

# Project Presentation

Topic:- Eigen Frequency analysis of  
finite beams

**Presented By:-**

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MSR-SMD, 1<sup>st</sup> Year  
(231050406)

**Under The Guidance of:-**

**Dr. Akhilesh Mimani**

# **1. CANTILEVER BEAM**

*(Free Vibration\_LANCZOS ITERATION )*

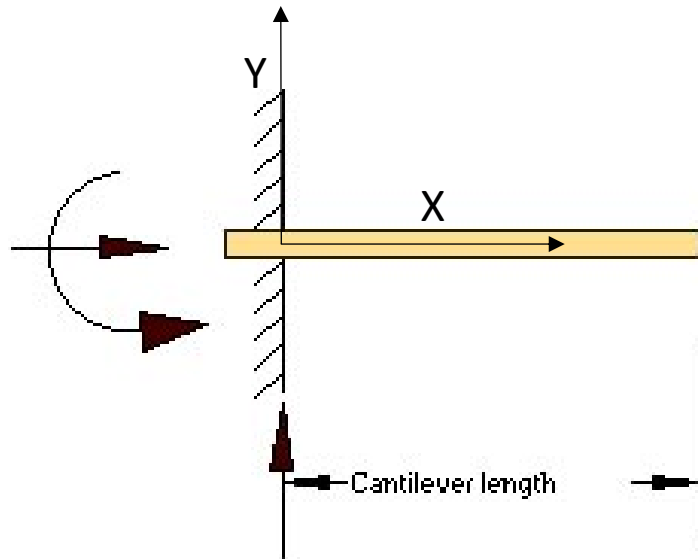
## Geometry

Attributes	Values
Length	0.45 <i>m</i>
Width	0.02 <i>m</i>
Height	0.003 <i>m</i>
Moment Of Inertia	$4.5 \times 10^{-11}m^4$ <i>And</i> $2 \times 10^{-9}m^4$

## Material

Attributes	Values
Material Name	Structural Steel
Young Modulus (E)	$2.1 * 10^{11}Pa$
Poisson ratio (Mue)	0.3
Density	$7850 \frac{Kg}{m^3}$

# Boundary Condition

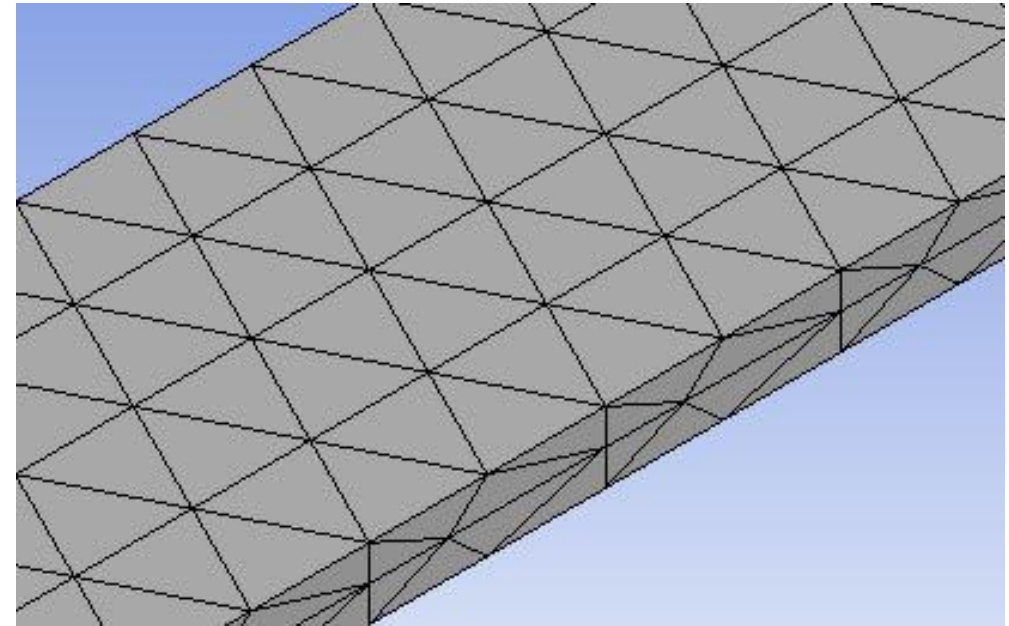
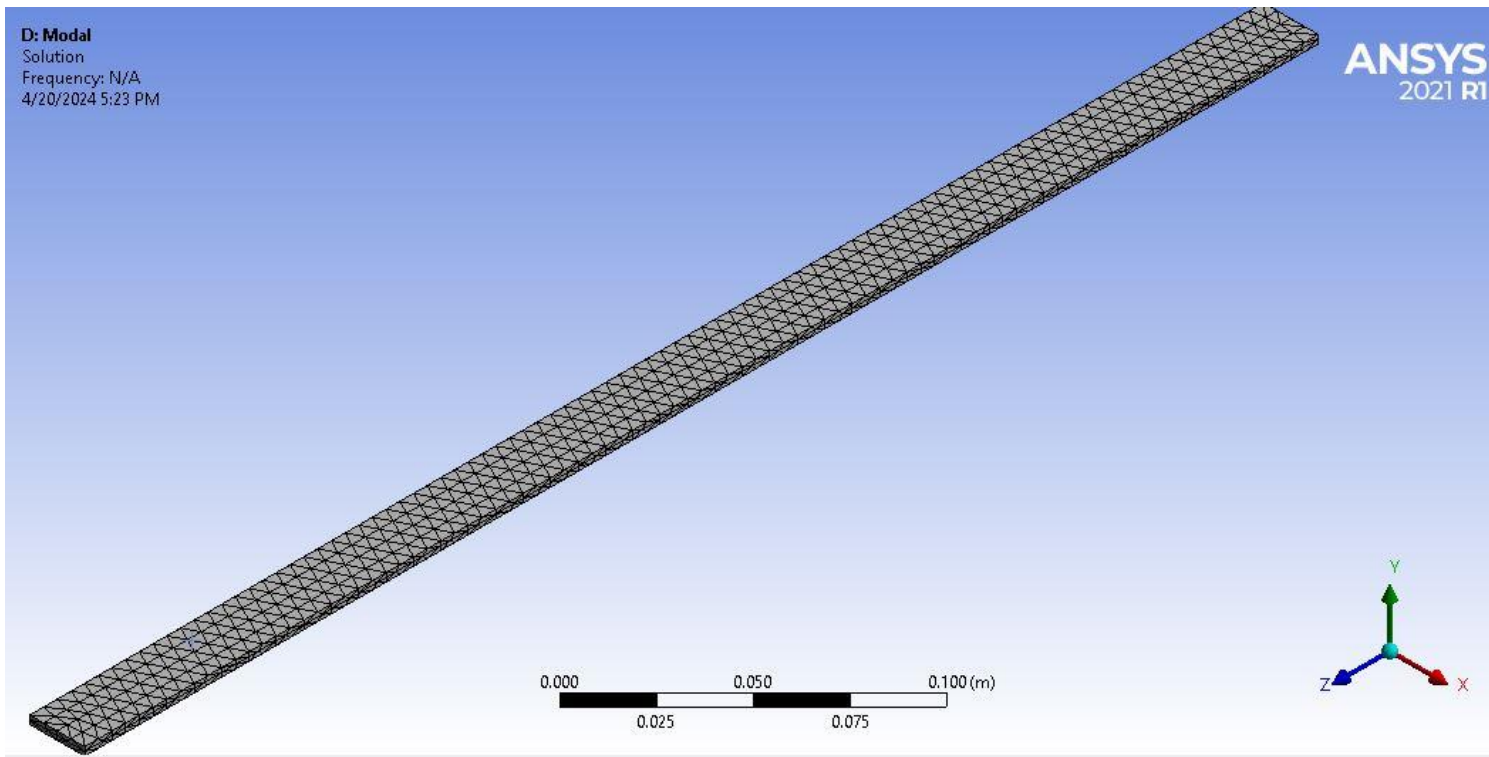


(a) Cantilever beam

$$y = 0 \quad @ \quad x = 0$$

$$\frac{dy}{dx} = 0 \quad @ \quad x = 0$$

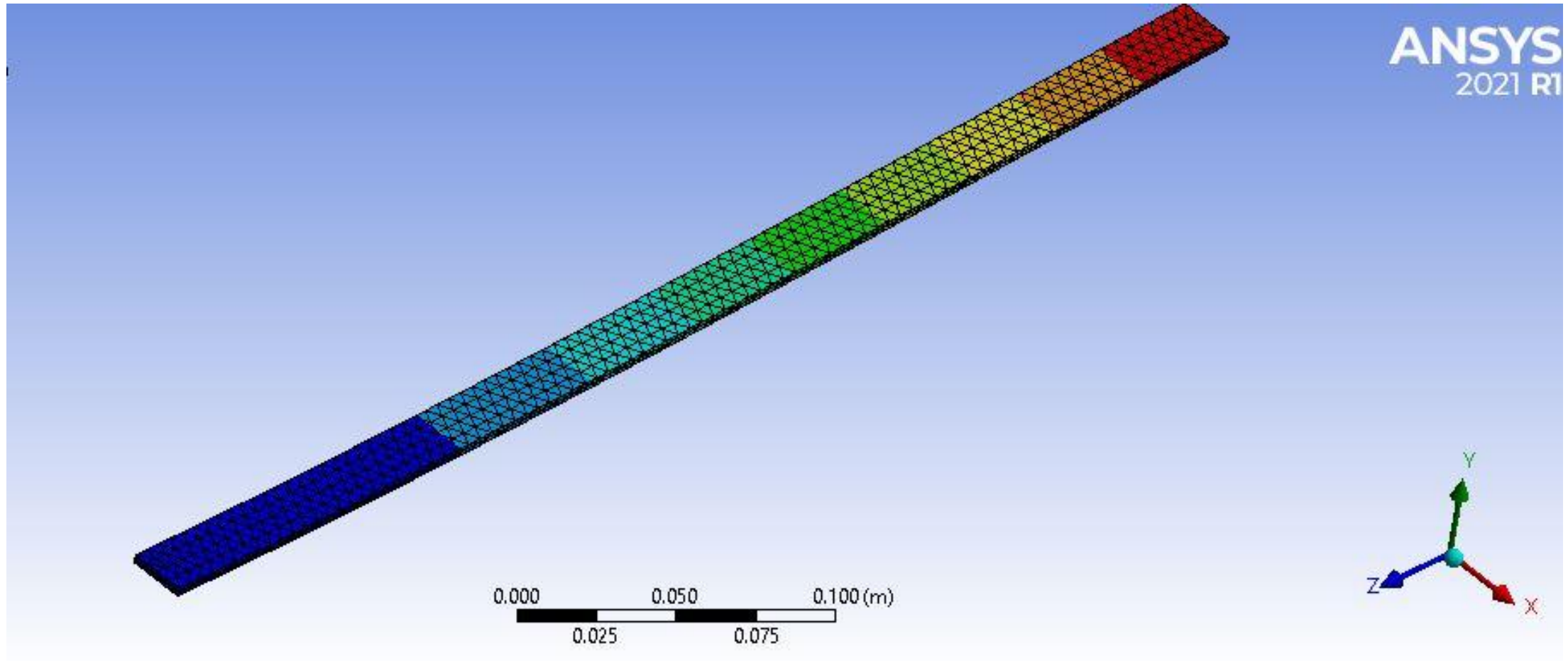
# Meshing (Size = 0.01 mm)



# **Mode Shapes & Animation**

Mode-1

# Mode Shape





# Animation

**A: Cantilever**

Total Deformation

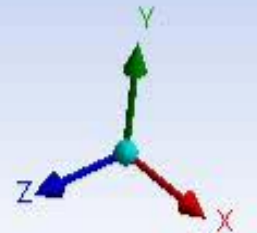
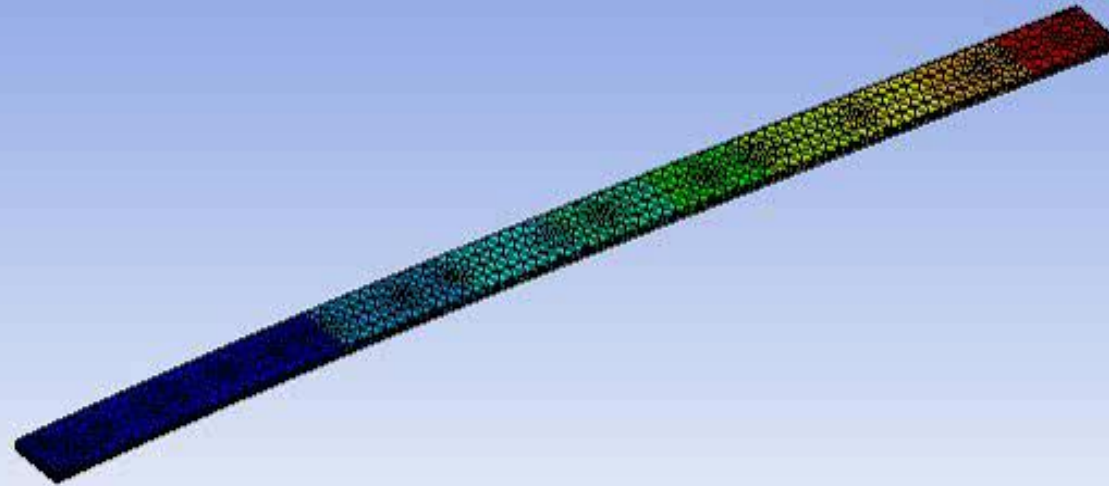
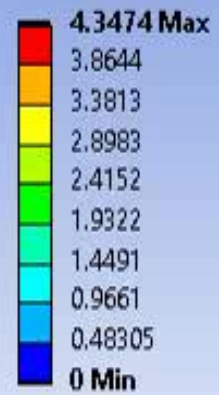
Type: Total Deformation

