



***Universitat Politècnica De Catalunya, BarcelonaTech  
Masters in Computational Mechanics***

***Course  
Computational Structural Mechanics and Dynamics***

# **Assignment 8**

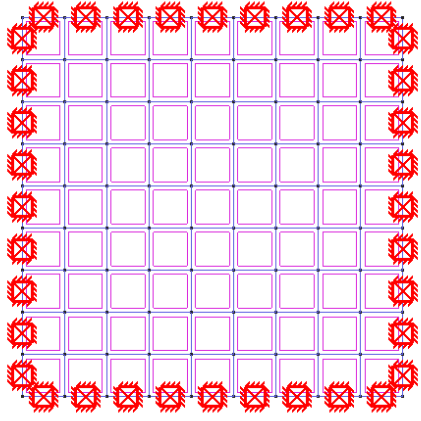
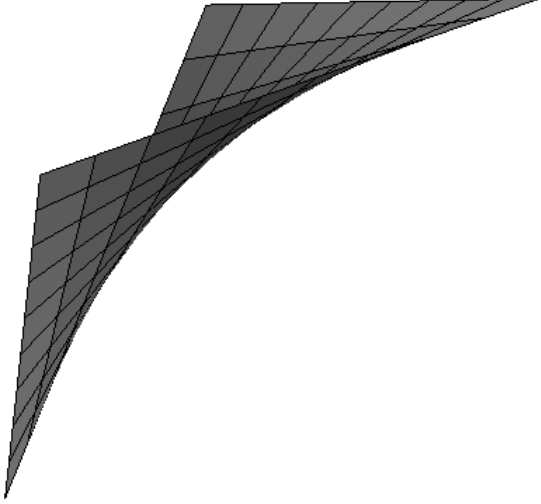
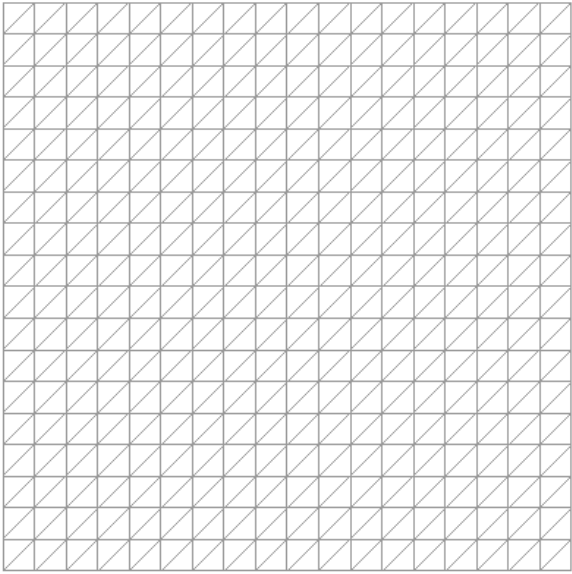
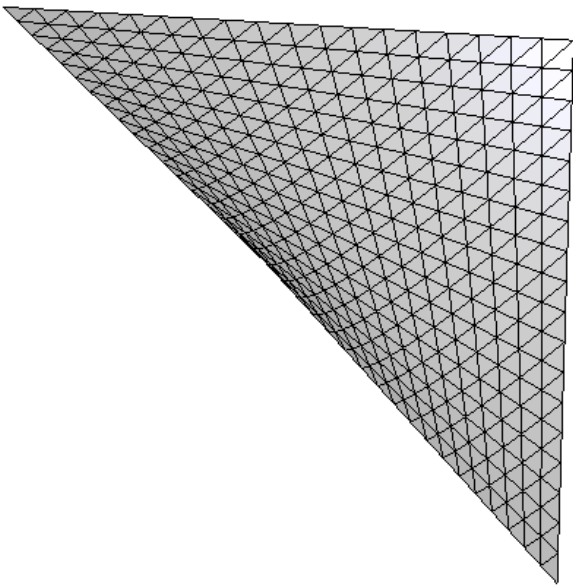
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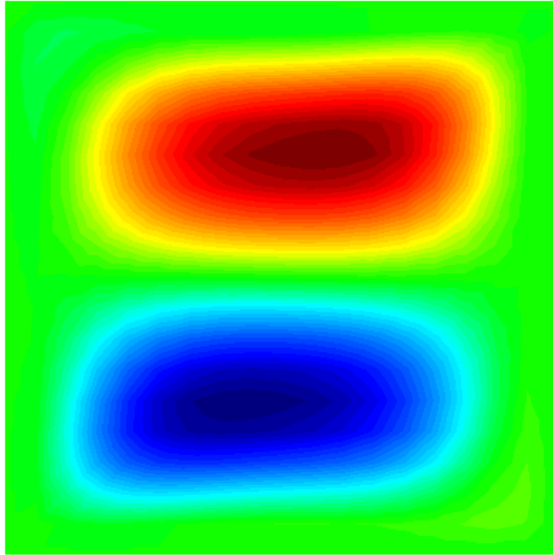
**SAMADRITA KARMAKAR**

