MKSSS's Cummins College of Engineering for Women, Pune

Development of GUI in MATLAB for Experimental Modal Analysis of Transverse Vibrations in 2D Domain

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Introduction to Modal Analysis

- MODAL ANALYSIS- Modal analysis is the process of determining the inherent dynamic characteristics of a system in forms of natural frequencies, damping factors and mode shapes, and using them to formulate a mathematical model for its dynamic behaviour.

- NATURAL FREQUENCY- Natural frequency is the frequency of free vibration of the system . It is a constant for given system.

- MODE SHAPE- Mode Shape is a characteristic displacement pattern, which may be real or complex and corresponds to a natural frequency.

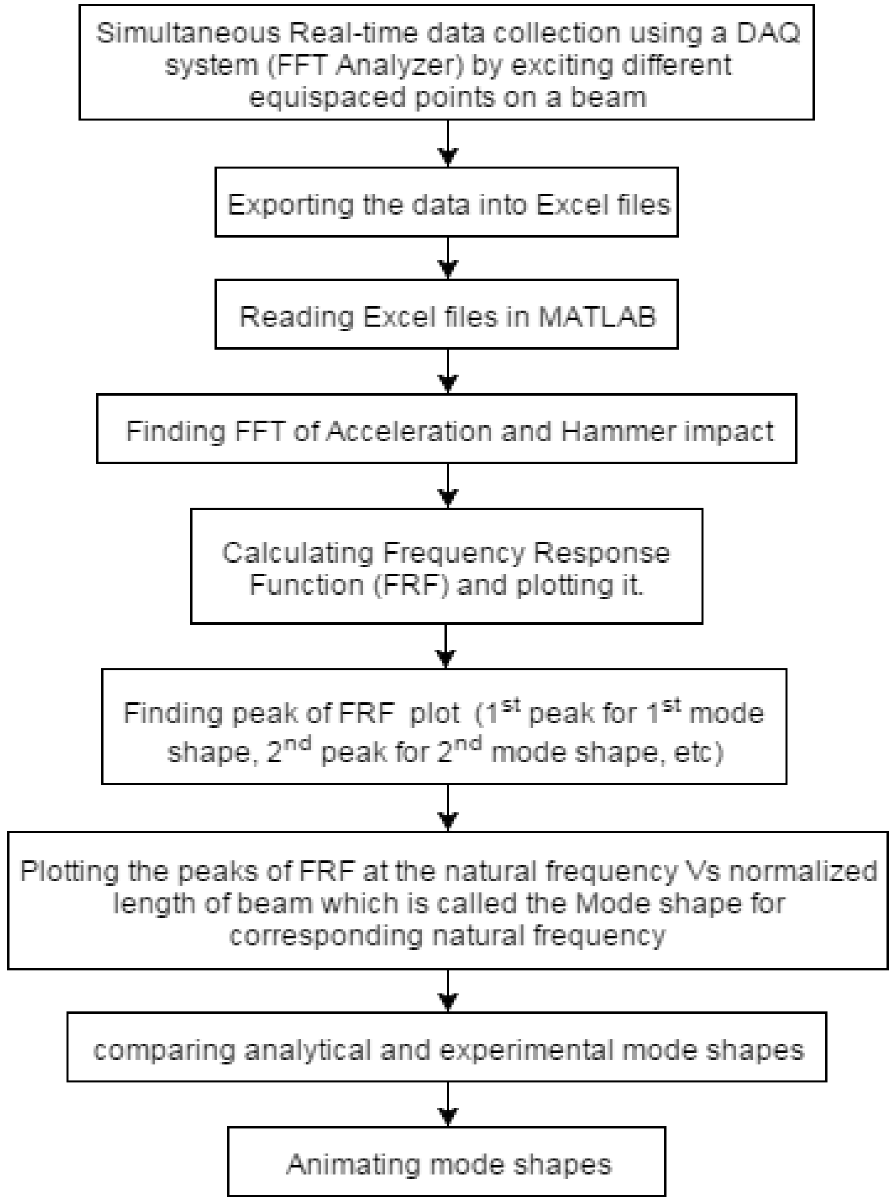
1-D Domain

Validating Data with 1-D Domain

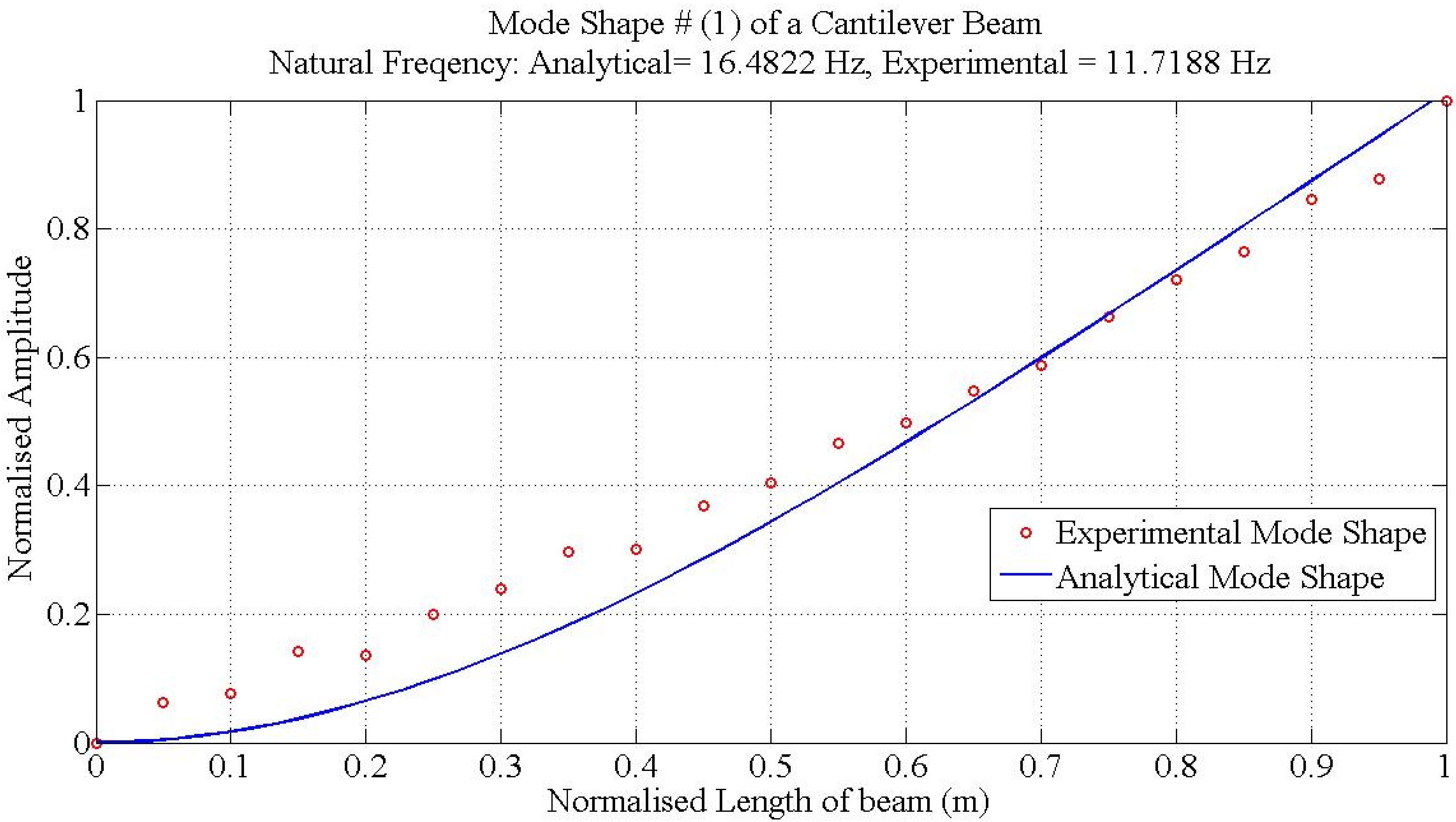
- Boundary Condition : Fixed-Free (Cantilever Beam)

- Methodology :
  - Finding analytical natural frequencies and mode shapes from Equations of Motion using MATLAB.
  - Finding experimental natural frequencies and mode shapes using MATLAB.
  - Verifying the experimental results by comparing with analytical results.