Frequency: 12.116 Hz

Unit: m

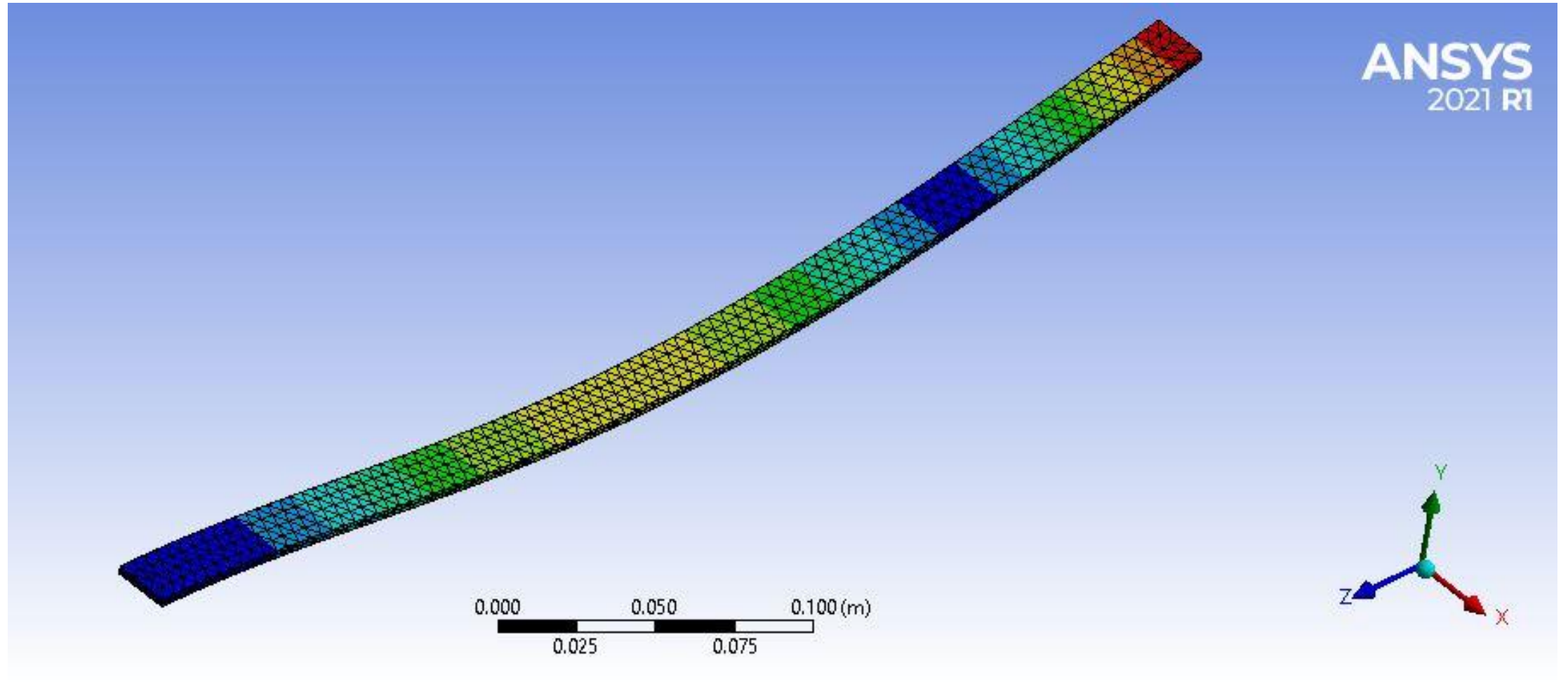
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# **Mode-2**

# Mode Shapes



# Animation

## A: Cantilever

Total Deformation 2

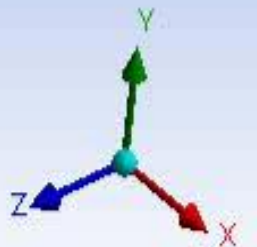
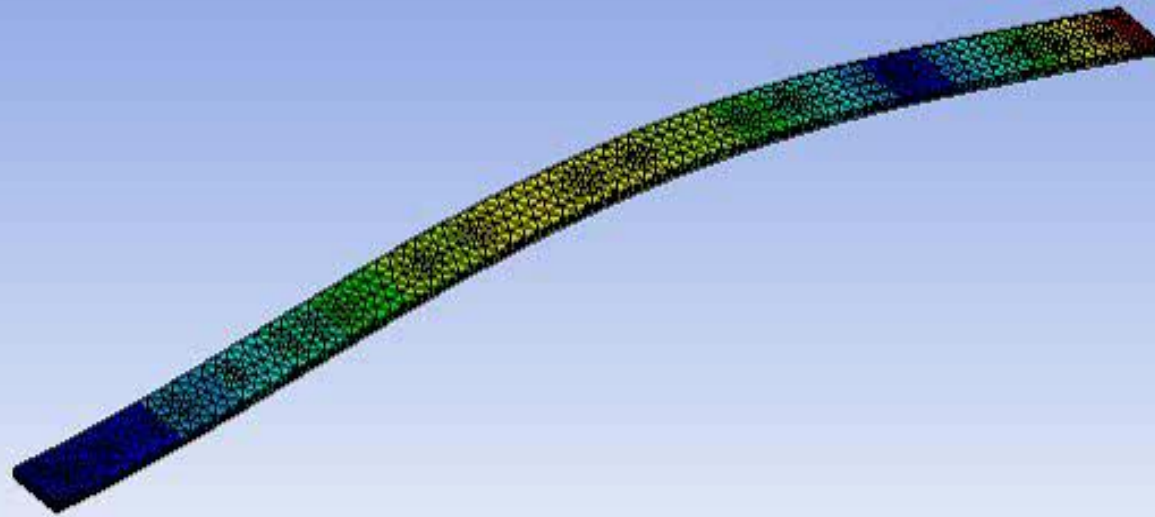
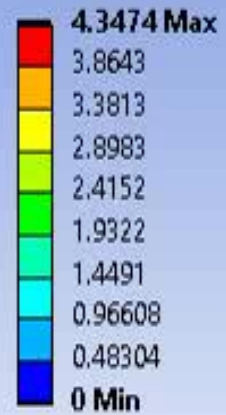
Type: Total Deformation

Frequency: 75.917 Hz

Unit: m

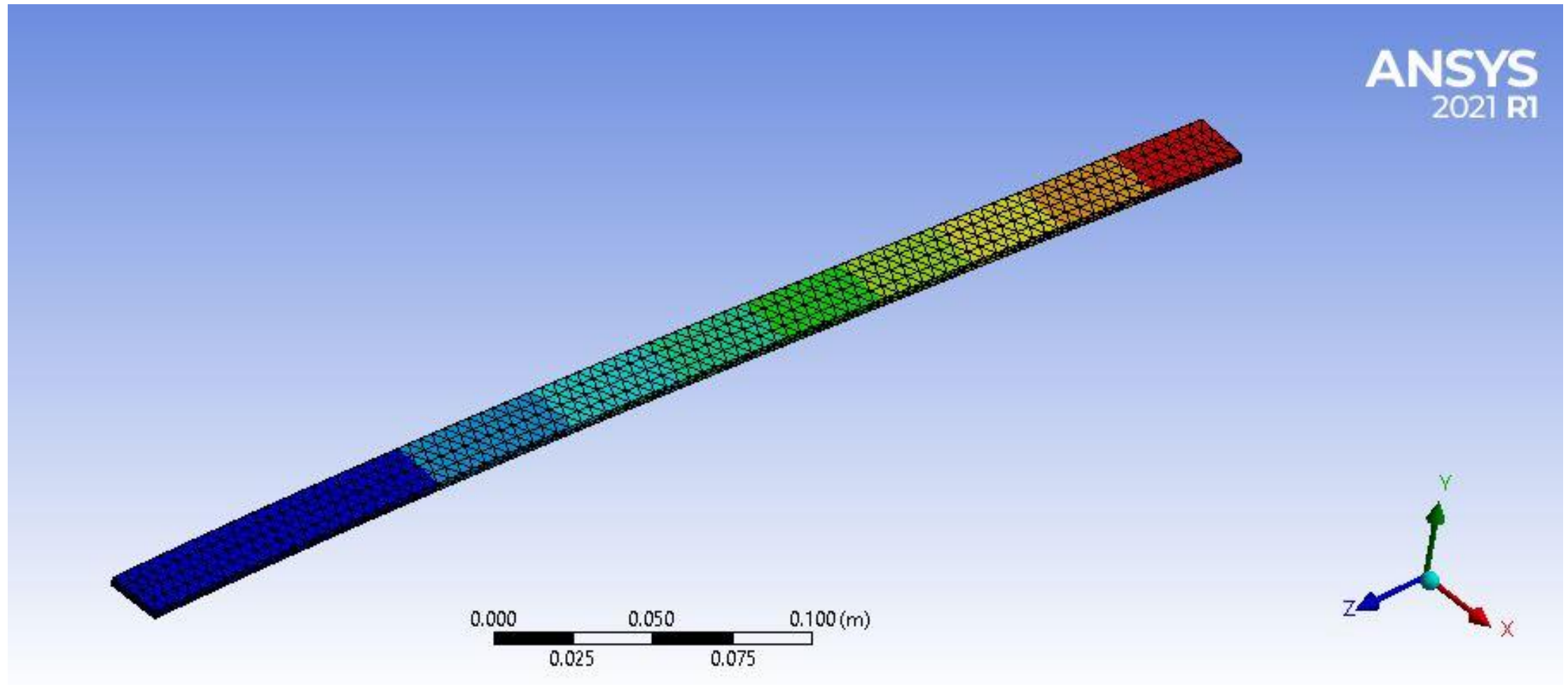
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Mode-3

# Mode Shapes



# Animation

**A: Cantilever**

Total Deformation 4

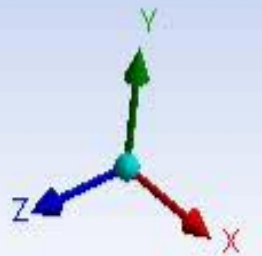
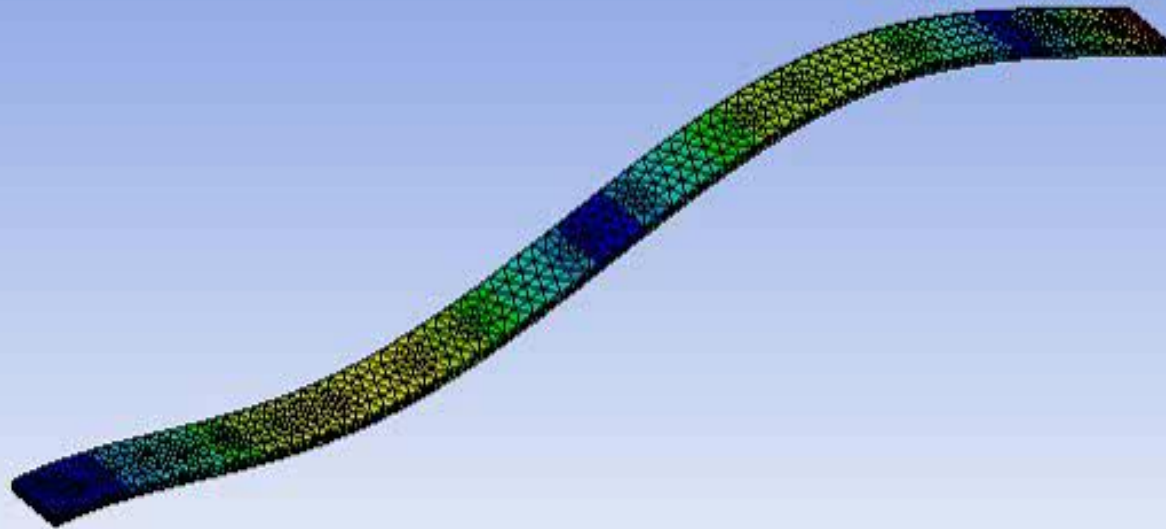
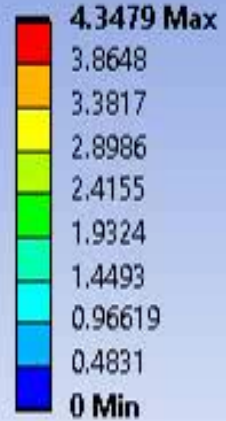
Type: Total Deformation