## Assignment

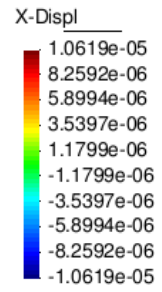
Analyse the following concrete hyperbolic Shell under self weight. Explaining the behaviour of all the Stresses presented.  $T = 0.1$

### Analysis:

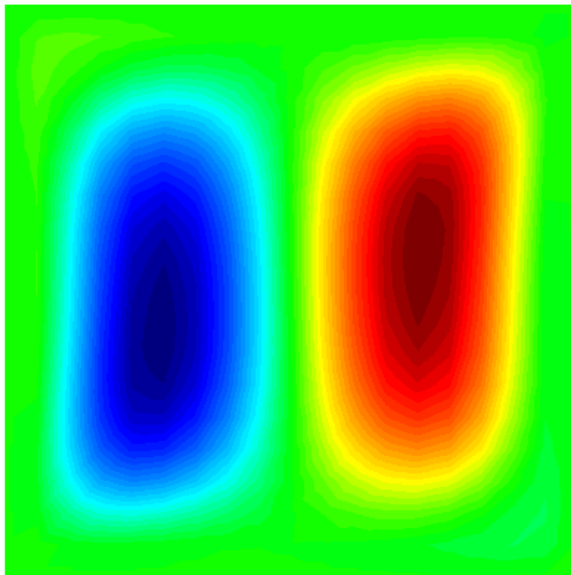
 <p>A top-down view of a hyperbolic shell structure. The shell is represented by a grid of purple squares. The outer boundary of the shell is marked with red 'X' symbols, indicating where constraints are applied. The shell is roughly circular in shape, with a slight inward curve at the top and bottom.</p>	 <p>A 3D perspective view of the hyperbolic shell. The shell is shown as a dark gray surface with a grid of lines. The shell is curved, with a slight inward curve at the top and bottom, and a slight outward curve at the sides. The shell is shown from a perspective that highlights its hyperbolic nature.</p>
<p>Top View With Constraints</p>	<p>View to show the Hyperbolic Nature of Geometry</p>
 <p>A top-down view of the mesh used for the analysis. The mesh is a grid of small triangles, colored in light gray. The mesh is roughly circular in shape, with a slight inward curve at the top and bottom. The mesh is shown from a perspective that highlights its hyperbolic nature.</p>	 <p>A 3D perspective view of the meshed hyperbolic shell. The shell is shown as a dark gray surface with a grid of lines. The shell is curved, with a slight inward curve at the top and bottom, and a slight outward curve at the sides. The shell is shown from a perspective that highlights its hyperbolic nature.</p>
<p>Top View of Mesh Number of Triangle Elements 648. Number of Nodes 361</p>	<p>View to show the Hyperbolic Nature of Meshed Geometry</p>



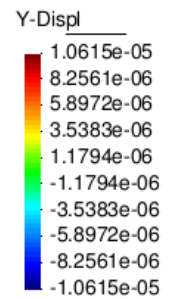
Contour Fill of Displacement, X-Displ.