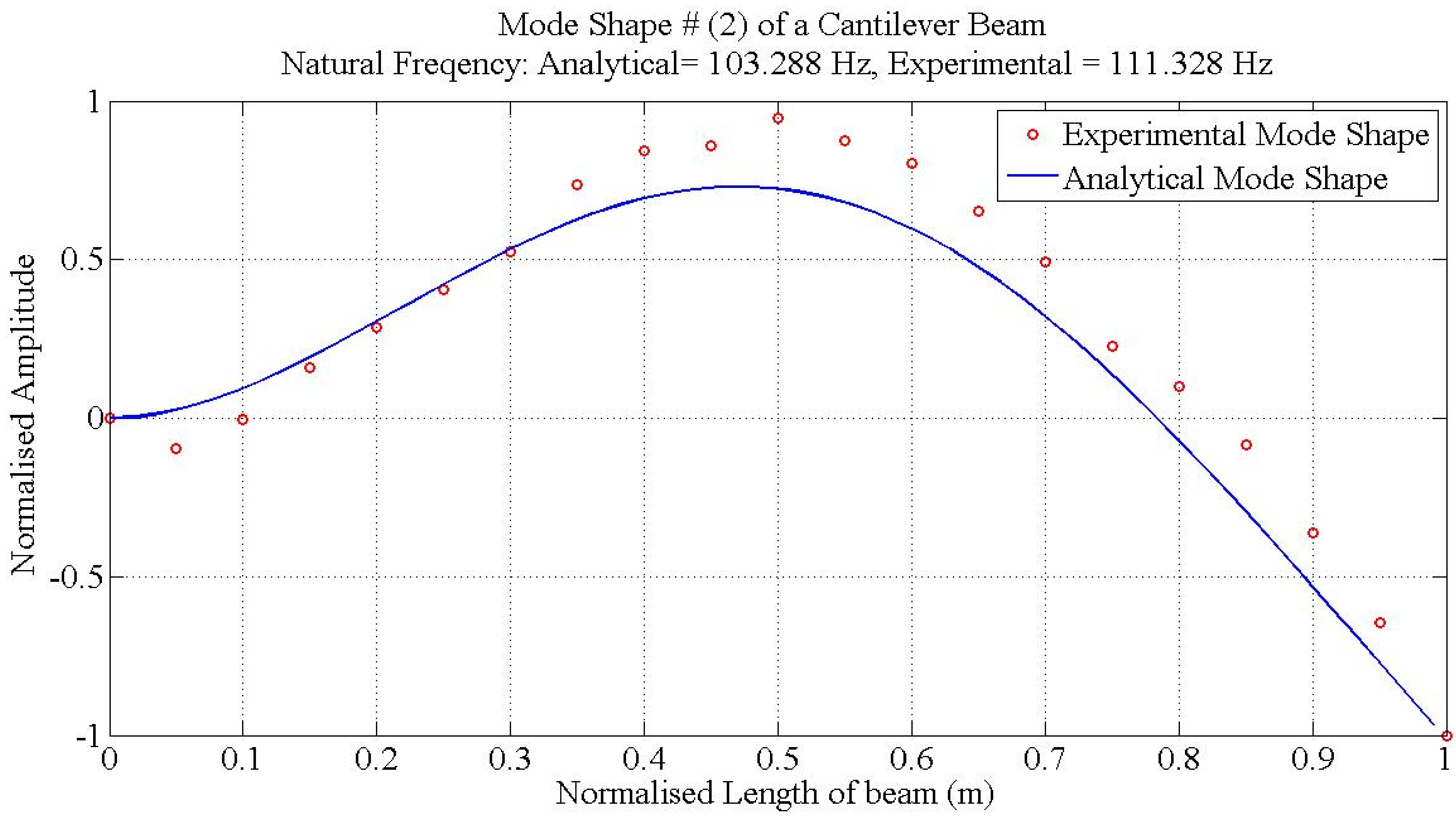
Methodology for 1-D Domain



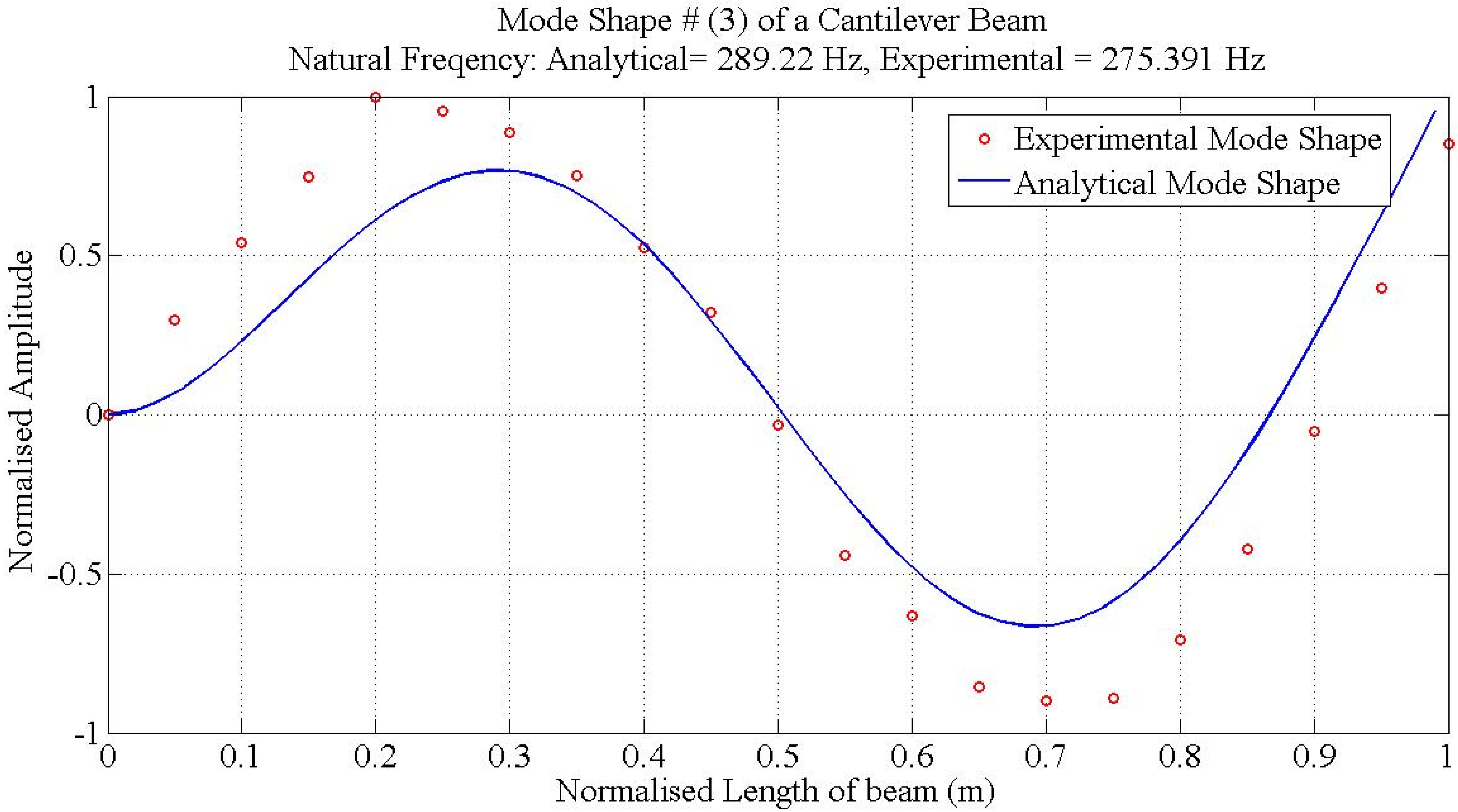
Results Obtained for Beam



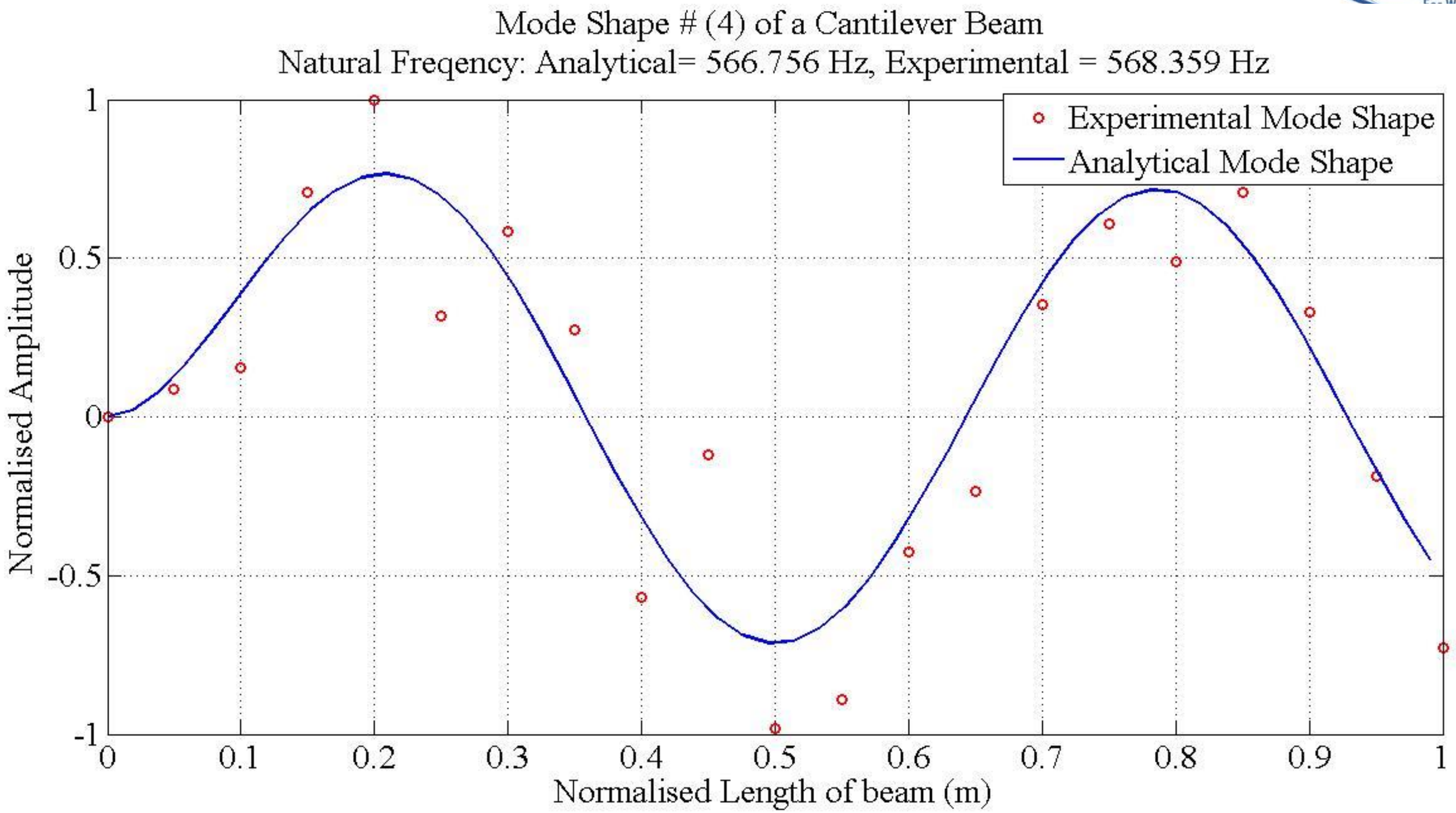
Results Obtained for Beam



Results Obtained for Beam



Results Obtained for Beam



For animation of mode shapes, please watch attached videos in 'BEAM_MODESHAPES_AVI' folder.

2-D Domain

