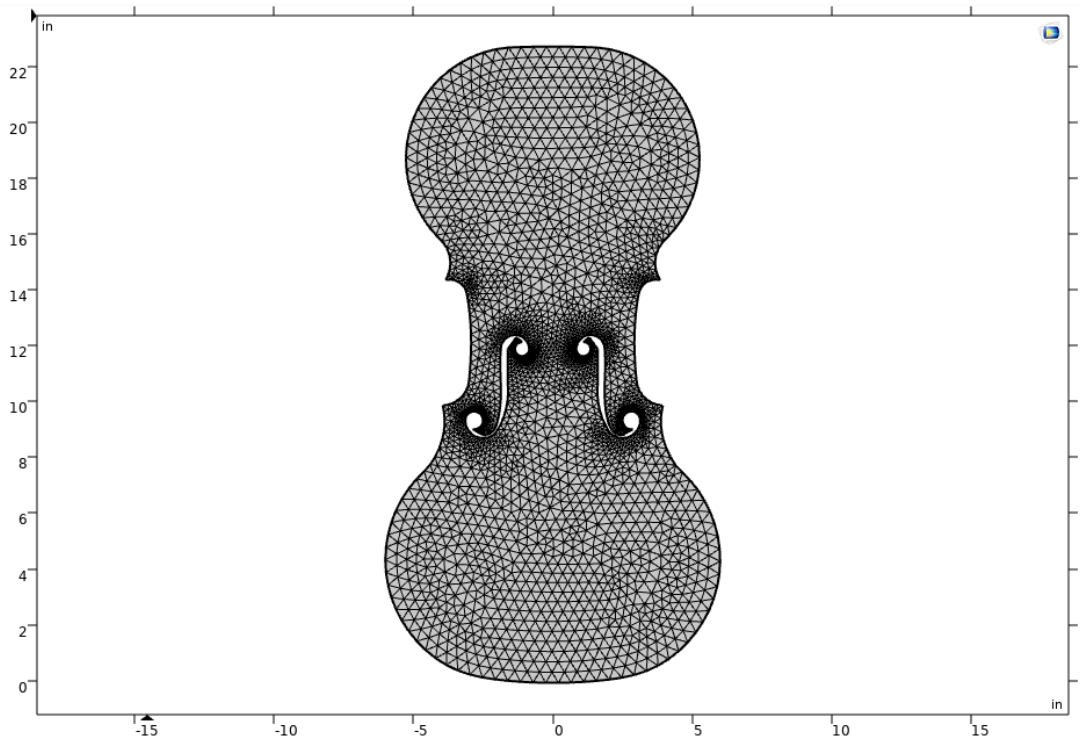
- After validating my model was working like the previously constructed one, I could go in and add more geometries