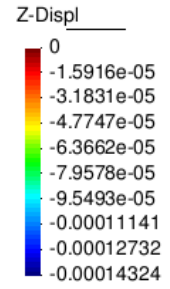
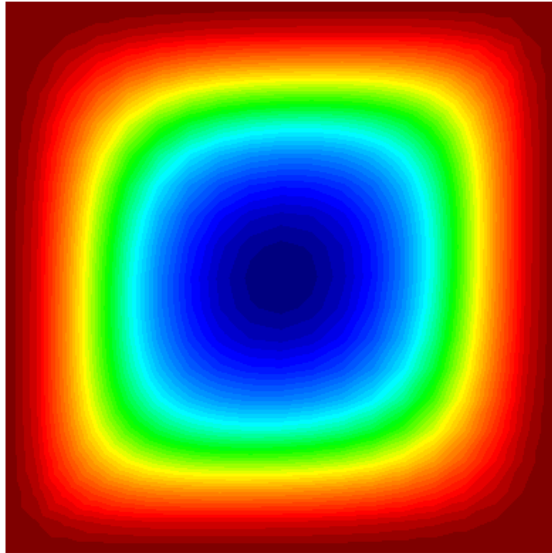
### Displacement in X-Direction



Contour Fill of Displacement, Y-Displ.

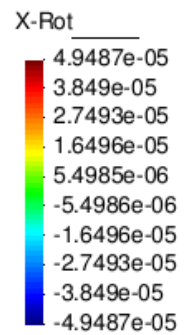
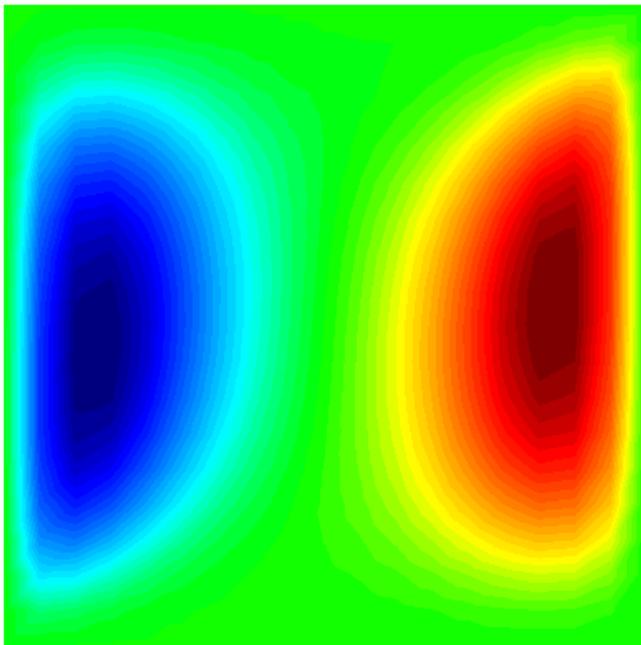


### Displacement in Y-Direction



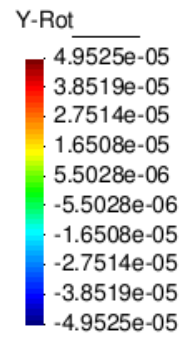
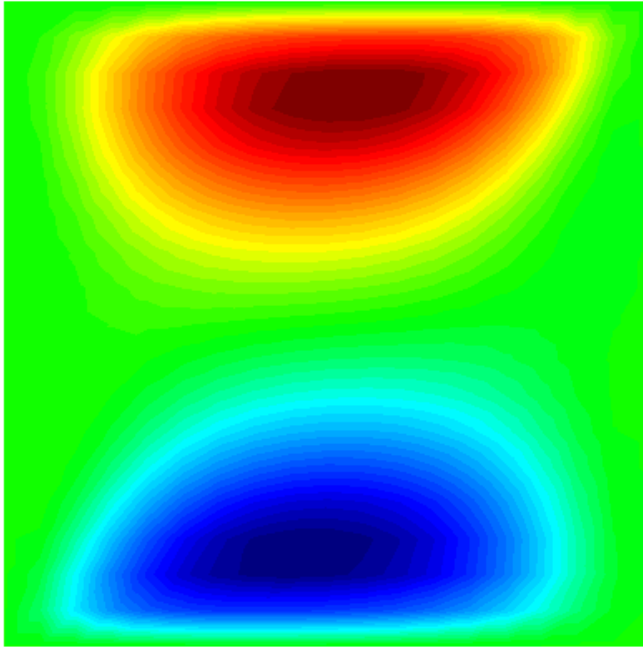
Contour Fill of Displacement, Z-Displ.