Analytical Solution for 2–D Domain

- Boundary Condition : Simply Supported on all the four sides

- Analytical Governing Equation:

W(x,y)=A*(sin(((m.*x.*pi)./a))).*(sin(((n.*y.*pi)./b)))

Where:

A-Amplitude of Vibration

a-Length of the plate

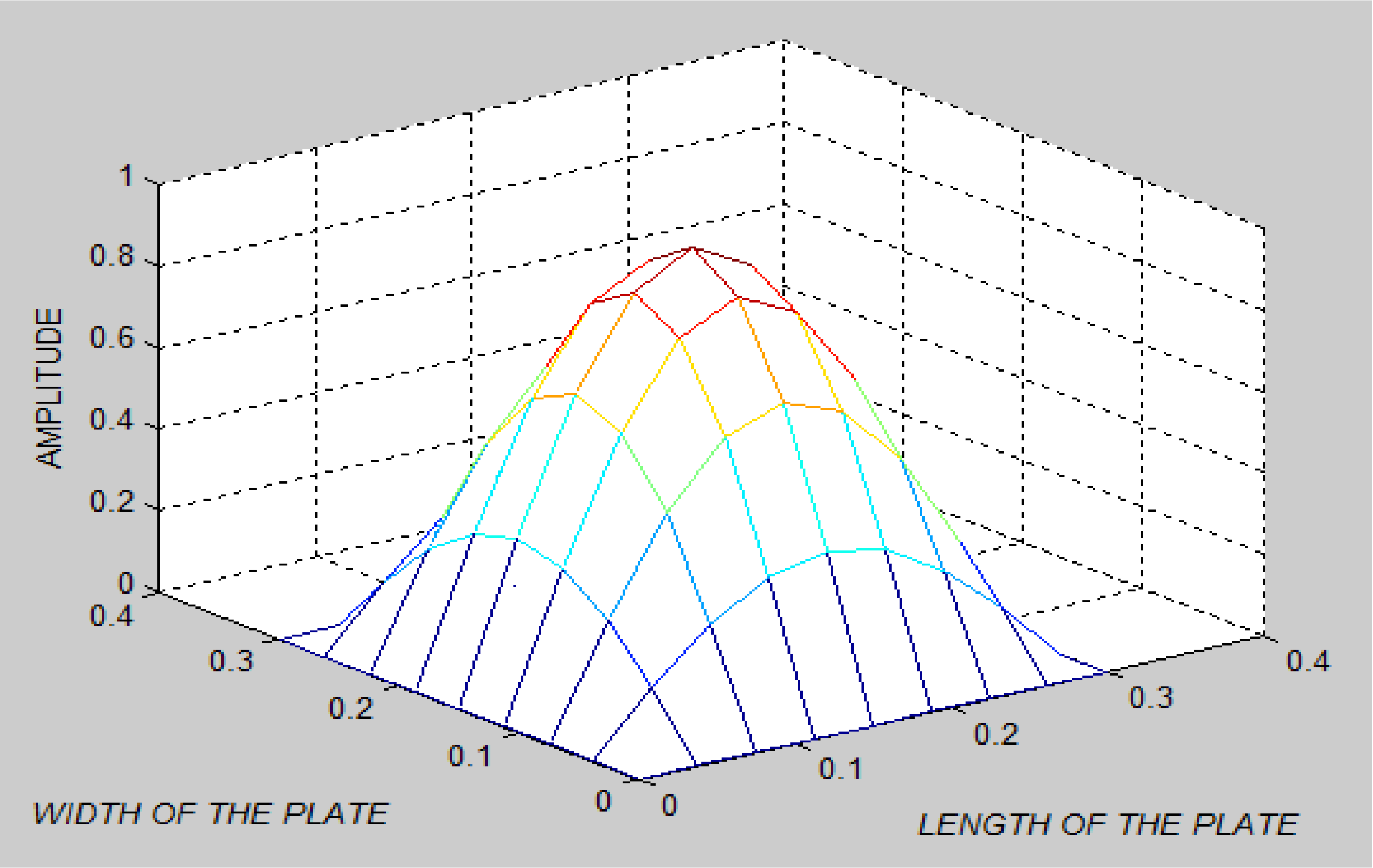
b-Width of the plate

(Reference : Vibrations of Continuous Media by S. S. Rao)