Frequency: 212.55 Hz

Unit: m

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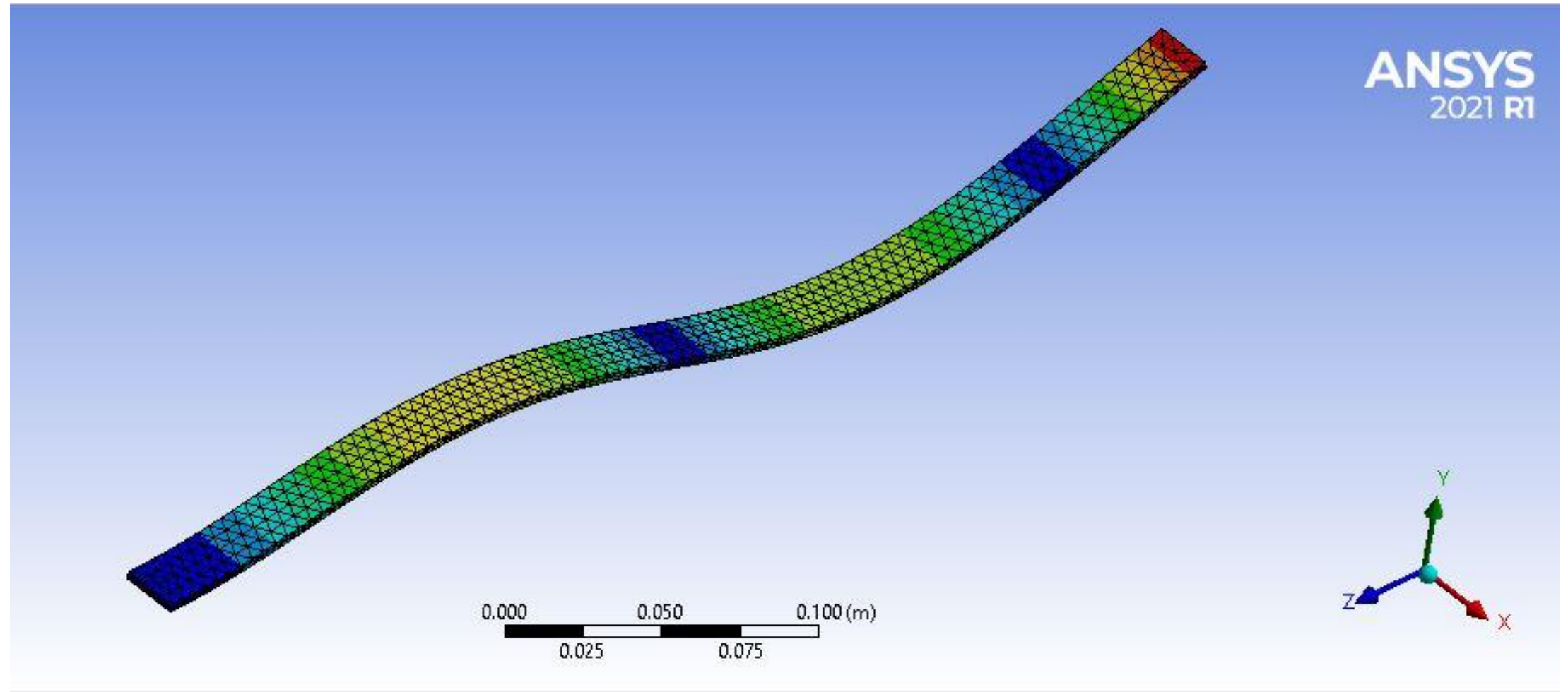
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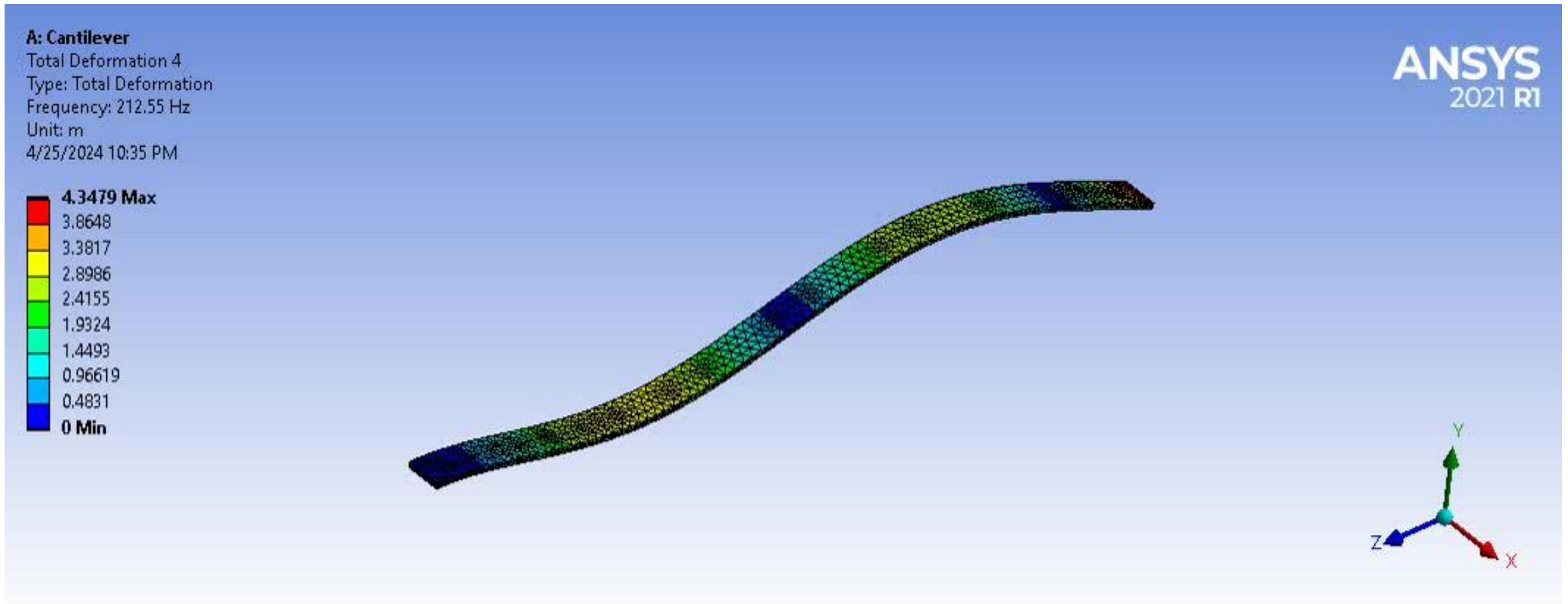
Mode-4



# Mode Shapes

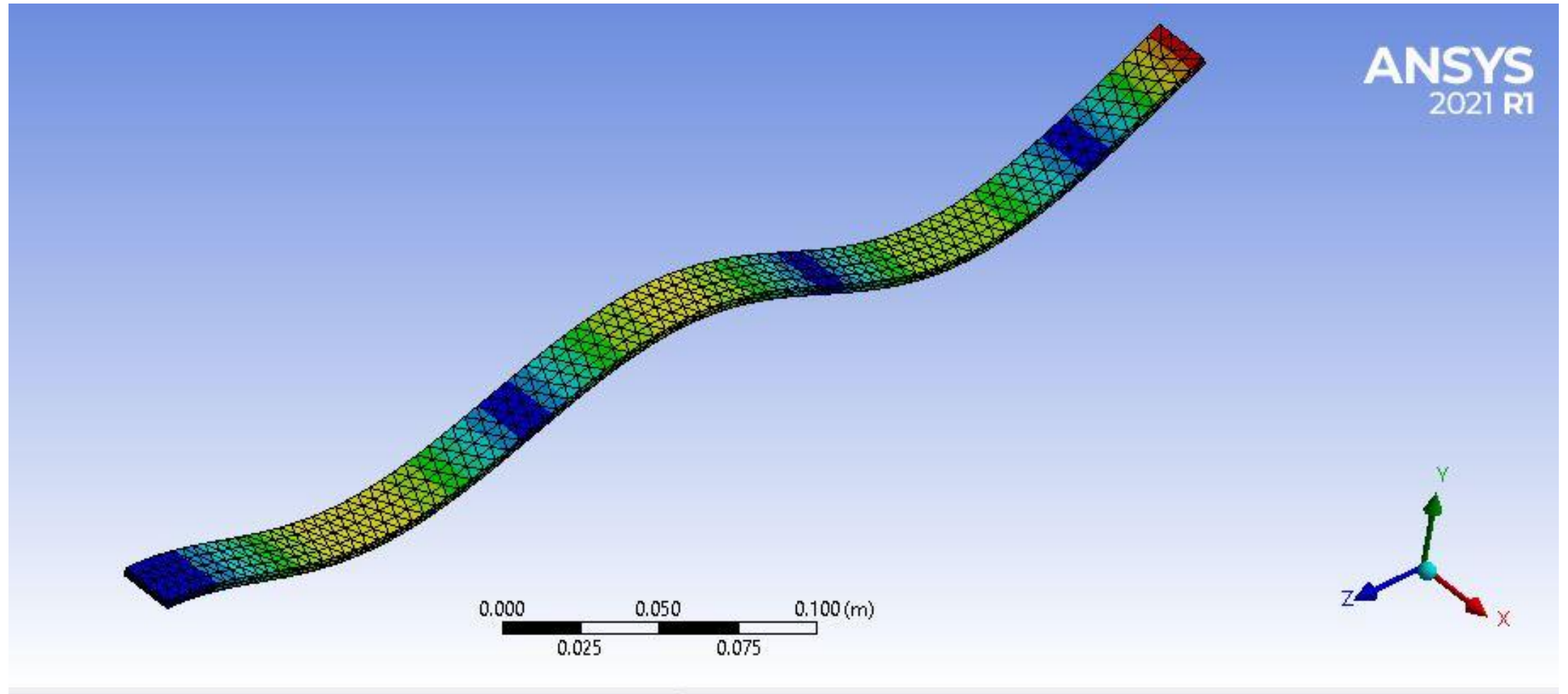


# Animation



Mode-5

# Mode Shapes



# Animation

## A: Cantilever

Total Deformation 5

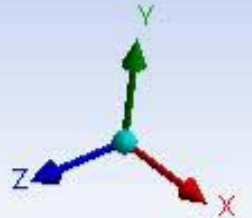
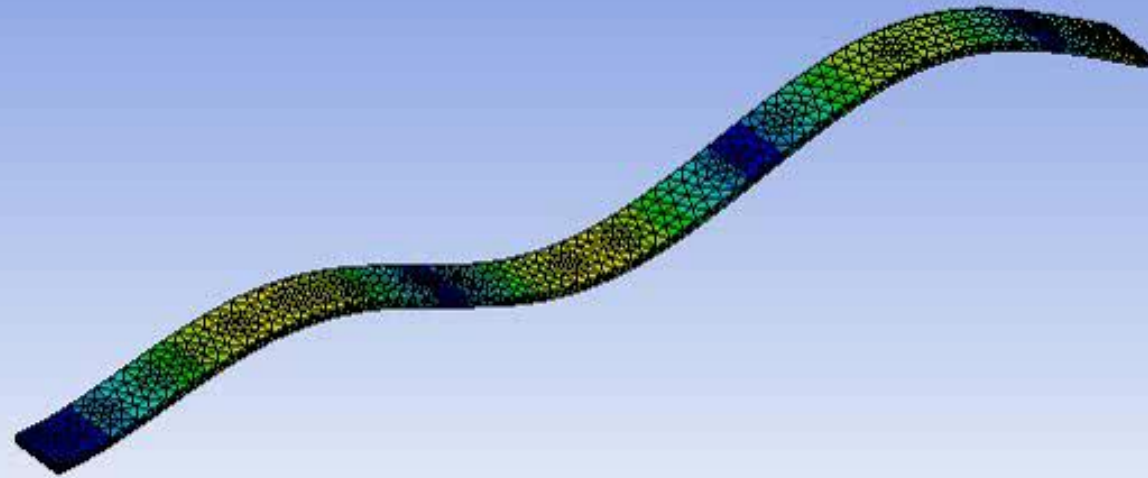
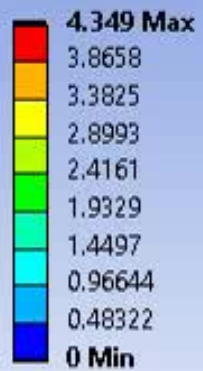
Type: Total Deformation

Frequency: 416.47 Hz

Unit: m

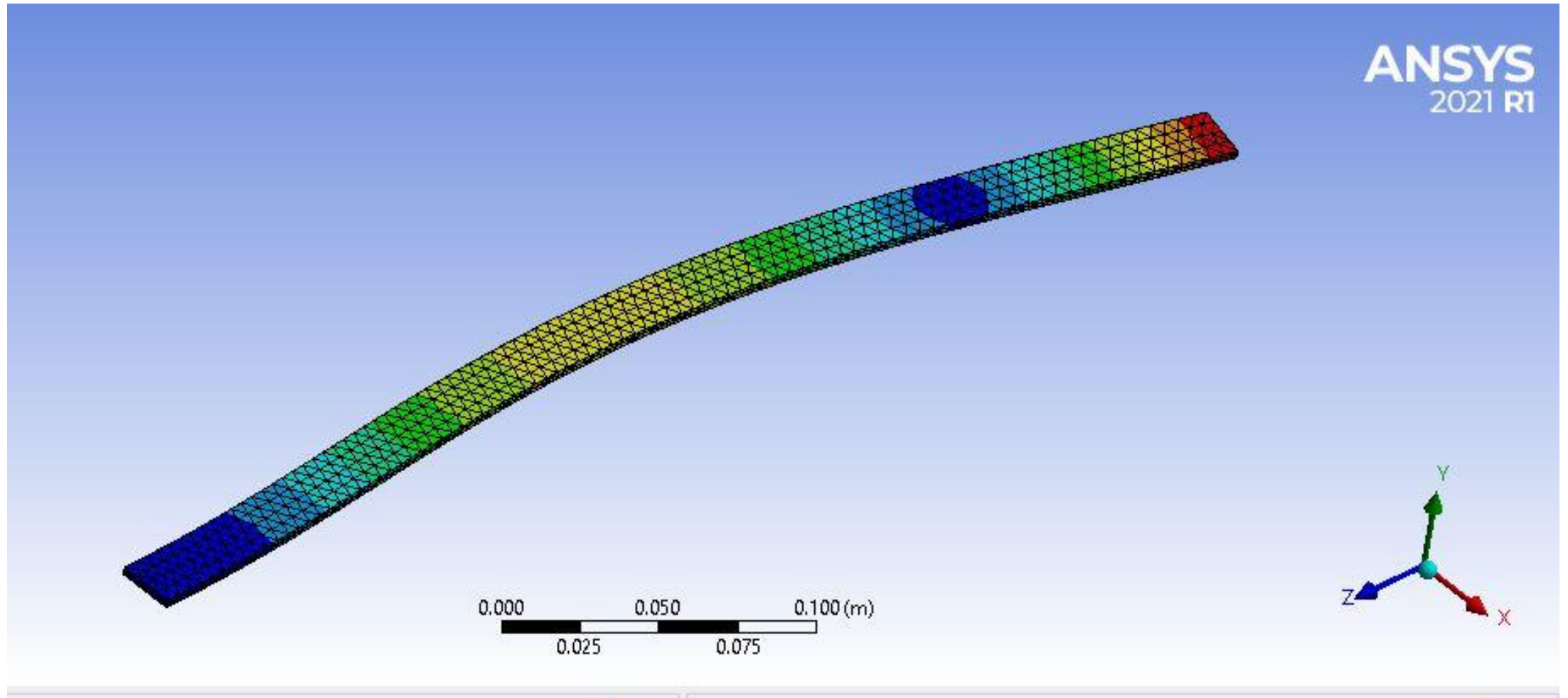
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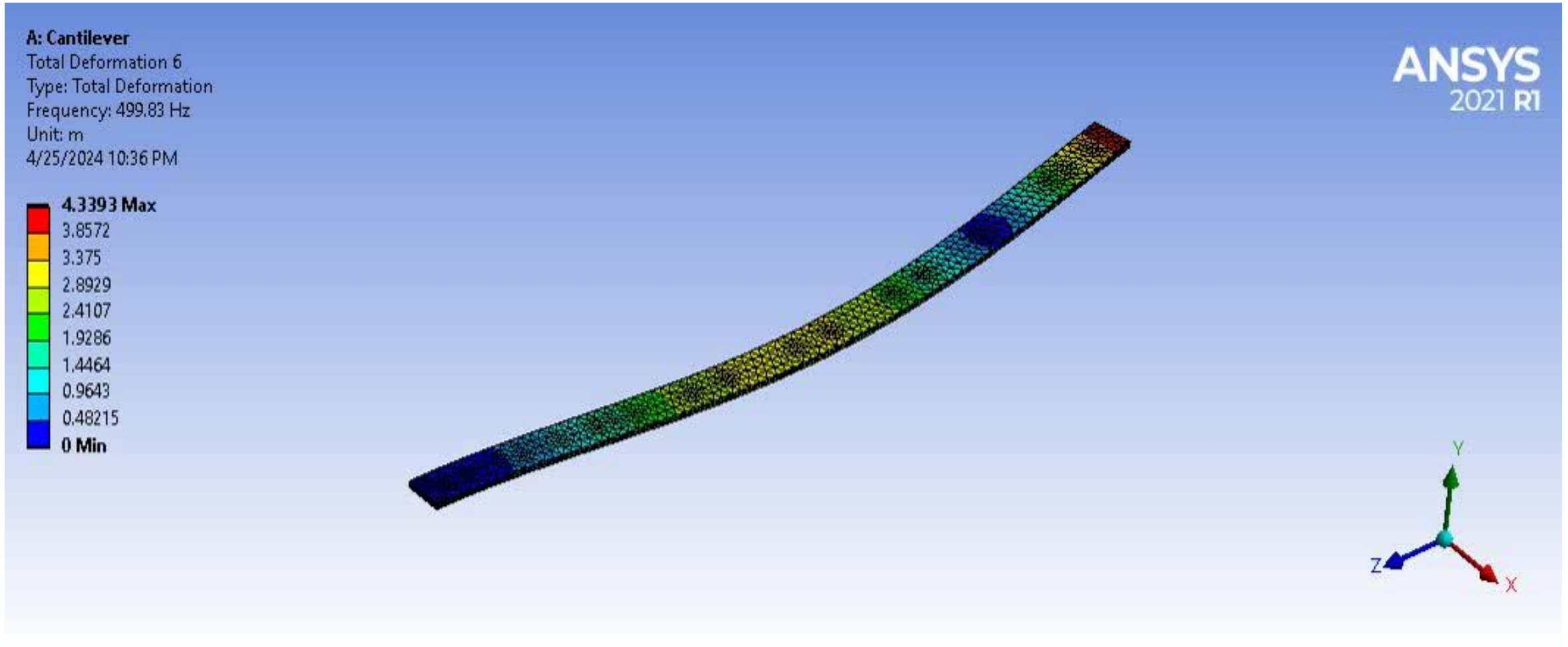