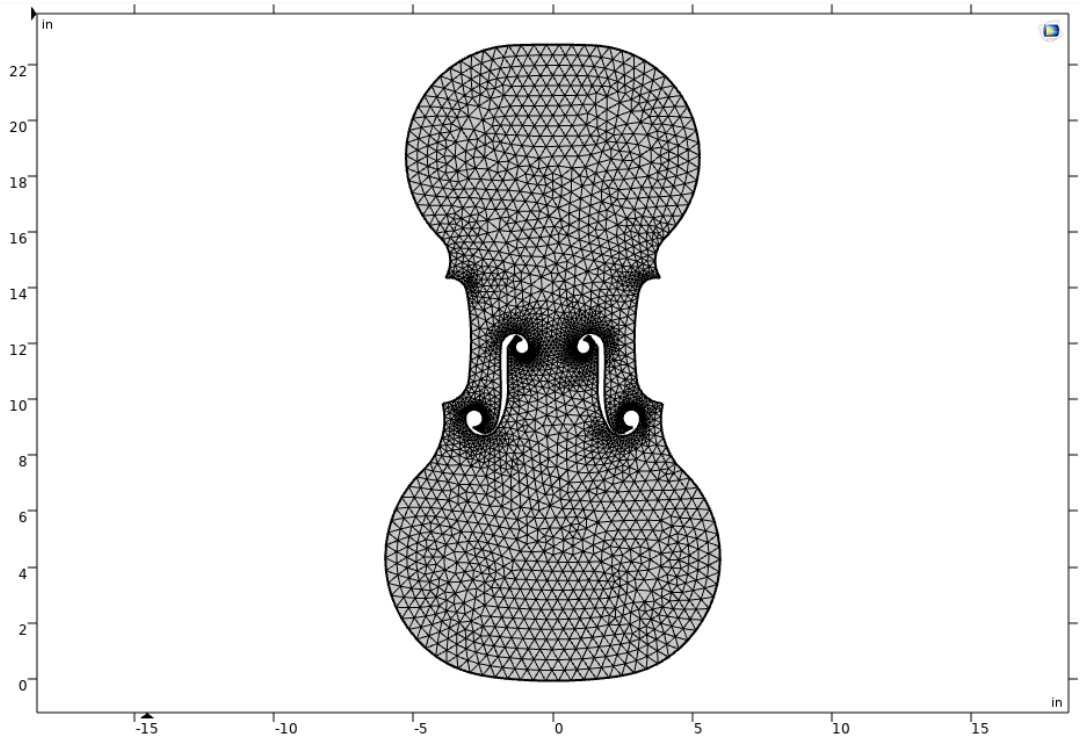
Improvement - Violin





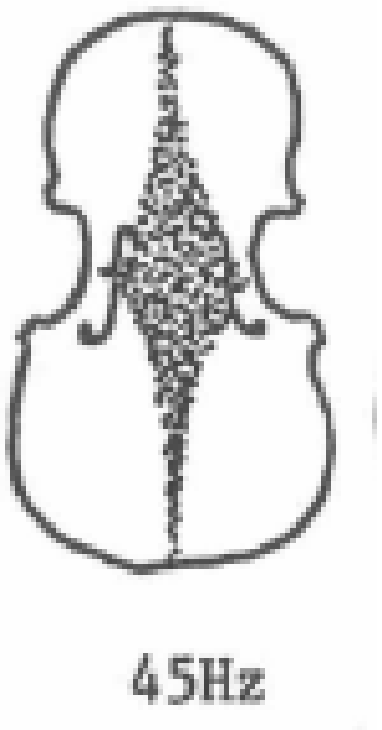
Improvement - Violin

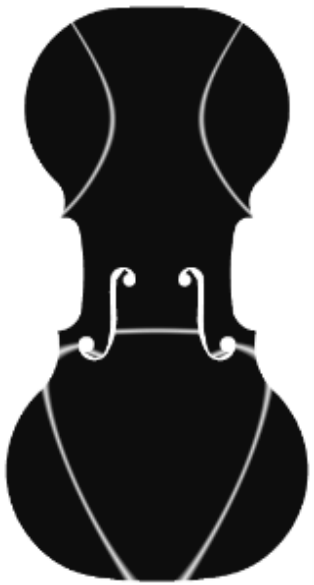
- Mesh:
  - Tetrahedral Elements
  - Physics-Controlled
    - Extra Fine
  - Elements: 213397
  - Average Quality: 0.63
- Material: Generic Softwood



Improvement - Violin

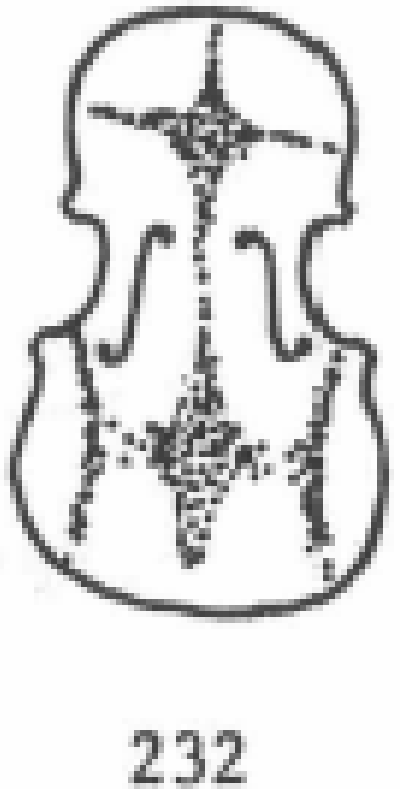
176.13 Hz





420.4 Hz

1272.7 Hz



Causes of Error

- Generic Softwood
  - Pine vs Maple vs Spruce
- Wood is anisotropic
  - Variance with grain pattern
- 2D vs 3D
  - Curvature in z-direction
- Thickness
  - Variable thickness at different parts of the violin

Benefits

- Lowered Material Cost
  - Because the exact geometry is known for the violin, no excess material needs to be bought to account for building inaccuracies
- Lowered Labor Cost
  - As everything is electronic, it will take less time for these violins to be produced, allowing for lowered labor costs as there is not as much work to be done
- Better Sound Quality
  - The violins made using this geometry will sound much better than those that are made by similar processes. This will allow for a better variety and a better quality of affordable violins.

Going Forward

- Implement more materials
- Improve geometry
  - Front plate
  - Full body
- Create a working application
- Perform a sound quality study
  - Metrics
    - Pitch, tone, timbre, loudness
  - Jury studies
- My hope is that some day, this research will be used to make violins better and more affordable, so that more children can experience the love and appreciation I have both for the violin and for music as a whole.

Acknowledgements

Dr. Ivana Milanovic

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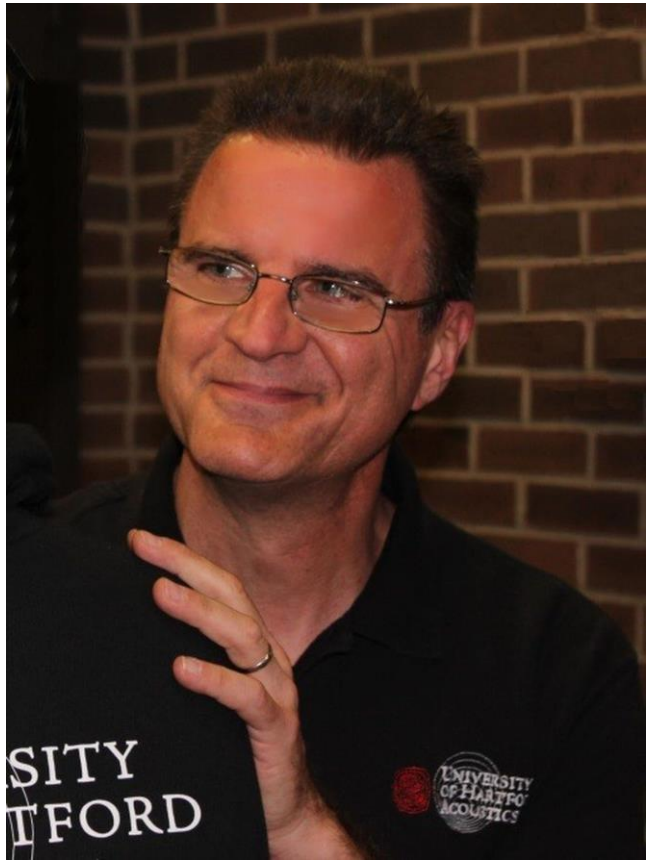
THE WOMEN'S ADVANCEMENT INITIATIVE

CONTINUING THE LEGACY OF HARTFORD COLLEGE FOR WOMEN



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