Analytical Mode Shapes

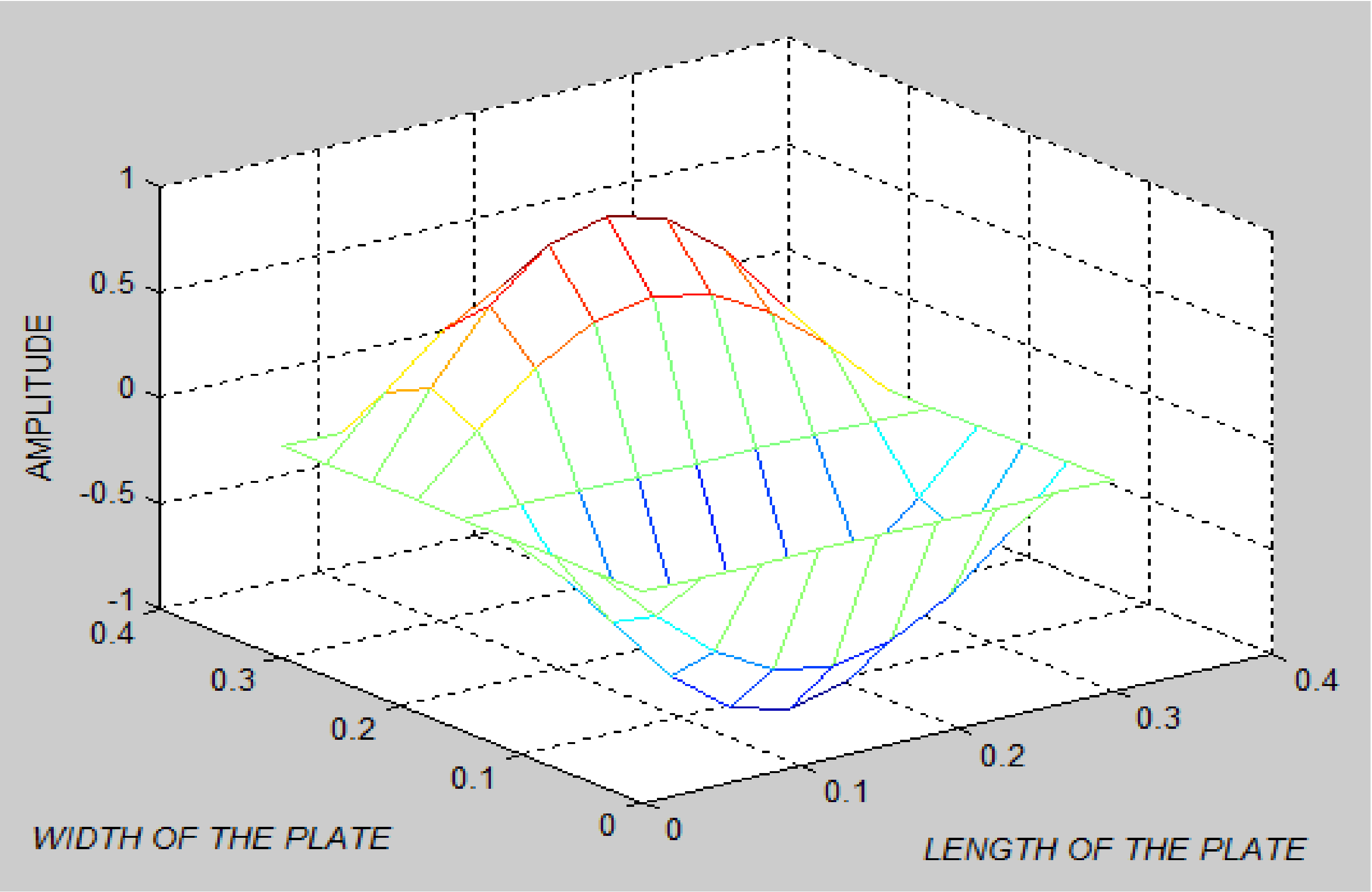
- Obtained For 2-D Domain Using MATLAB.

First Mode Shape(fn=437Hz)



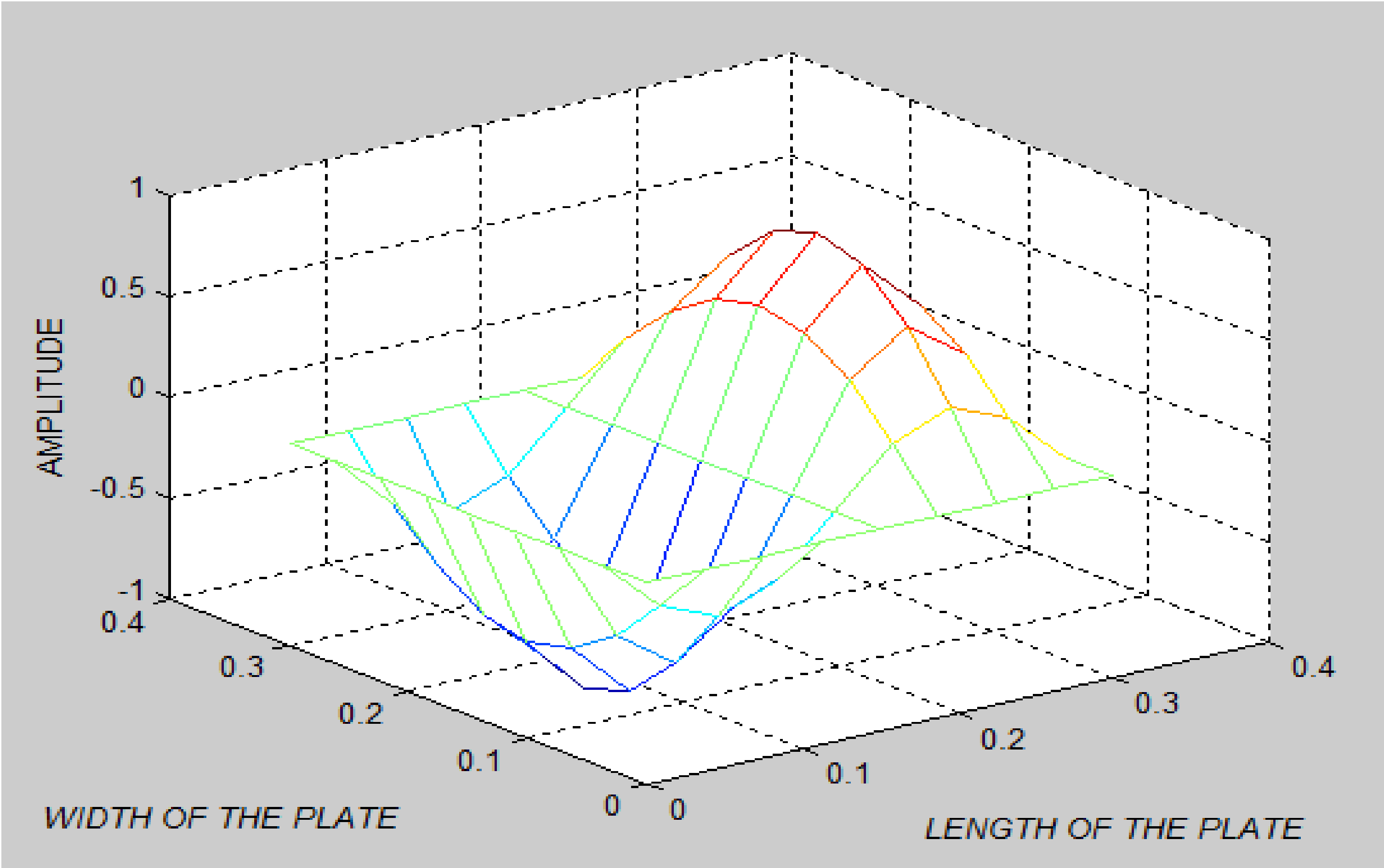
Analytical Mode Shapes Contd...

Second Mode Shape(fn=1093Hz)