### Displacement in Z-Direction



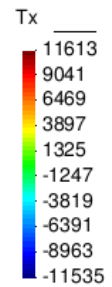
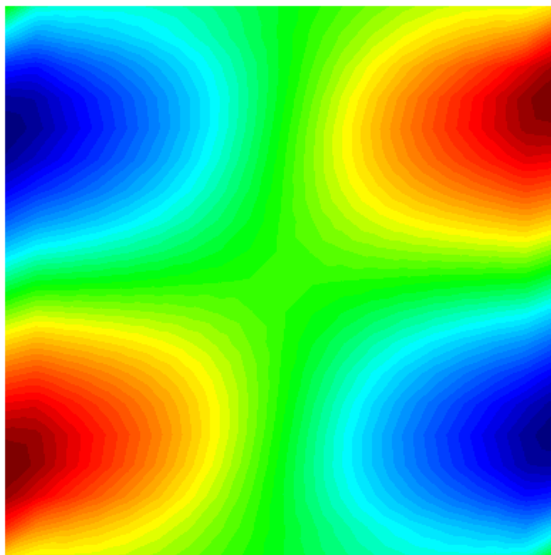
Contour Fill of Local Rotation, X-Rot.

### Rotation in X-Direction



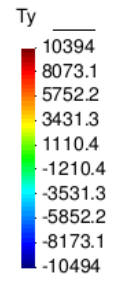
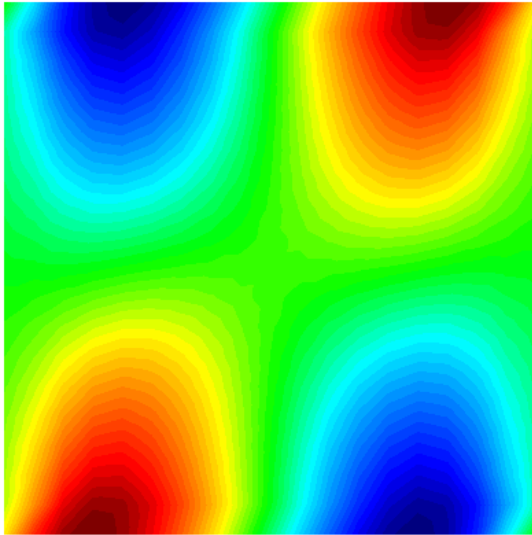
Contour Fill of Local Rotation, Y-Rot.

Rotation in Y-Direction



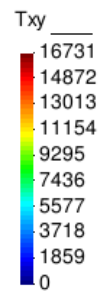
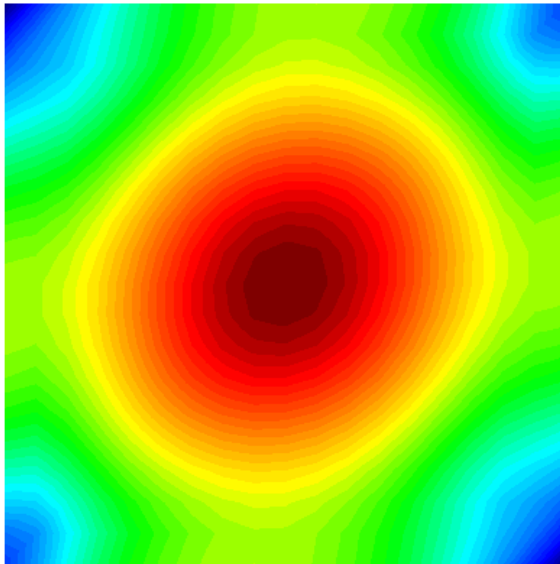
Contour Fill of Membrane, T\_x.