Mode-6

# Mode Shapes



# Animation



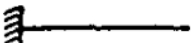
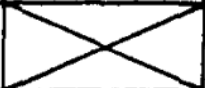


# Eigen frequency comparison (Analytical vs Ansys )

Mode	Analytical (Hz)	Ansys (Hz)
1	12.0857	12.137
2	75.7407	76.047
3	80.5719	80.506
4	212.0761	212.9
5	415.5849	417.13
6	504.9379	500

Used formula for analytical result:-

$$f_n = \frac{(\beta_n l)^2}{2\pi l^2} \sqrt{\left(\frac{EI}{\rho A}\right)}$$

Case	$\beta_0 l$	$\beta_1 l$	$\beta_2 l$	$\beta_3 l$	$\beta_4 l$	$\beta_5 l$
		1.875	4.694	7.855	10.996	14.137

## **2. Plate**

**(Free Vibration\_LANCZOS ITERATION )**

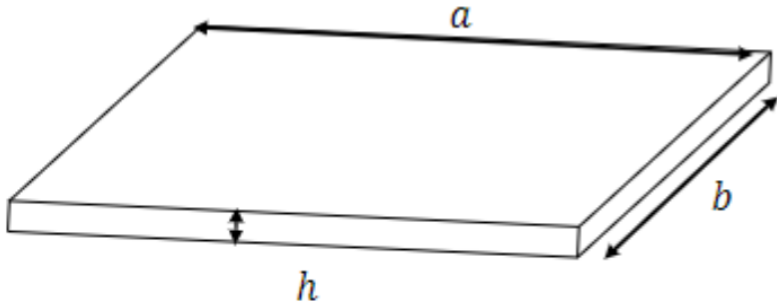
# Geometry

Attributes	Values
Length	$1\text{ m}$
Width	$2\text{ m}$
Height	$0.002\text{ m}$

# Material

Attributes	Values
Young Modulus (E)	$70 * 10^9 Pa$
Poisson ratio (Mue)	0.33
Density	$2700 \frac{Kg}{m^3}$

# Boundary Condition



**Fig. 1.** Dimensions of the rectangular plate

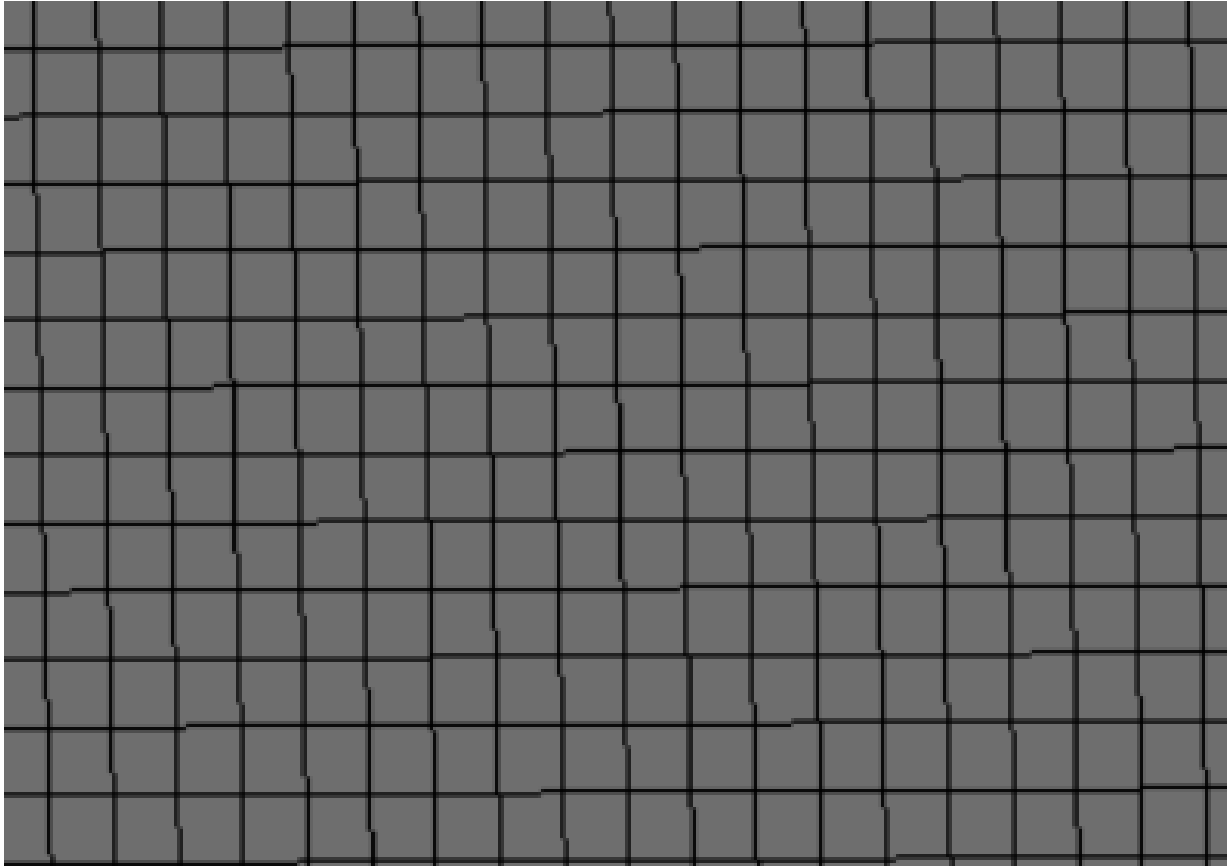
1. Edge simply supported at  $x = x_0$ . Then

$$w = M_x = 0,$$

or, in terms of deflections,

$$w = \frac{\partial^2 w}{\partial x^2} + \nu \frac{\partial^2 w}{\partial y^2} = 0.$$

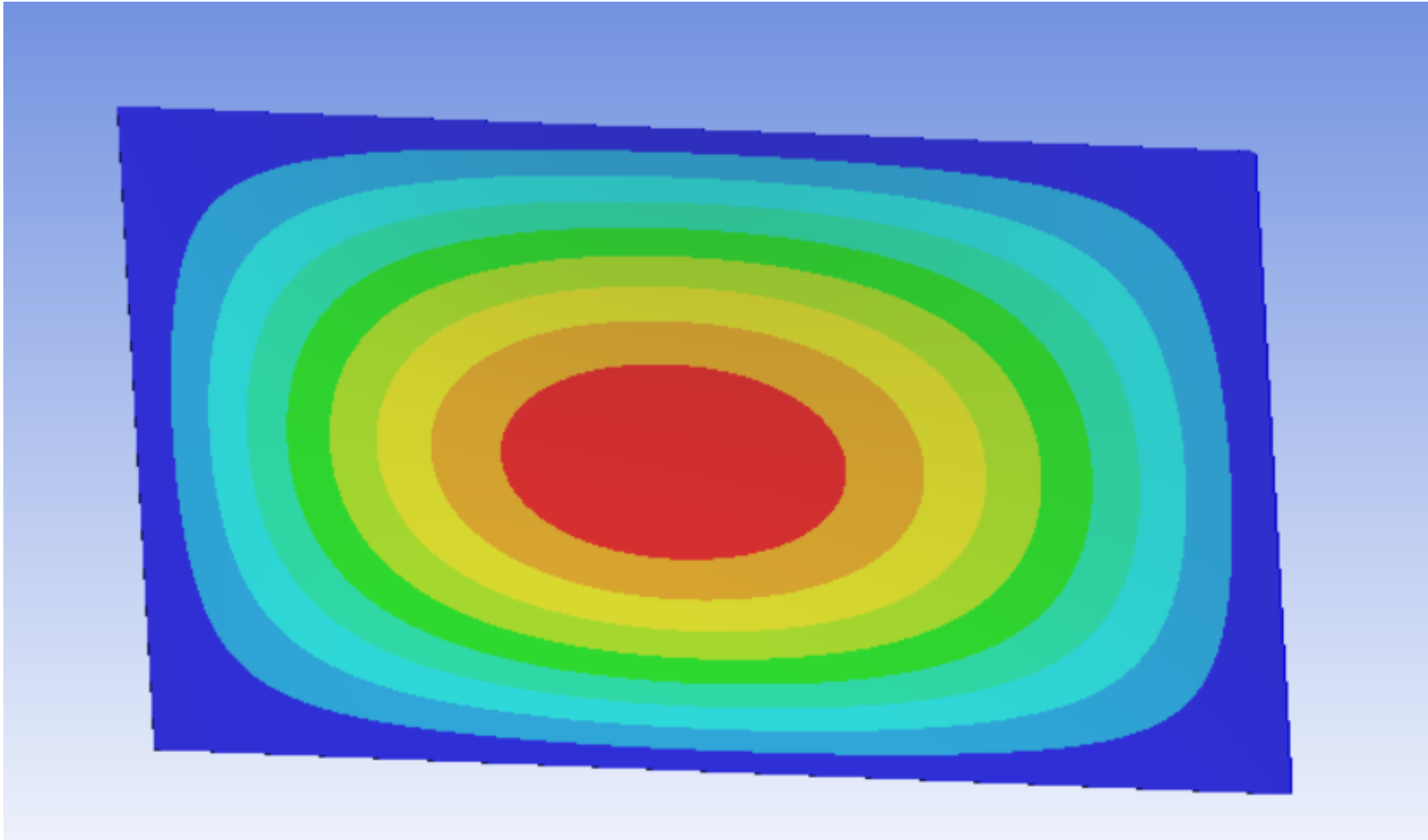
# Meshing (Size = 0.002 m)