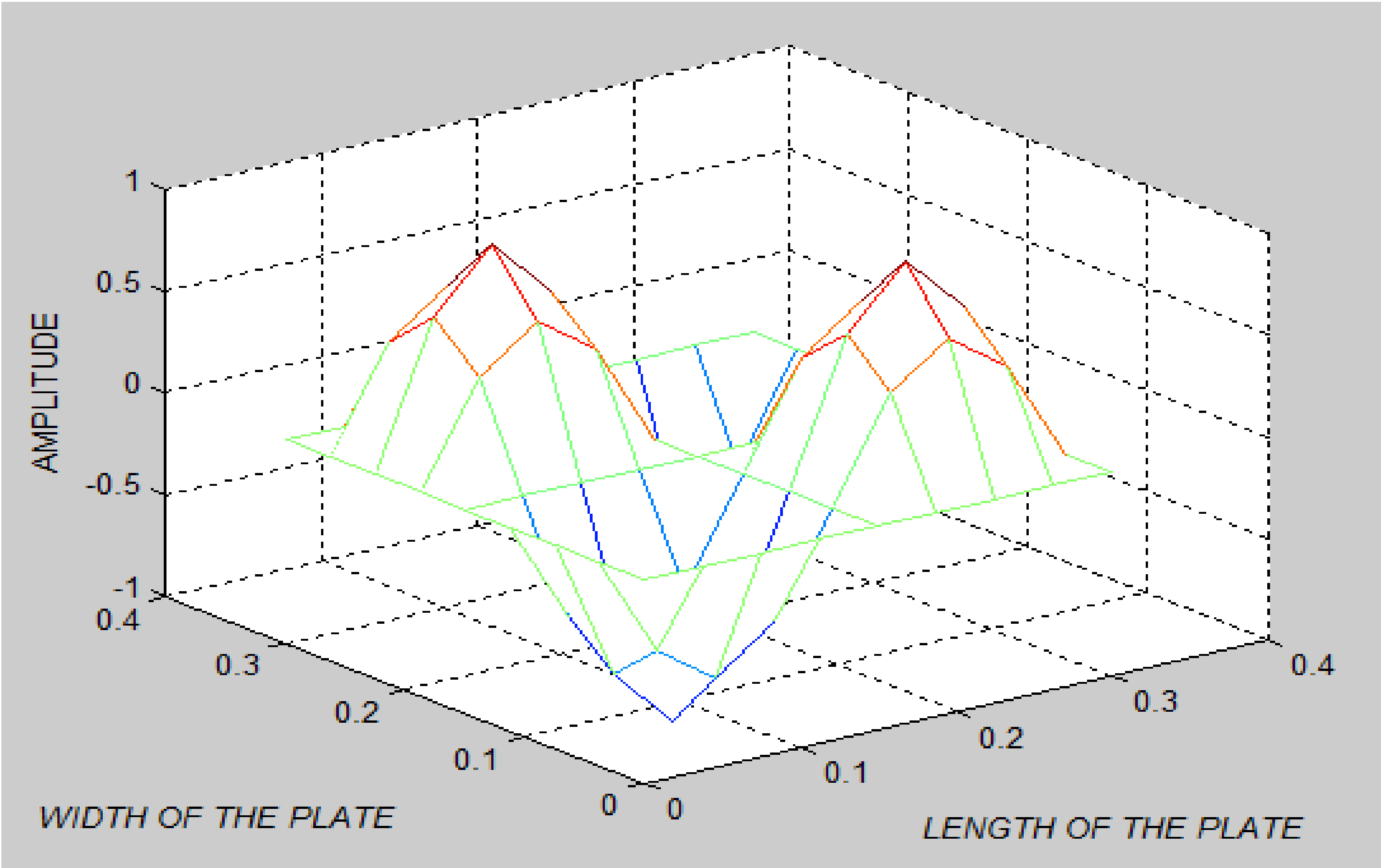
Analytical Mode Shapes Contd…

Third Mode Shape(fn=1093Hz)



Analytical Mode Shapes Contd...

Fourth Mode Shape(fn=1748Hz)



For animation of mode shapes, please watch attached videos in 'Animation_Plate_AVI' folder.

Analytical Solution for 2–D Domain

- Boundary Condition : SS-F-SS-F

  Where : SS-Simply supported

  F-Free

- Analytical Governing Equation:

$Xm=\sin(x\alpha);$

$Yn=(\square_1(\lambda^2+\alpha^2(1-\mu))^2\sinh(\square_2 b)-\square_2(\lambda^2-\alpha^2(1-\mu))^2\sin(\square_1 b))\ (\cosh(y.\square_2).$

$(\lambda^2-\alpha^2(1-\mu))+\cos(y.\square_1).(\lambda^2+\alpha^2(1-\mu)))-((\cosh(\square_2 b)-\cos(\square_1 b))(\lambda^4-\alpha^4(1-\mu)^2)$

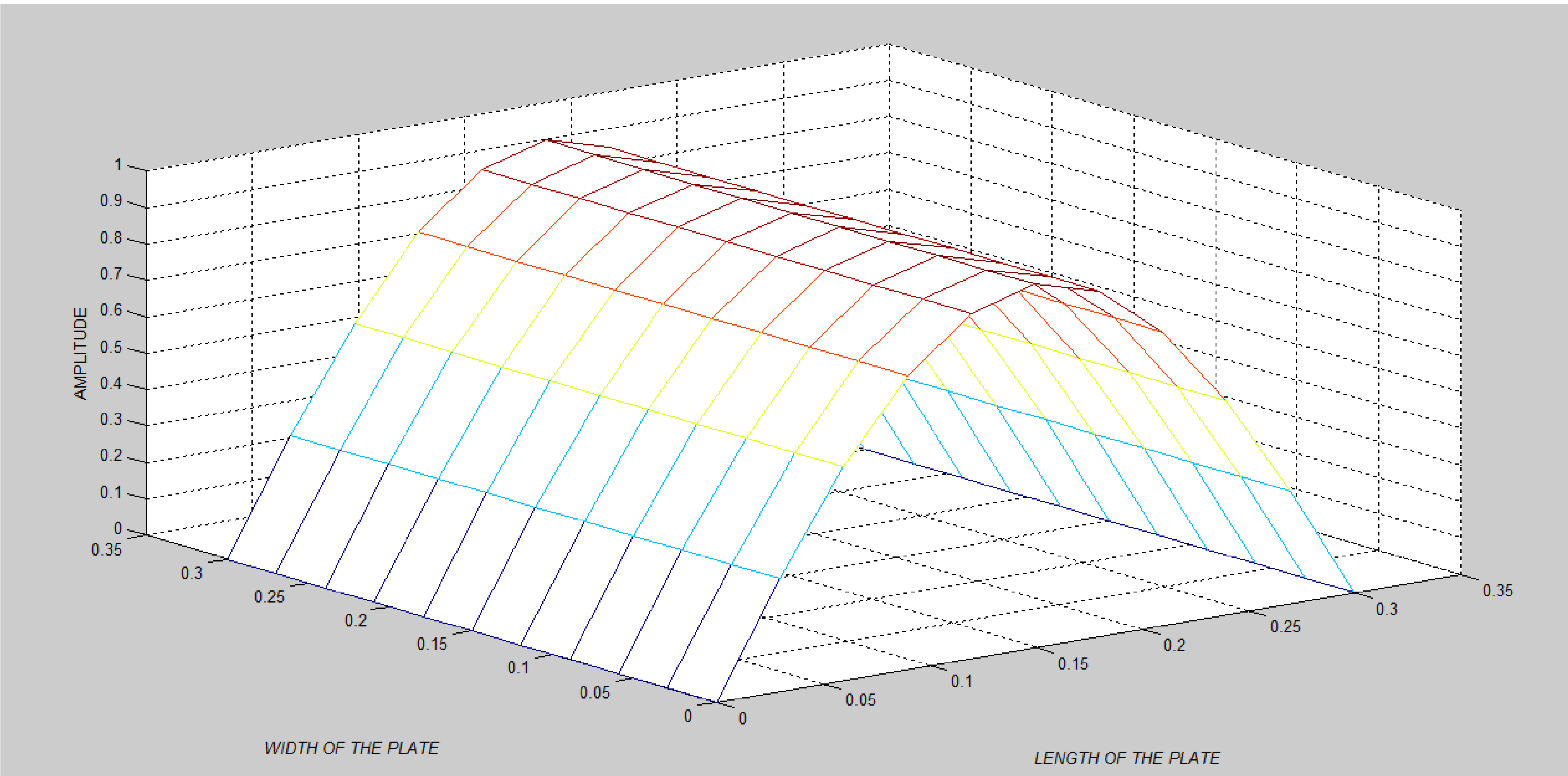
$(\square_1\sinh(y.\square_2).(\lambda^2+\alpha^2(1-\mu))+\square_2\sin(y.\square_1).(\lambda^2-\alpha^2(1-\mu))))$

$Z=A.Xm.Yn$

(Reference : Vibrations of Continuous Media by S. S. Rao)