Membrane T\_x



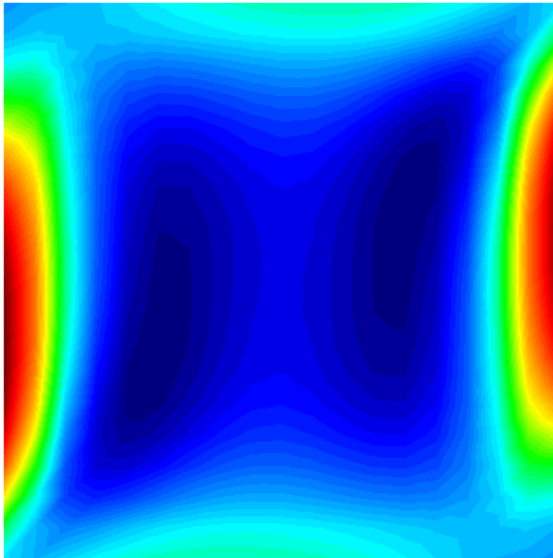
Contour Fill of Membrane,  $T_y$ .

Membrane  $T_y$

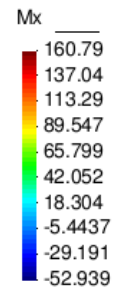


Contour Fill of Membrane,  $T_{xy}$ .

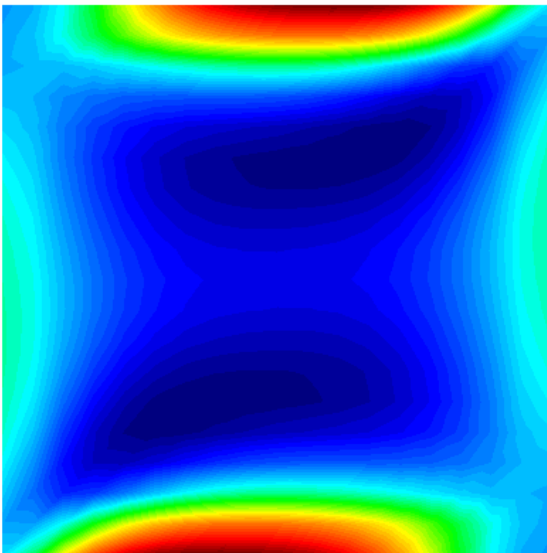
Membrane  $T_{xy}$



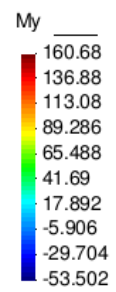
Contour Fill of Moment,  $M_x$ .



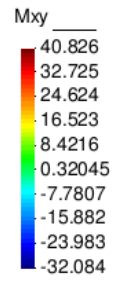
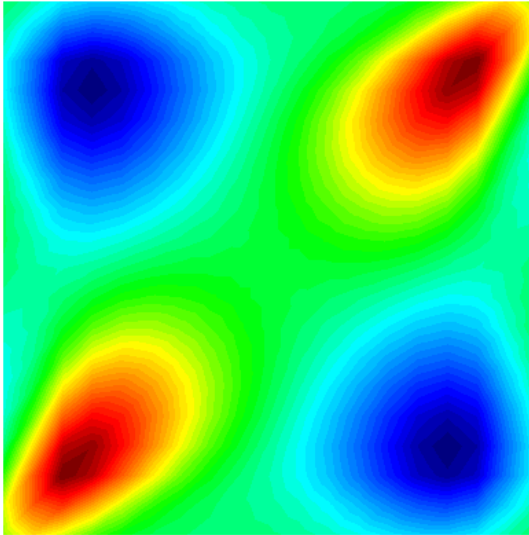
Moment in Direction  $M_x$



Contour Fill of Moment,  $M_y$ .