# **Mode Shapes & Animation**

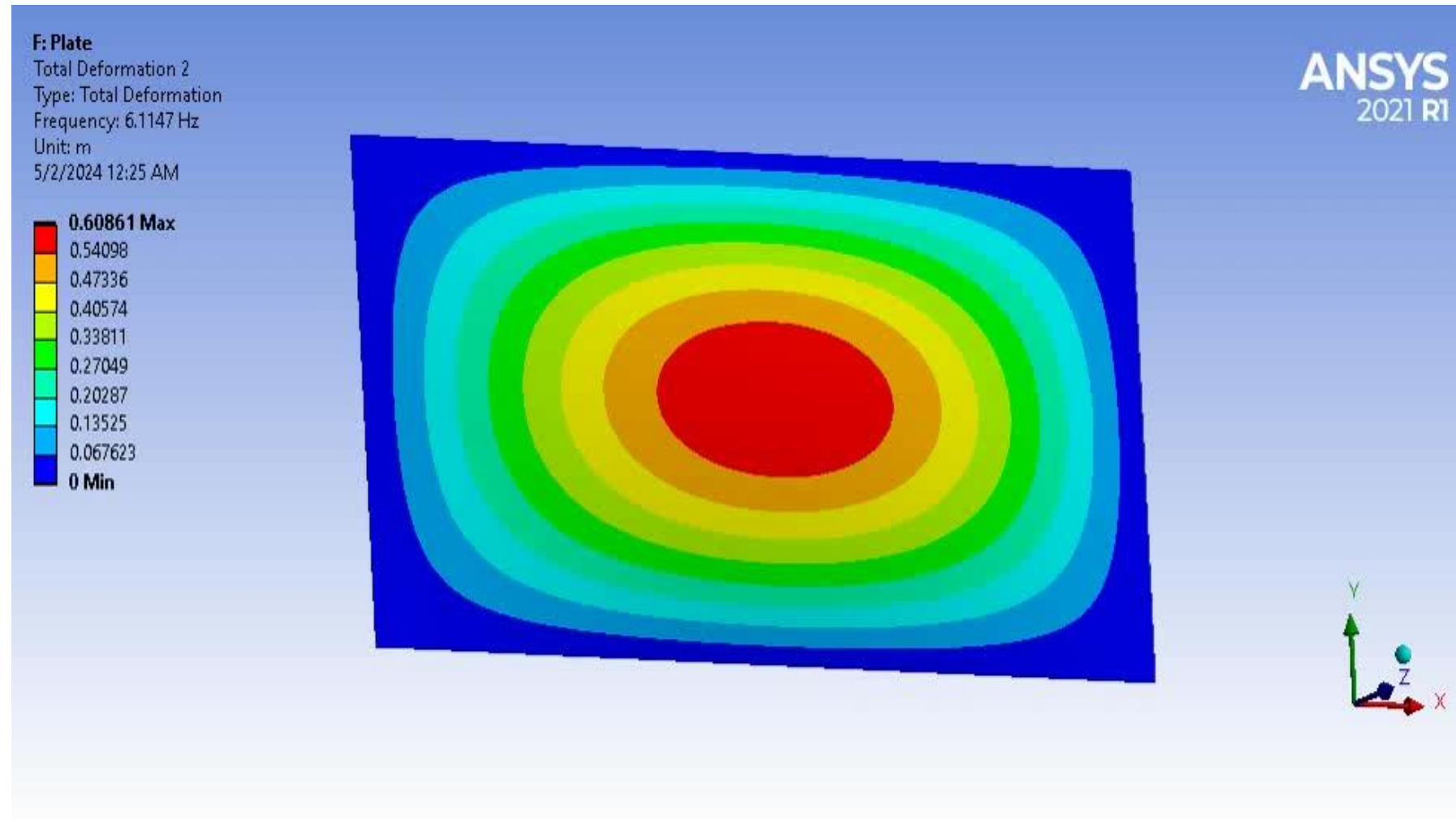
Mode-1

# Mode Shape



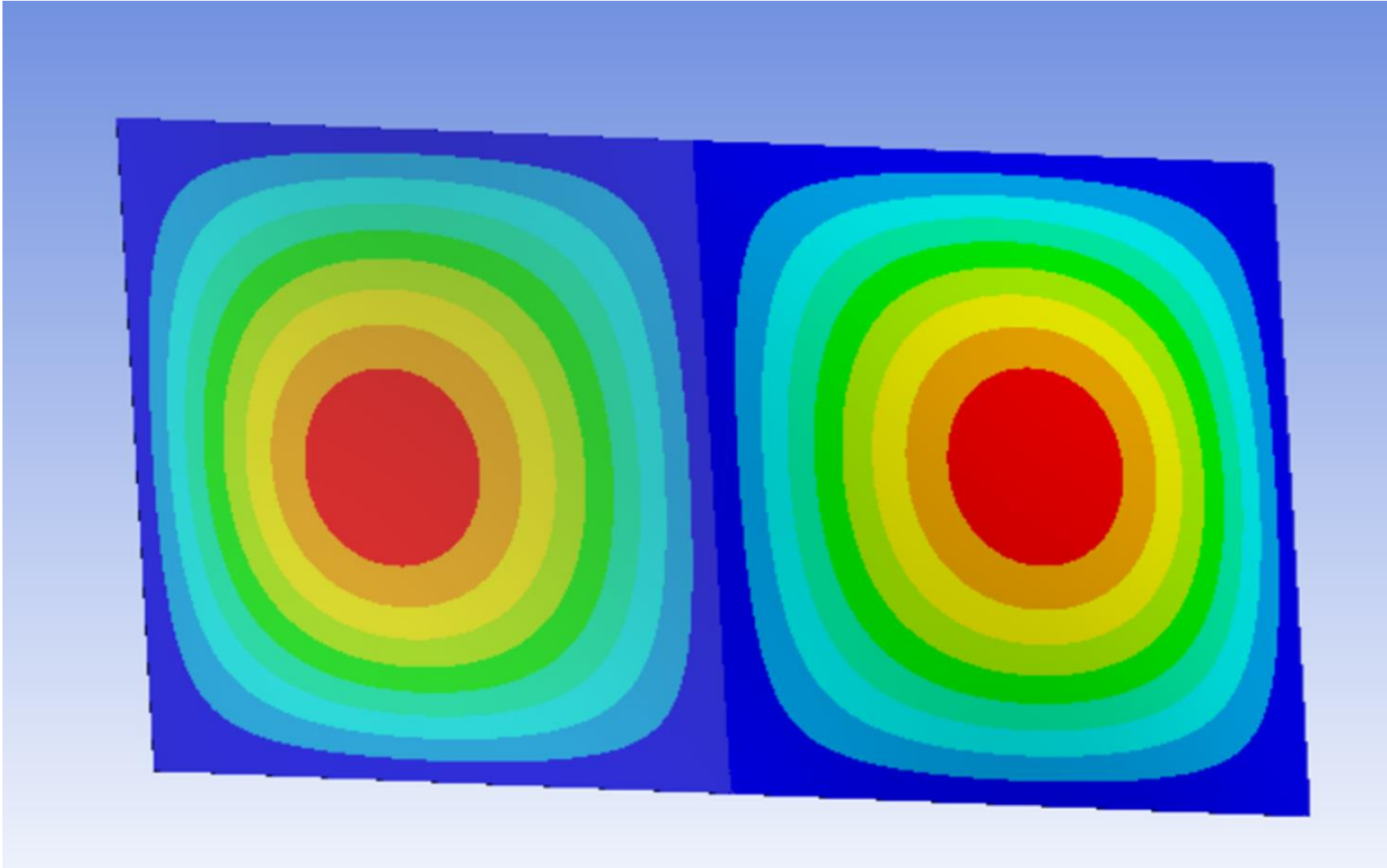


# Animation

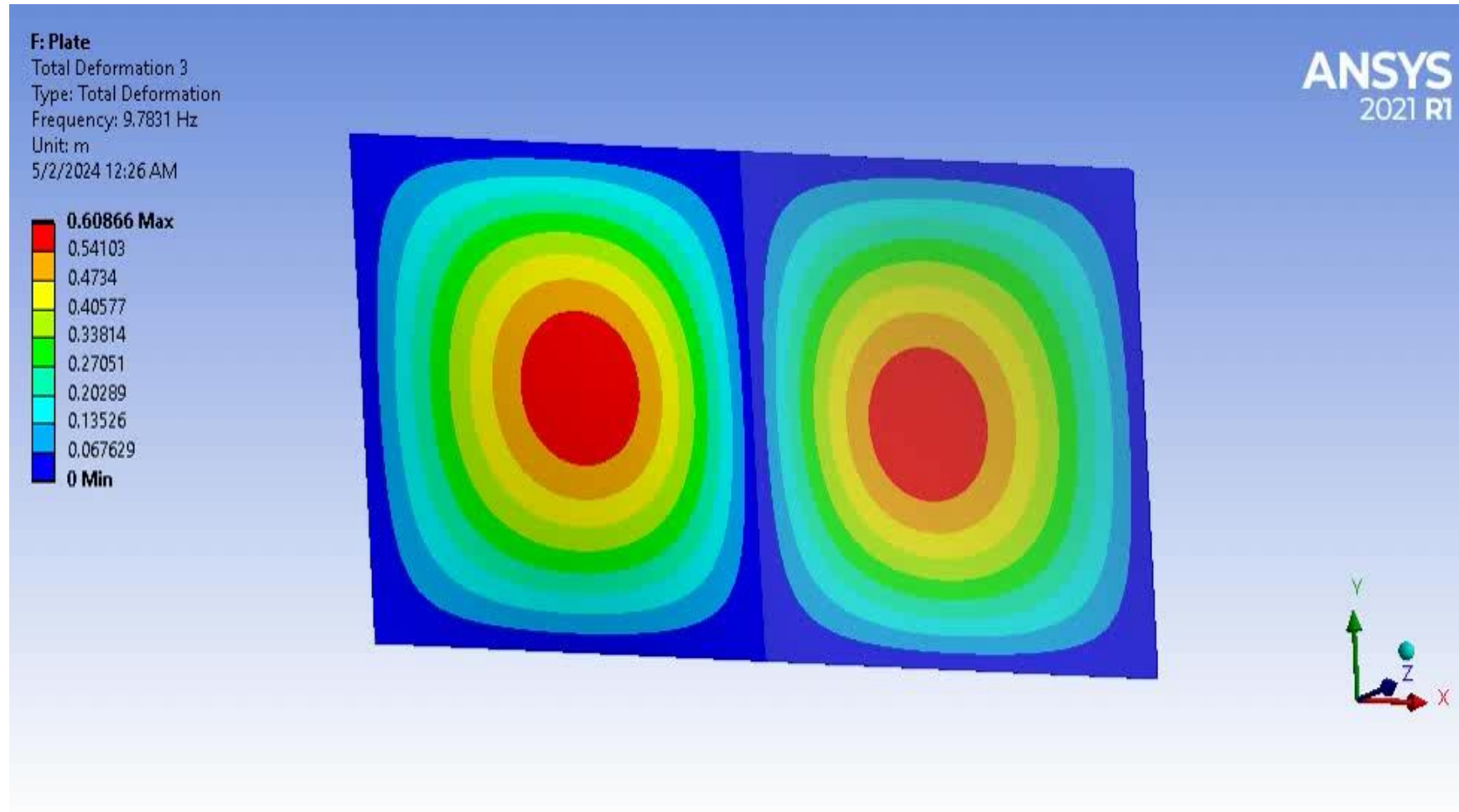


Mode-2

# Mode Shape

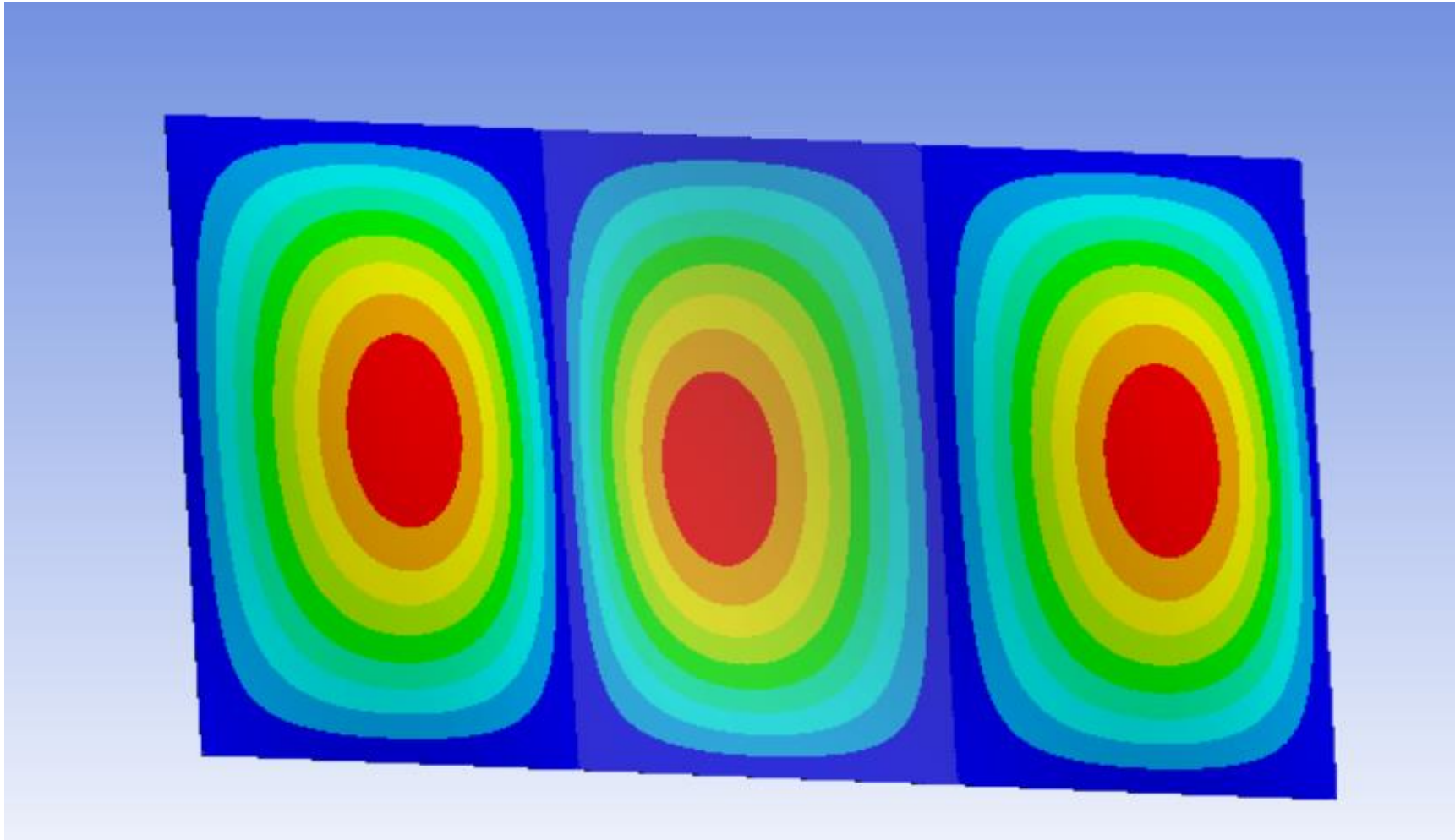


# Animation

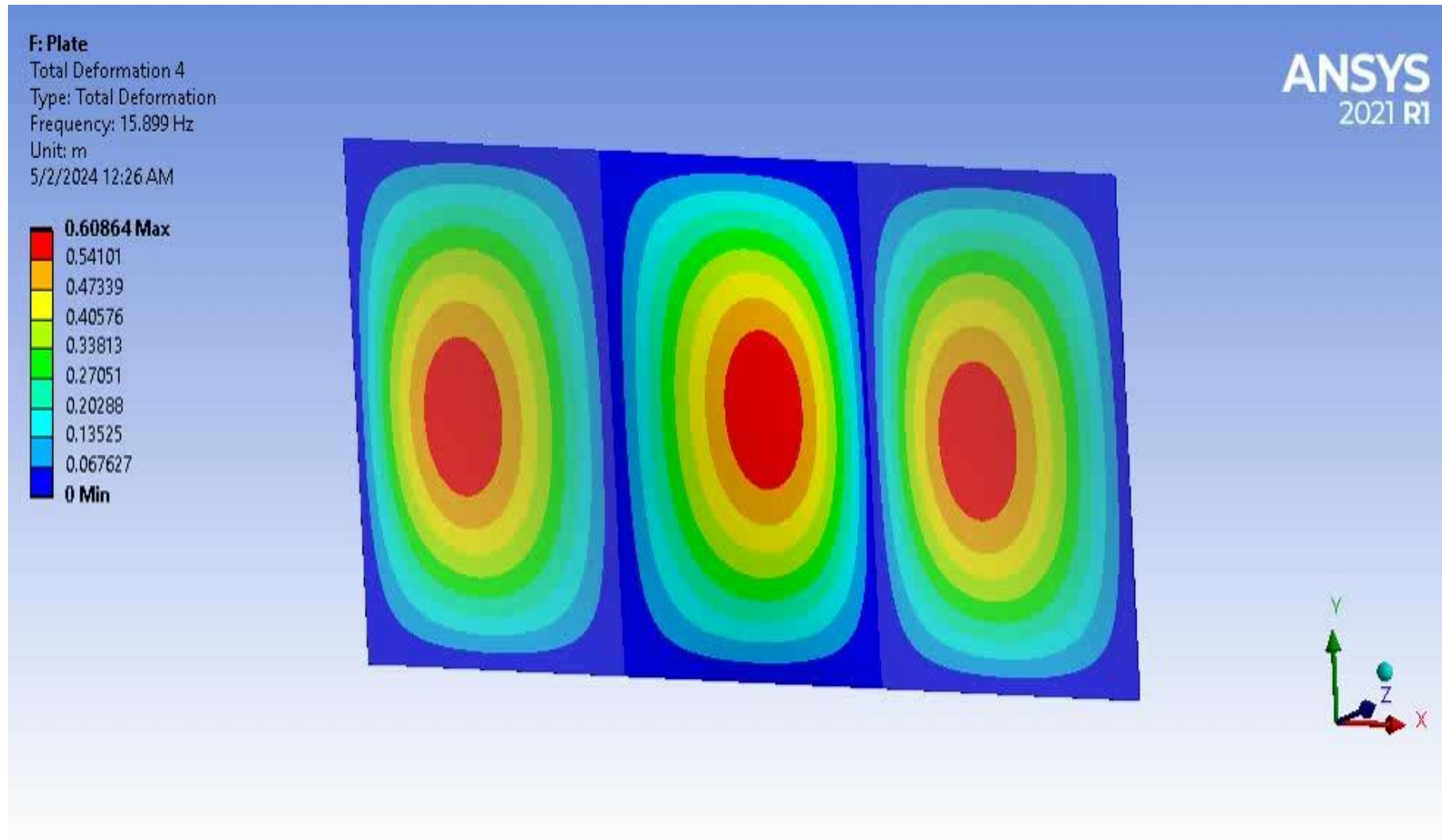


**Mode-3**

# Mode Shape



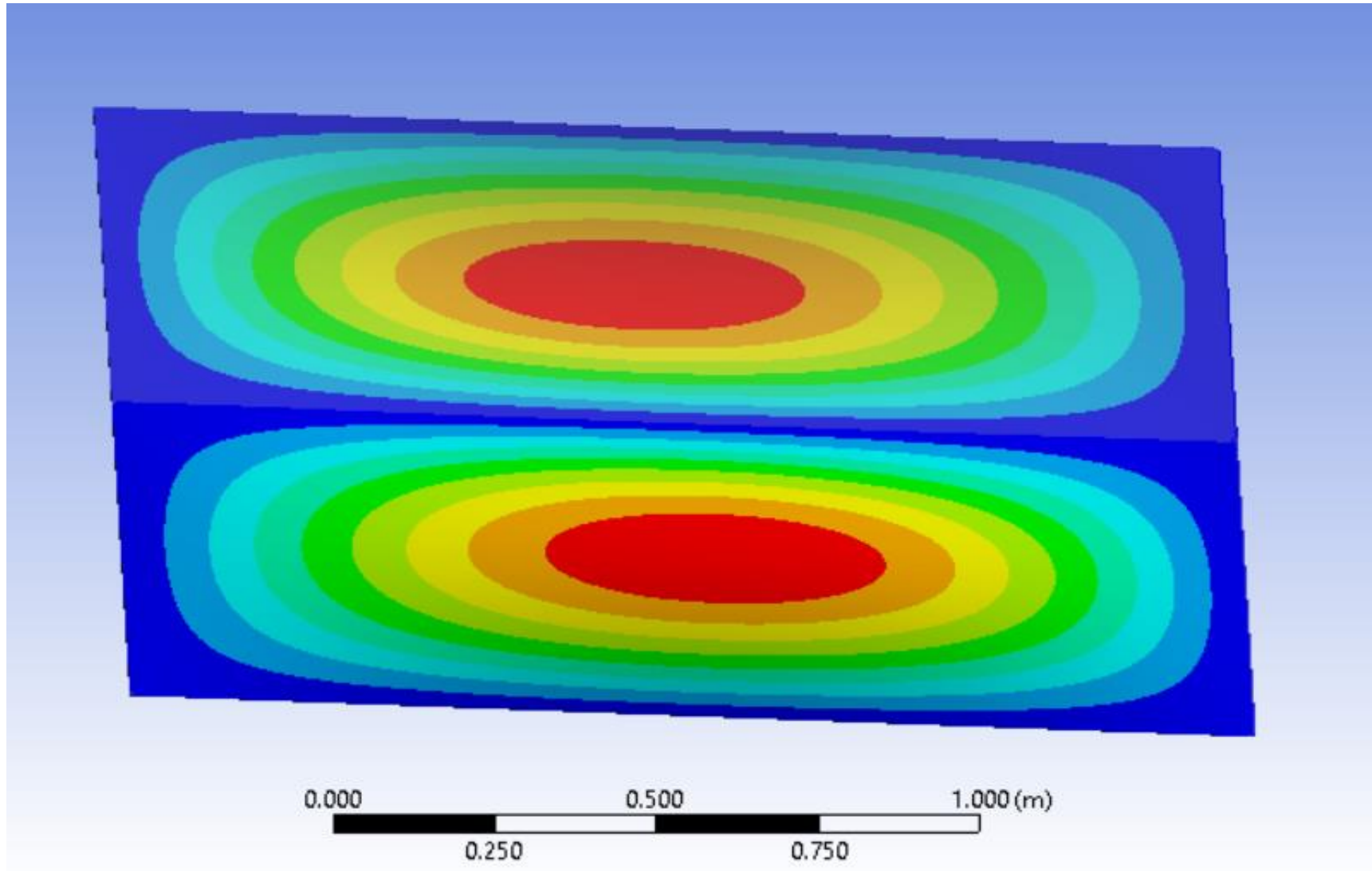