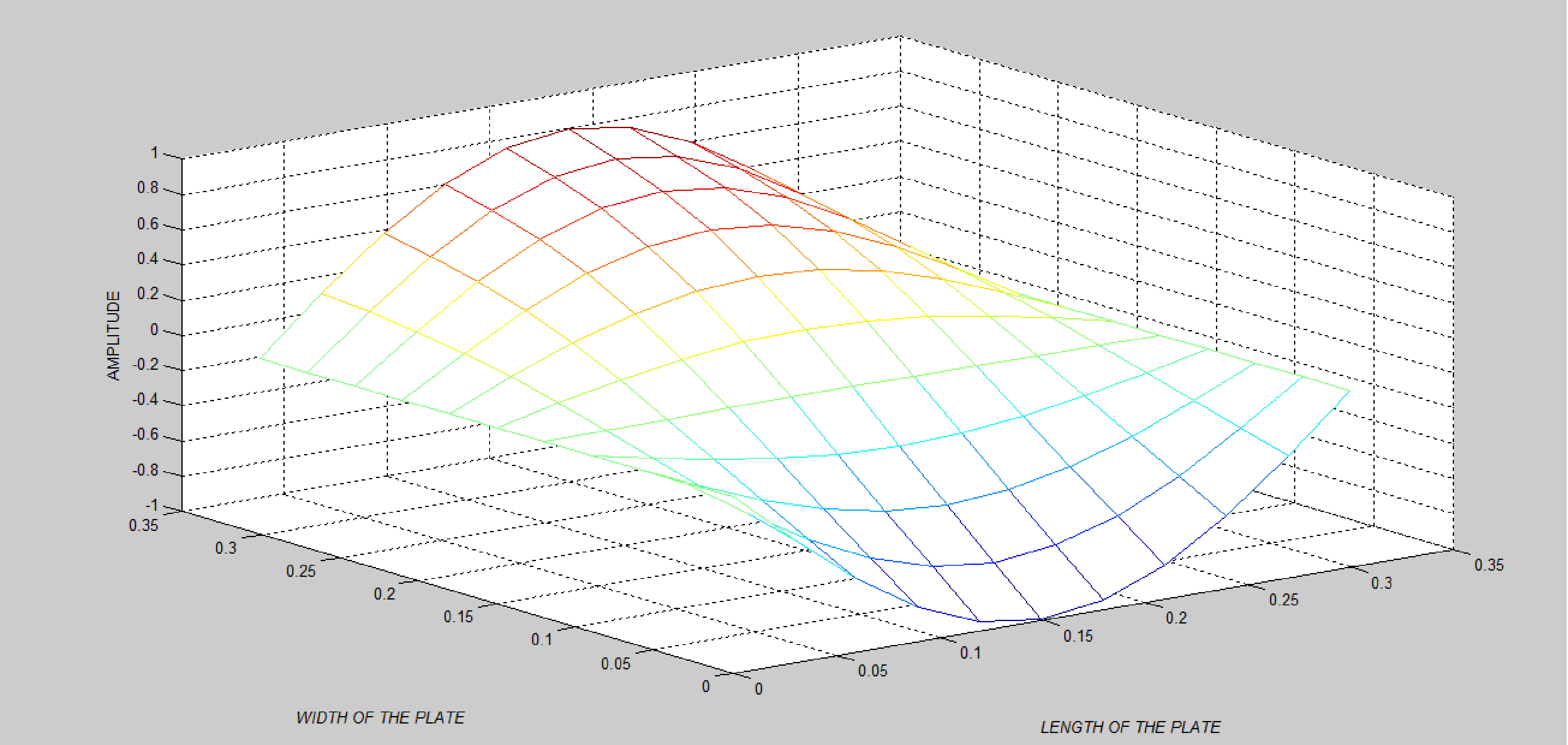
Analytical Mode Shapes

First Mode Shape



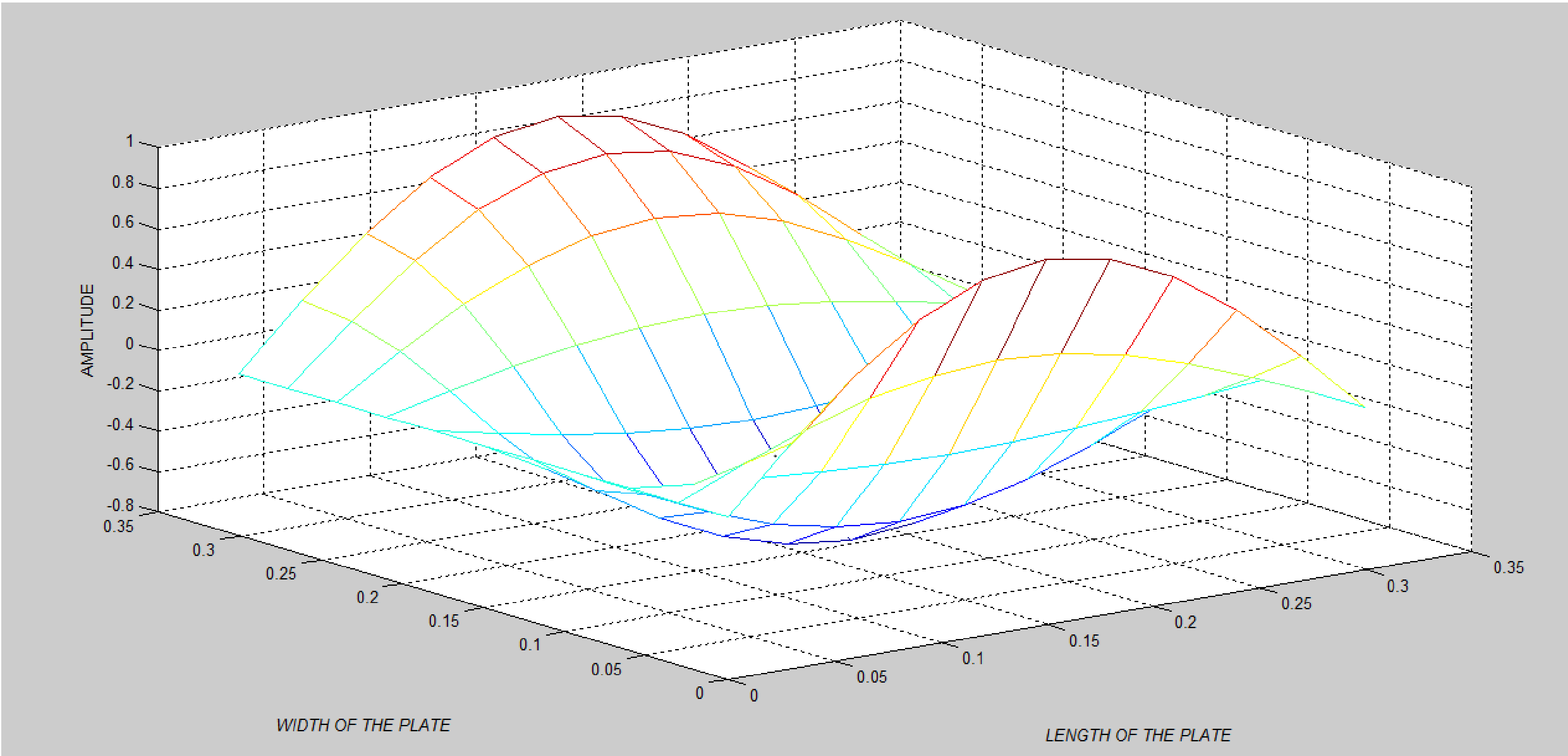
Analytical Mode Shapes Contd…

Second Mode Shape



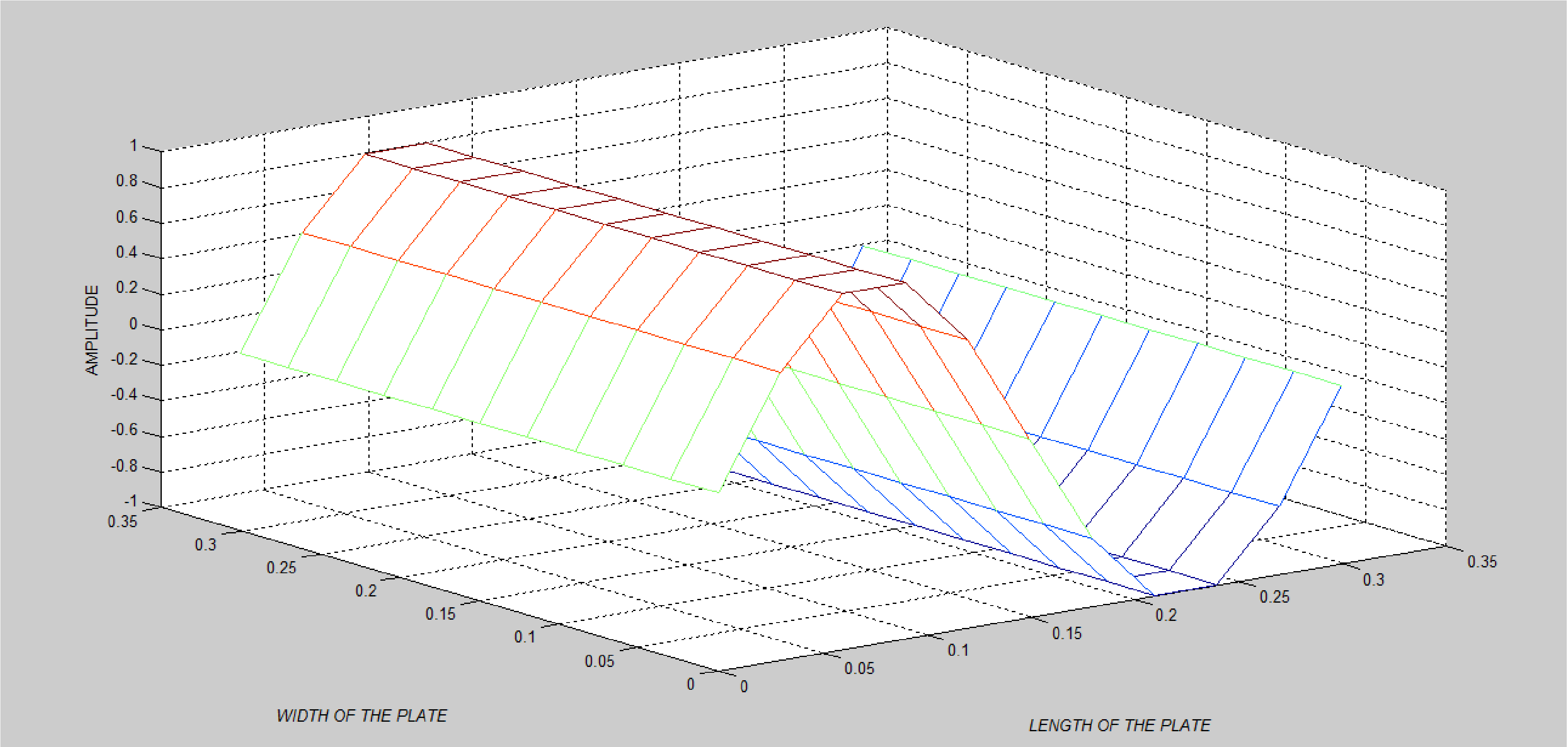
Analytical Mode Shapes Contd...