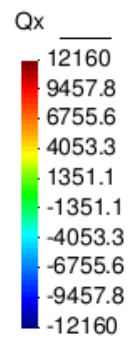
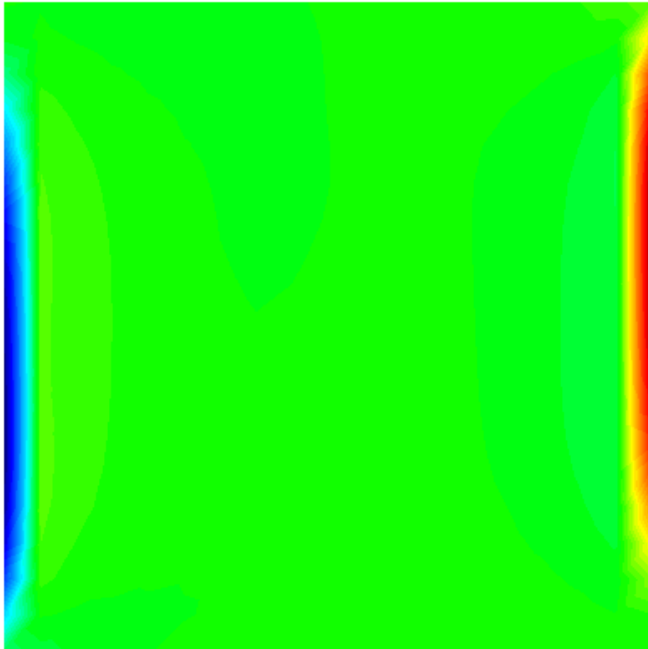


Moment in Direction  $M_y$



Contour Fill of Moment,  $M_{xy}$ .

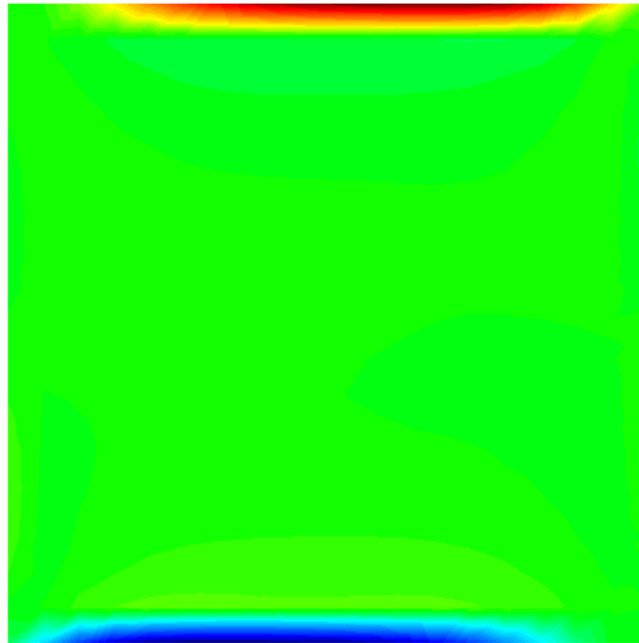
Moment in Direction  $M_{xy}$



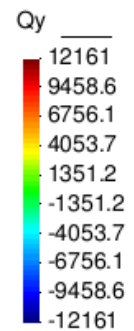
Contour Fill of Shear,  $Q_x$ .

Transverse Shear Stress  $Q_x$





Contour Fill of Shear,  $Q_y$ .



Transverse Shear Stress  $Q_y$

### Explanation (Observations)

Hyperbolic Structure are inherently stiff due to their shape. Hyperbolic structures are doubly curved. The deflections are less than when compared to flat plates. Same observations are also made in case of stresses which are generally low. They can also withstand in-plane shear stresses much better.

It is observed from the results that for Hyperbolic Structures clamped on all the edges, the structure tends to bend in opposite directions in terms of displacement. Similar observations are also made in terms of Bending Stresses.

Due to the Curved Shape of Shells they can carry transverse loads only by Tension forces. Since the shape of the structure is hyperbolic the tension forces  $T_x$  and  $T_y$  act in opposite directions in the opposite edges of the Structure.

It follows from the above observation that bending Stresses are also acting in opposite directions.

As expected from Hyperbolic Structures, the transverse shear stress are not observed in the centre of the structure but only limited to only the edges.