# Animation



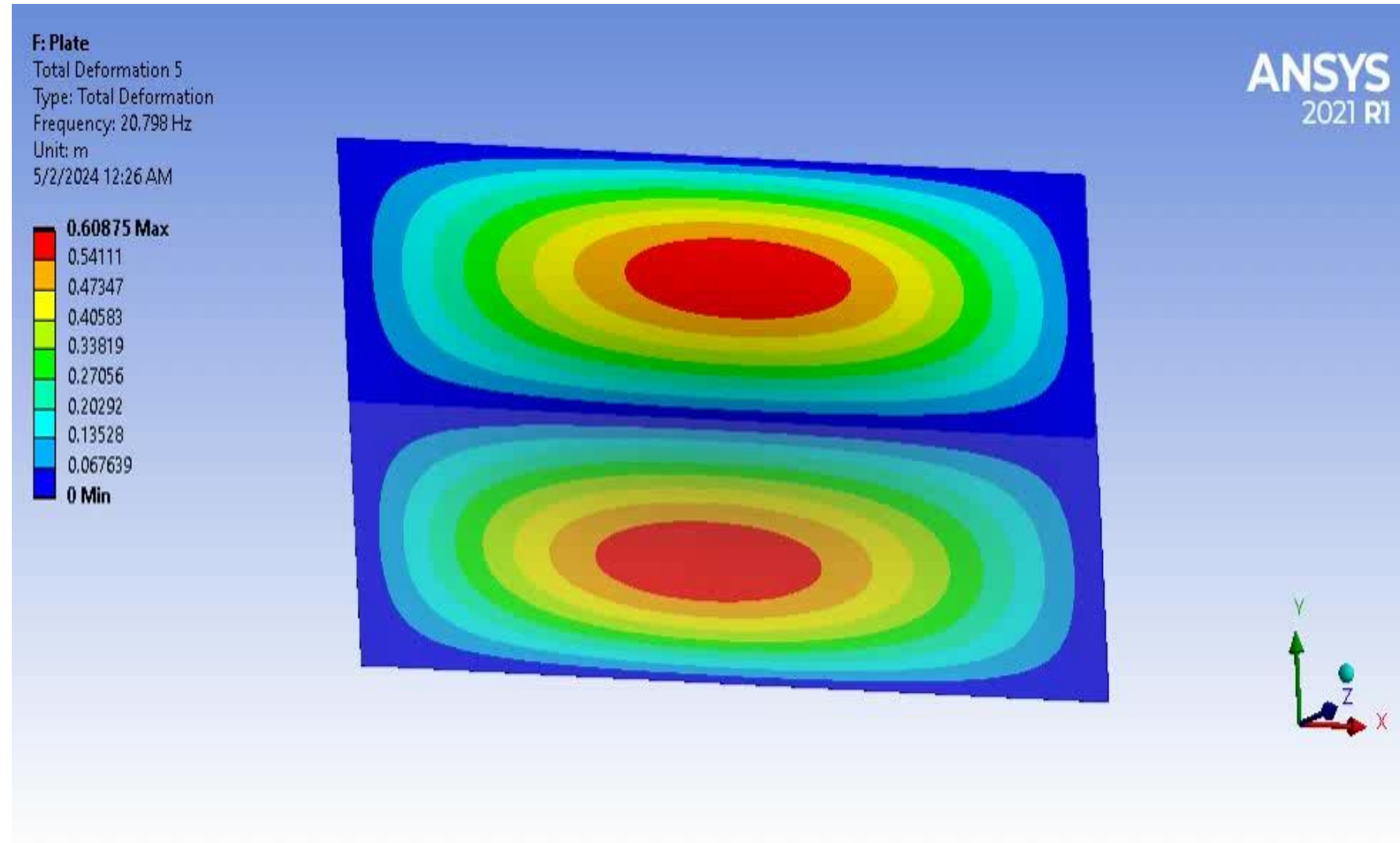
Mode-4



# Mode Shape

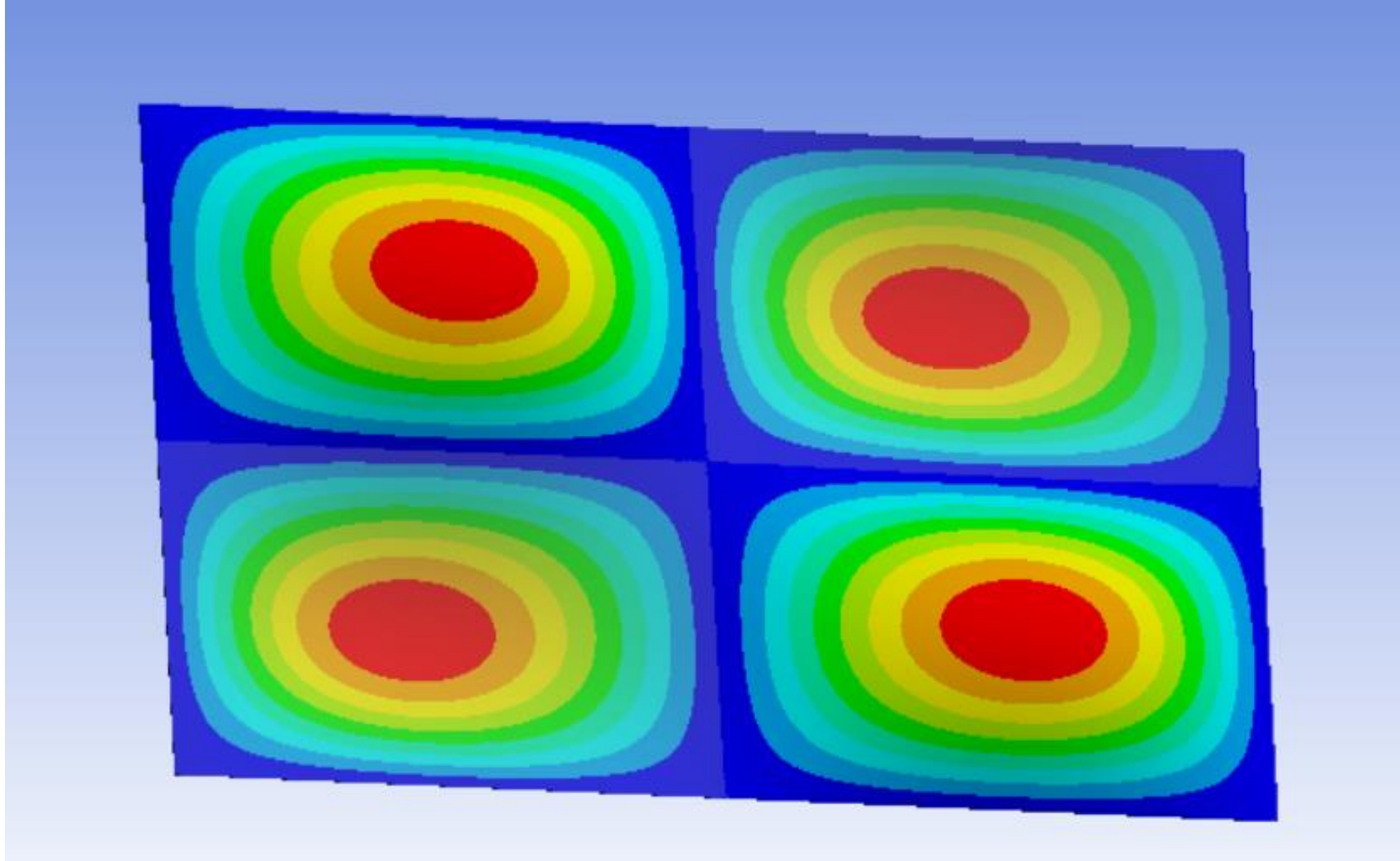


# Animation

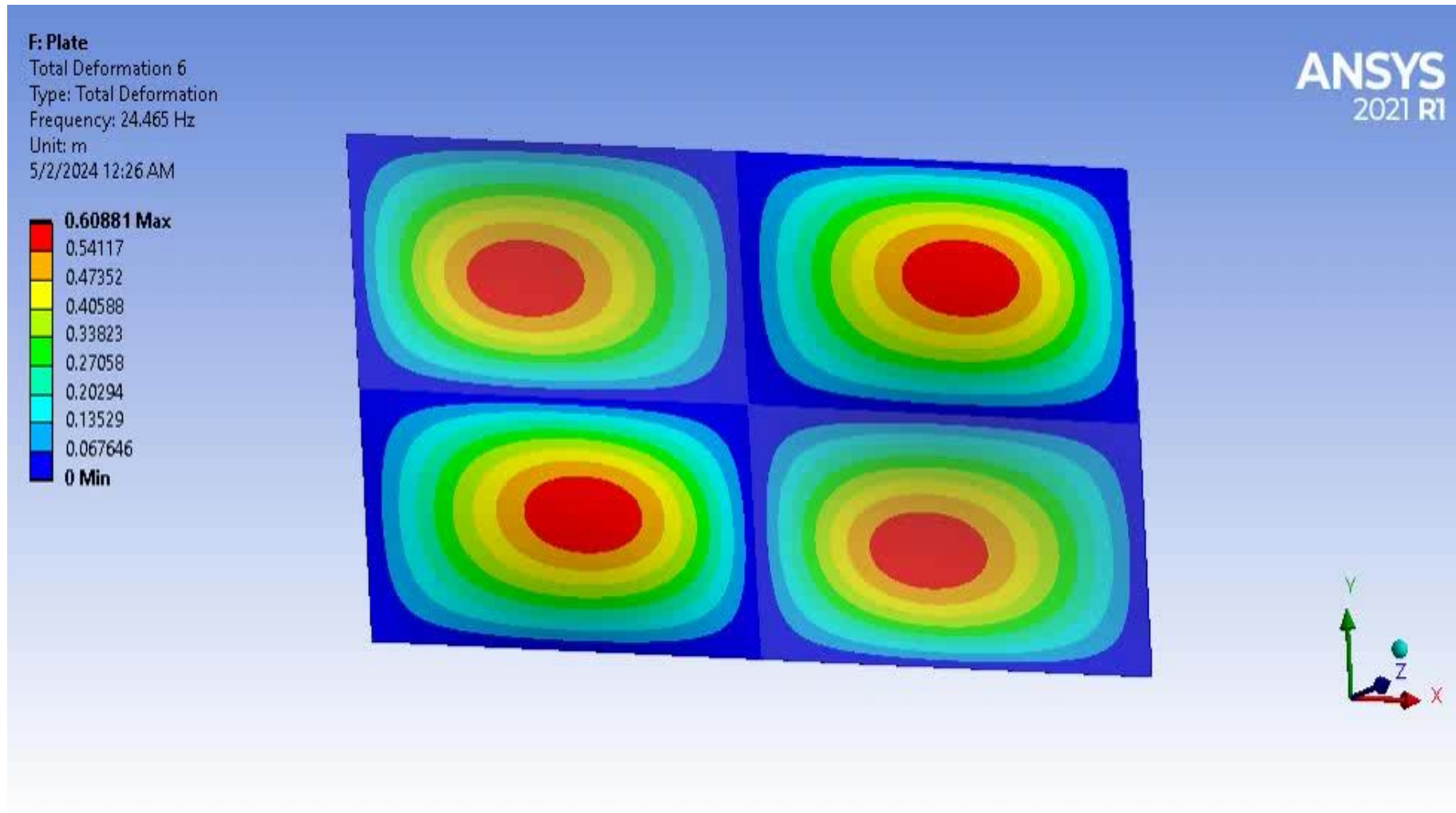


Mode-5

# Mode Shape



# Animation



# Eigen frequency comparison (Analytical vs Ansys )

Mode	Analytical (Hz)	Ansys (Hz)
1	6.115	6.1147
2	9.18	9.7831
3	15.9	15.899
4	20.779	20.798
5	24.446	24.465