Third Mode Shape

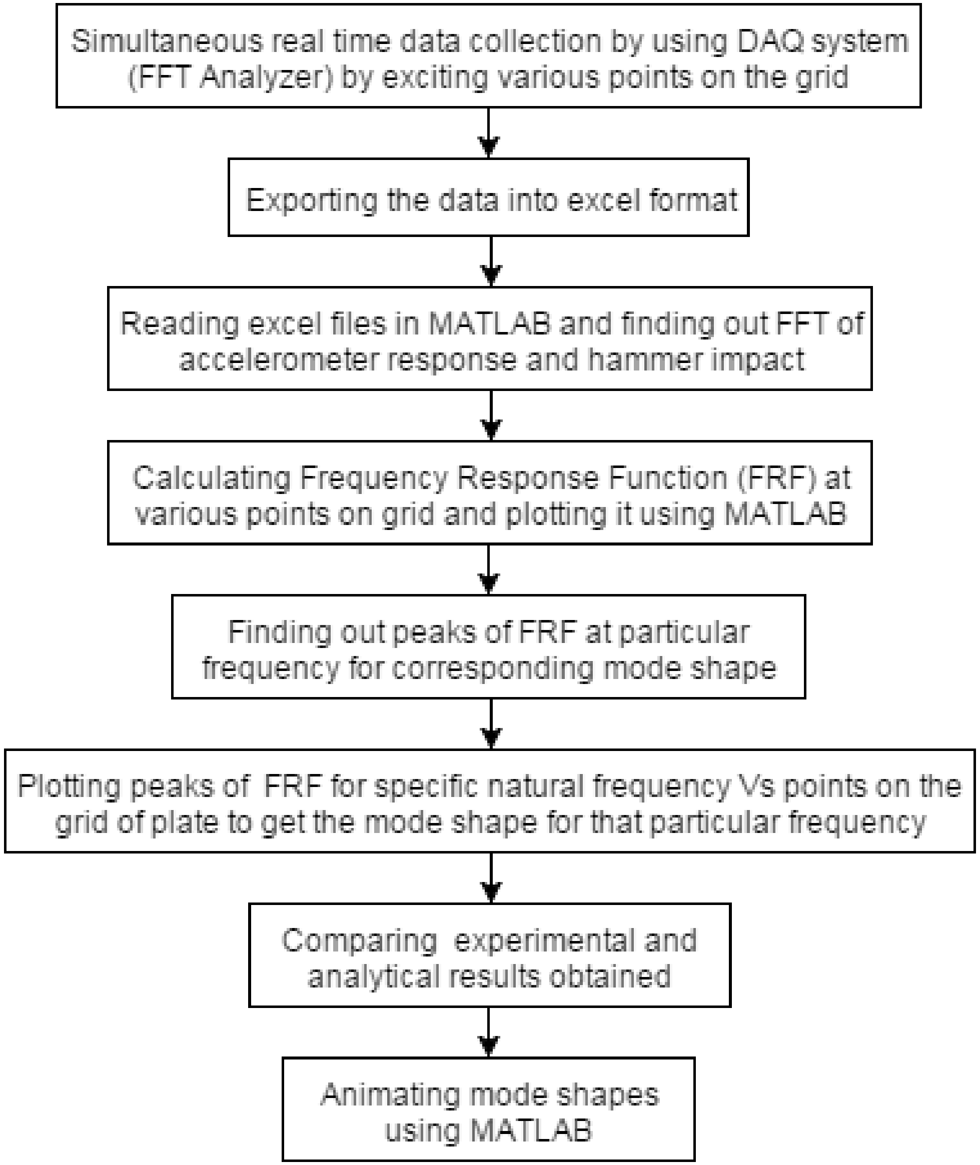


Analytical Mode Shapes Contd…

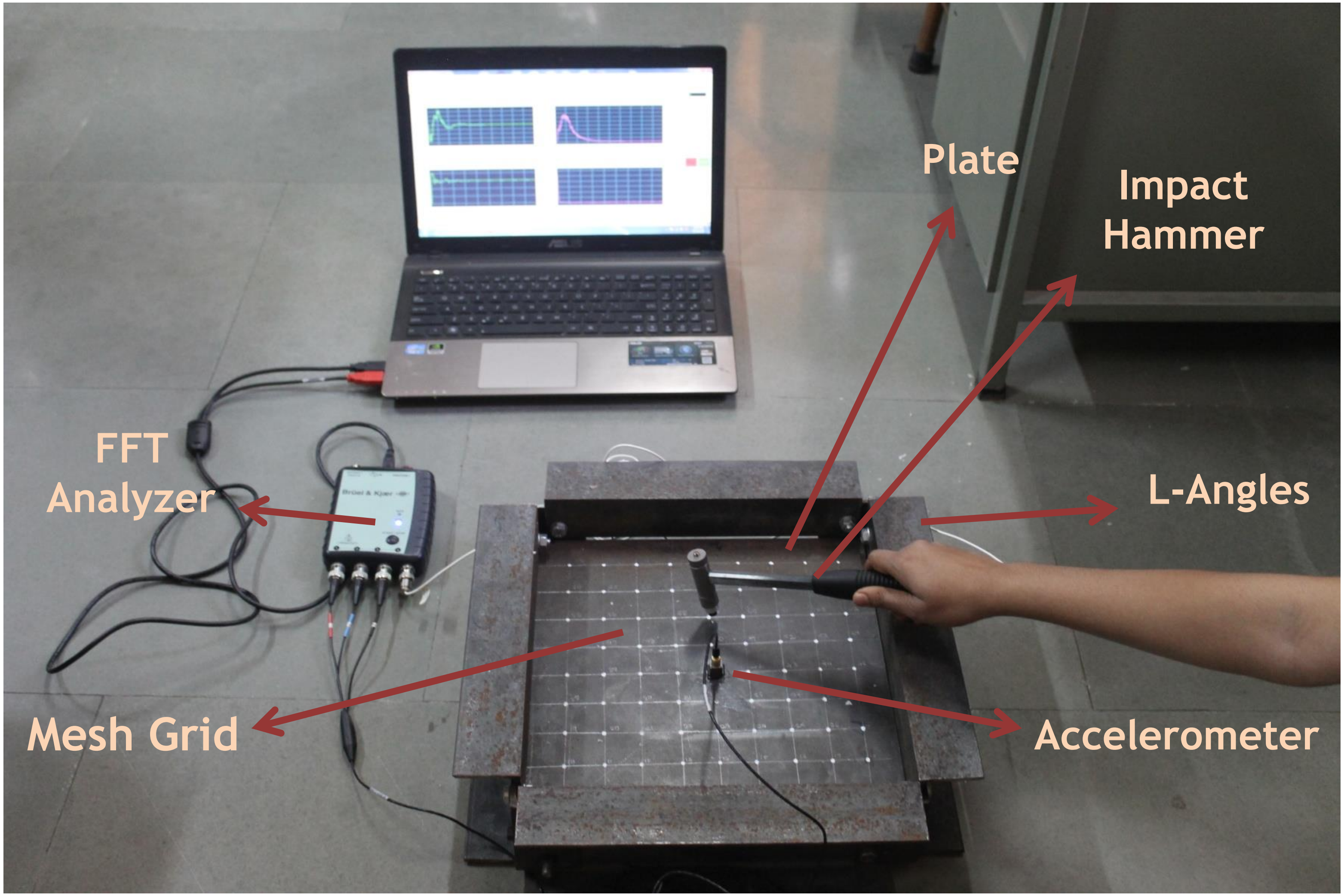
Fourth Mode Shape



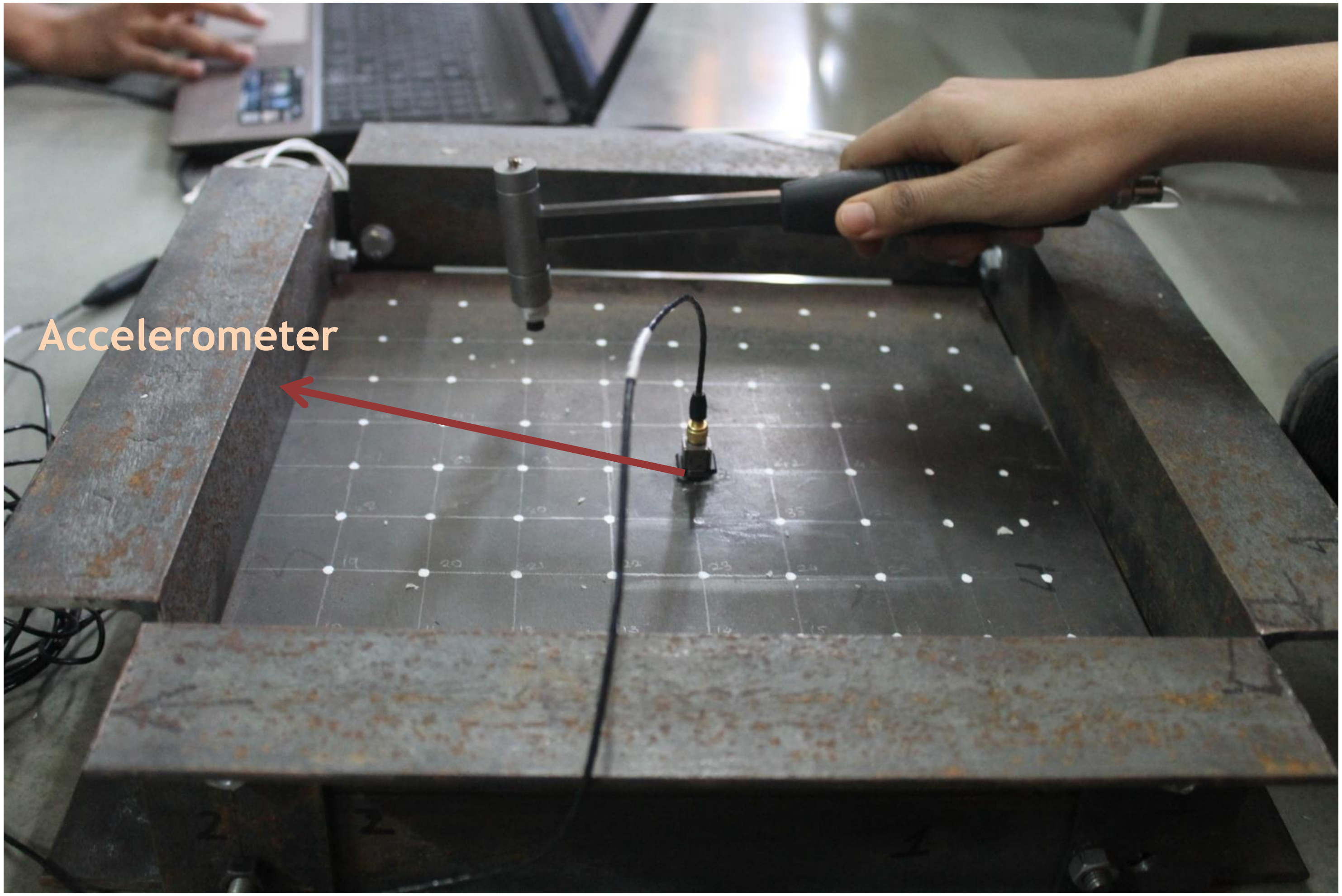
Methodology for 2–D Domain



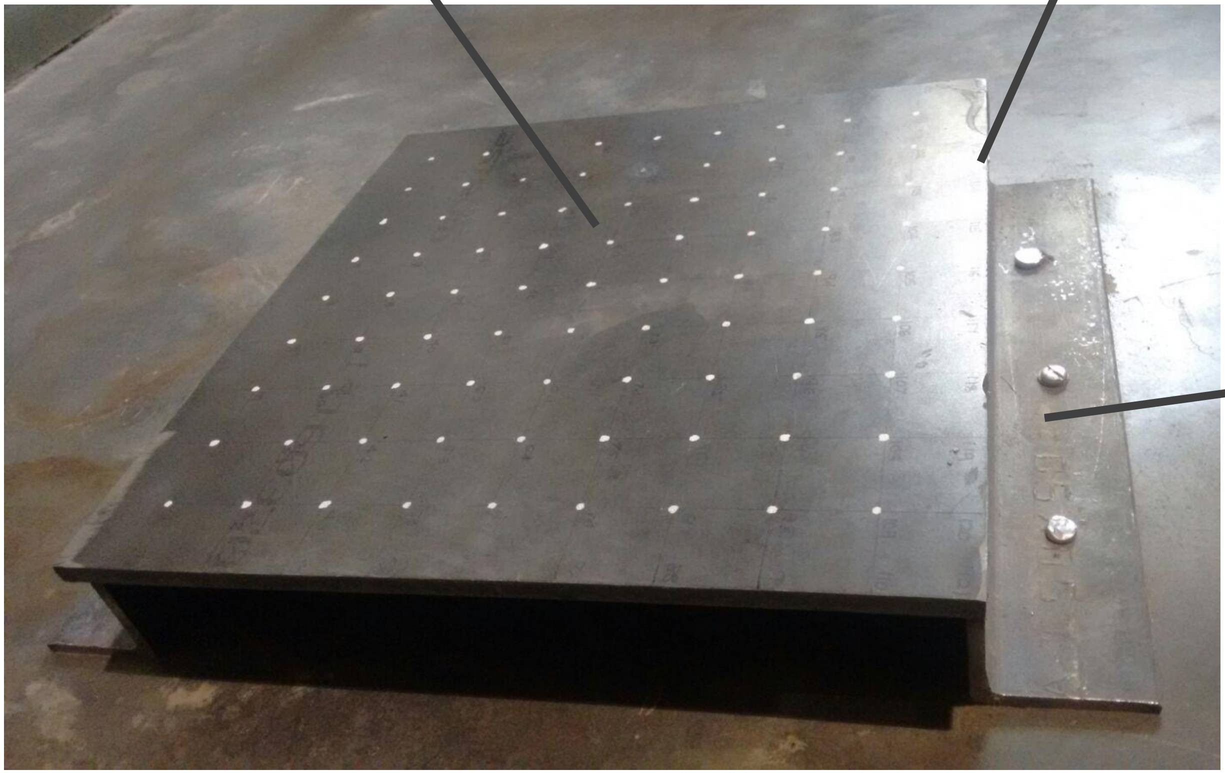
Experimental Setup for 2D Plate



Experimental Setup for 2D Plate Contd…



Experimental Setup for 2D Plate (SS-F-SS-F Boundary Condition)



Experimental Setup for 2D Plate Contd…

- Plate Dimensions: 300*300*8 mm
- Plate material: Mild Steel (E=210 GPa)
- Boundary Conditions: Set 1: SS-SS-SS-SS
  Set 2: SS-F-SS-F
- A grid of 9*9 (81) points for Set 1, and 11*11 (121) points for Set 2, has been made, with fixed numbering for each point.

Experimental Setup for 2D Plate Contd…

- A tri-axial Delta Tron accelerometer is attached at a particular point using beeswax (Make:B&K,Type:4524)

•ICP Impact hammer model 086C03 has been used to excite at all the points defined on the grid, so as to obtain required readings.(Make: PCB PIEZOTRONICS)

Experimental Setup for 2D Plate Contd…

- RT Photon software has been used for analysis.
- The real time data obtained from the Data Acquisition System (FFT Analyzer) is then used in the MATLAB code.
- Make:B&K

Experimental Mode Shapes

First Mode Shape