Used formula for analytical result:-

$$D = \frac{E \cdot h^3}{12(1 - \nu^2)}$$

$$\omega_{mn} = \left[ \frac{\pi^4 D}{\rho_m h} \left( \frac{m^2}{a^2} + \frac{n^2}{b^2} \right)^2 \right]^{\frac{1}{2}}$$

$$f_{mn} = \frac{\omega_{mn}}{2\pi}$$

### **3. Simply Supported Beam**

**( Free Vibration\_LANCZOS ITERATION )**

# Geometry

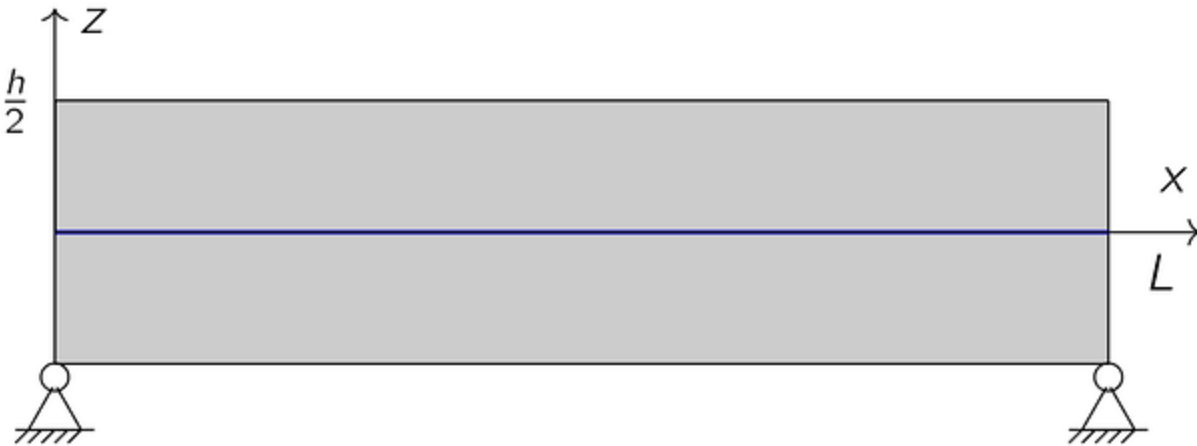
Attributes	Values
Length	0.45 <i>m</i>
Width	0.02 <i>m</i>
Height	0.003 <i>m</i>
Moment Of Inertia	$4.5 \times 10^{-11}m^4$ <i>And</i> $2 \times 10^{-9}m^4$

# Material

Attributes	Values
Material Name	Structural Steel
Young Modulus (E)	$2.1 \times 10^{11}Pa$
Poisson ratio (Mue)	0.3
Density	$7850 \frac{Kg}{m^3}$

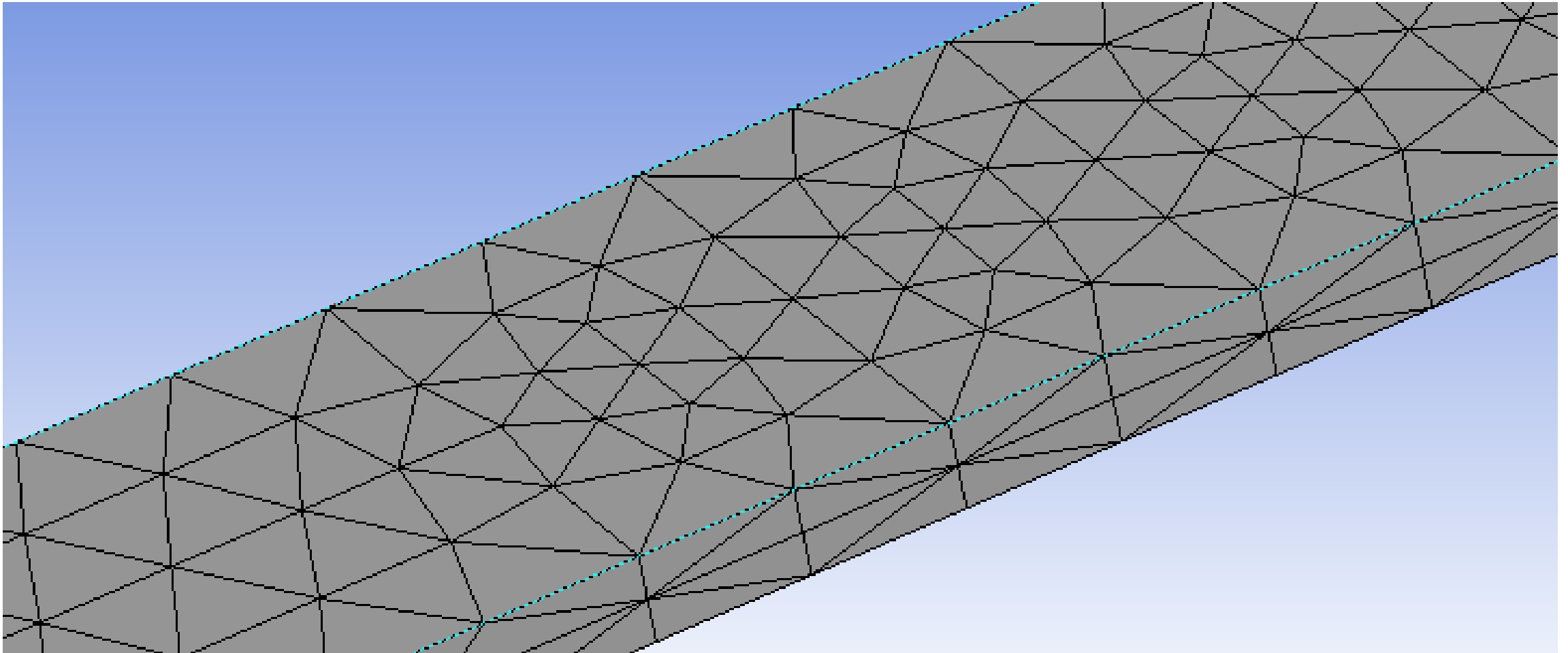


# Boundary Condition



- Definition	
Type	Remote Displacement
<input type="checkbox"/> X Component	0. m
<input type="checkbox"/> Y Component	0. m
<input type="checkbox"/> Z Component	0. m
Rotation X	Free
<input type="checkbox"/> Rotation Y	0. °
<input type="checkbox"/> Rotation Z	0. °
Suppressed	No
Behavior	Deformable
+ Advanced	

# Meshing (Size = 0.003 m)



# **Mode Shapes & Animation**

Mode-1

# Mode Shape

D: Simply supported free vibration

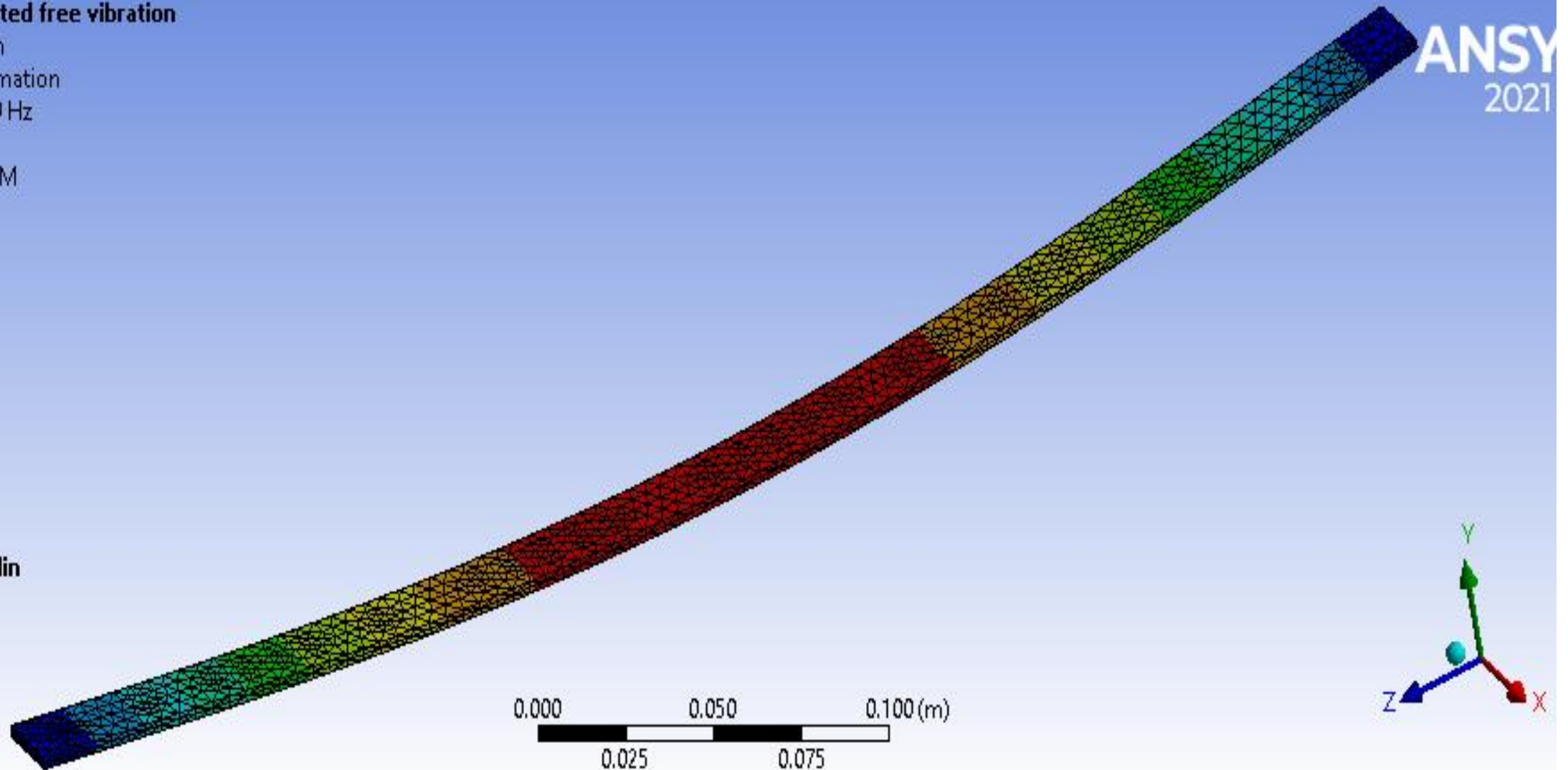
Total Deformation

Type: Total Deformation

Frequency: 33.909 Hz

Unit: m

4/26/2024 12:15 PM



# Animation

D: Simply supported free vibration

Total Deformation

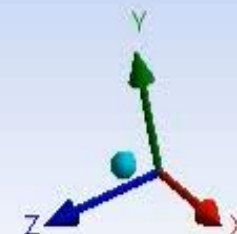
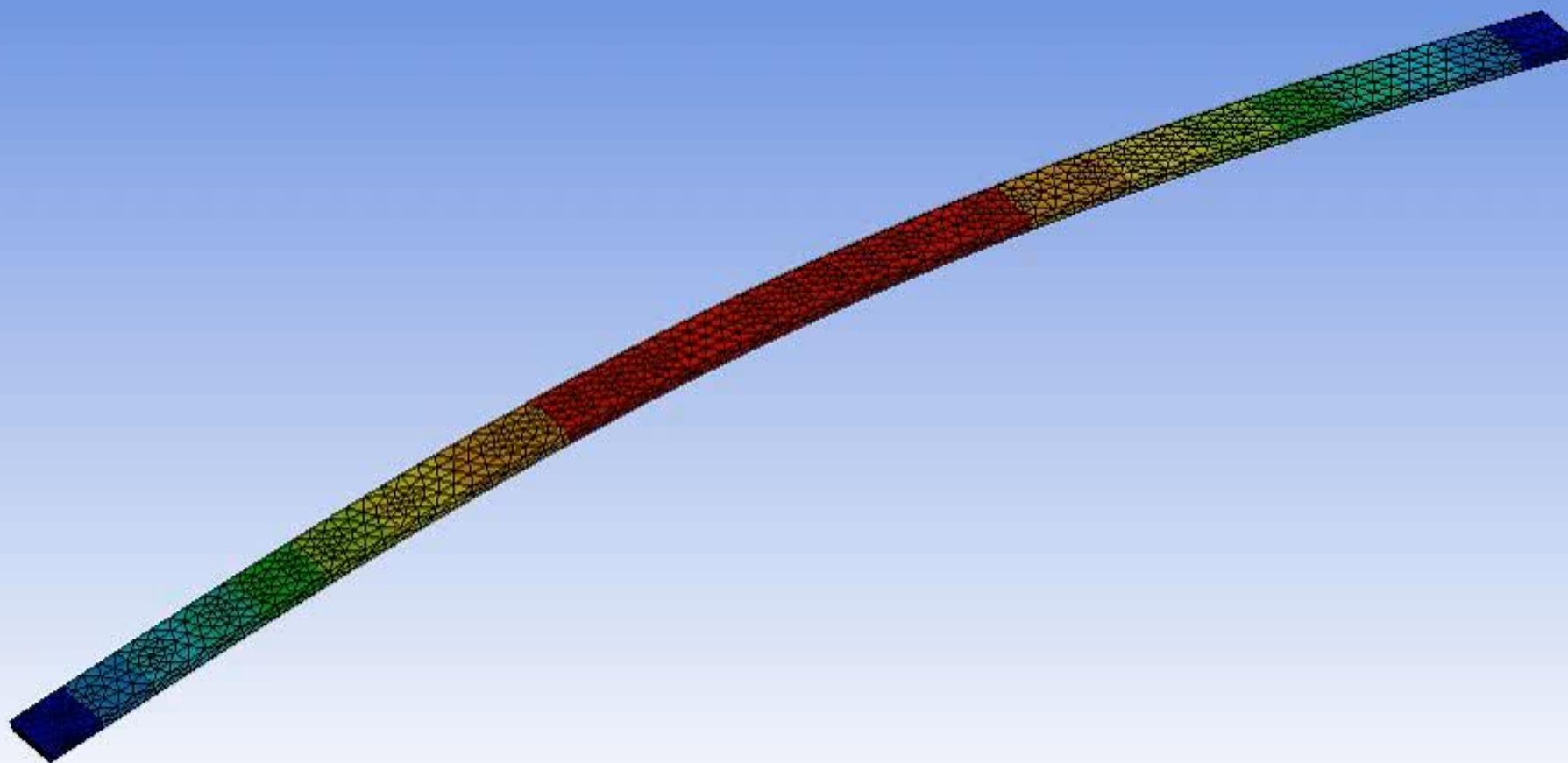
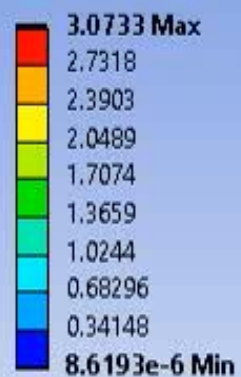
Type: Total Deformation

Frequency: 33.909 Hz

Unit: m

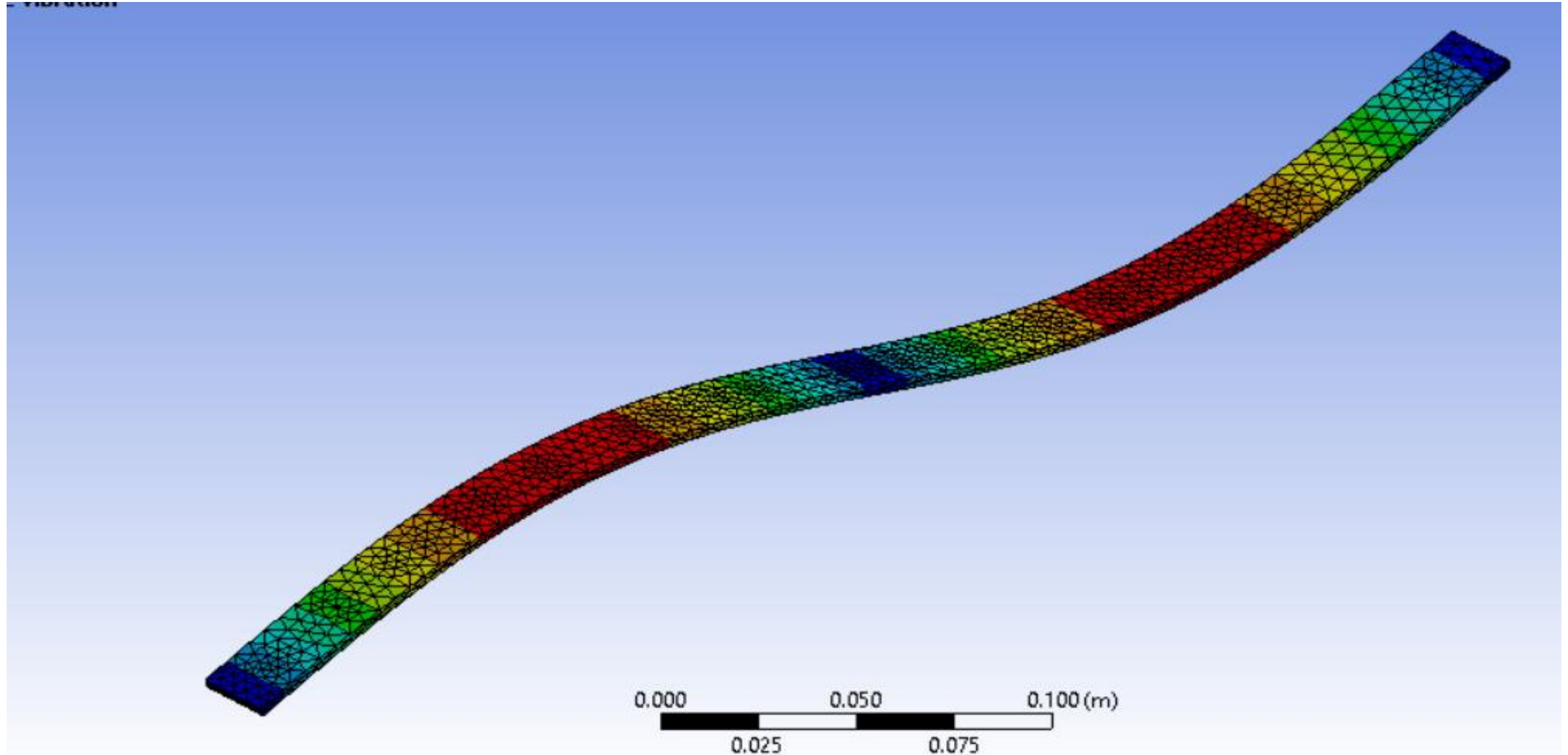
5/2/2024 11:19 AM

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2021 R1



Mode-2

# Mode Shape





# Animation

**D: Simply supported free vibration**

Total Deformation 2

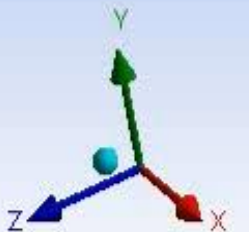
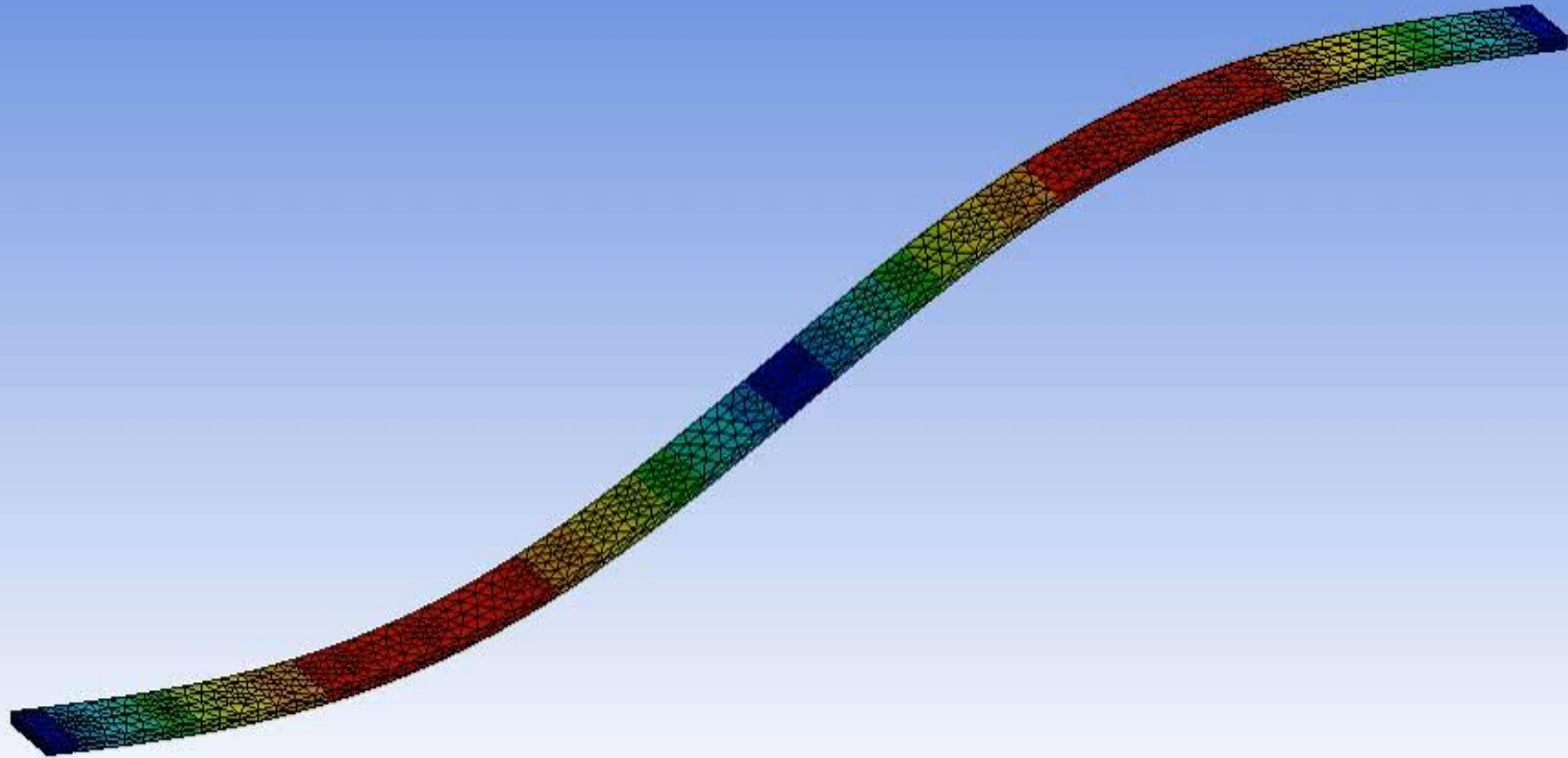
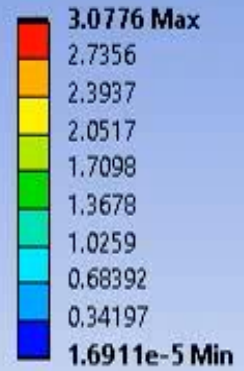
Type: Total Deformation

Frequency: 135.65 Hz

Unit: m

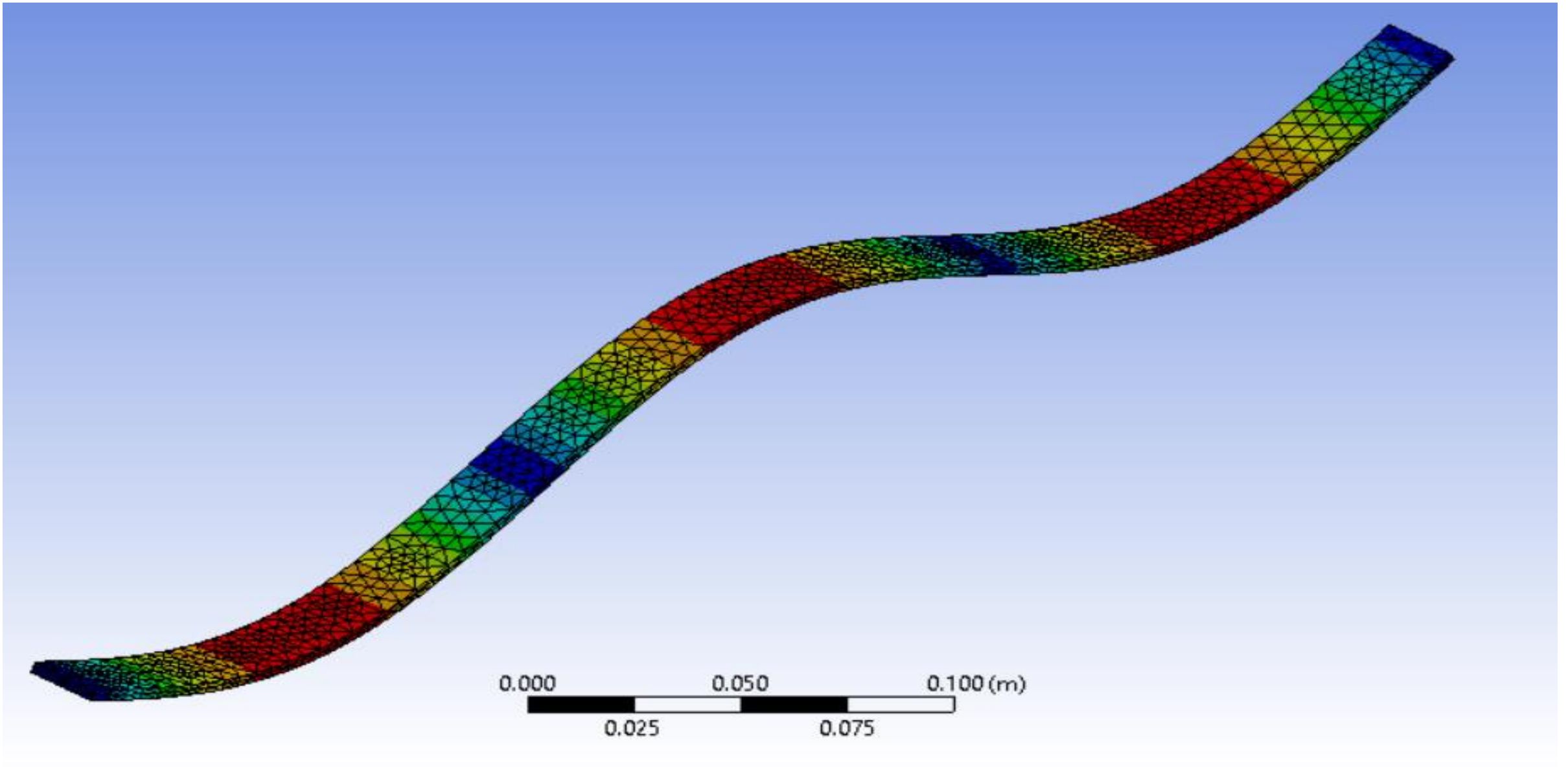
5/2/2024 11:19 AM

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**Mode-3**

# Mode Shape



# Animation

**D: Simply supported free vibration**

Total Deformation 3

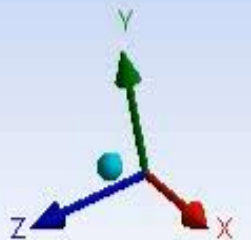
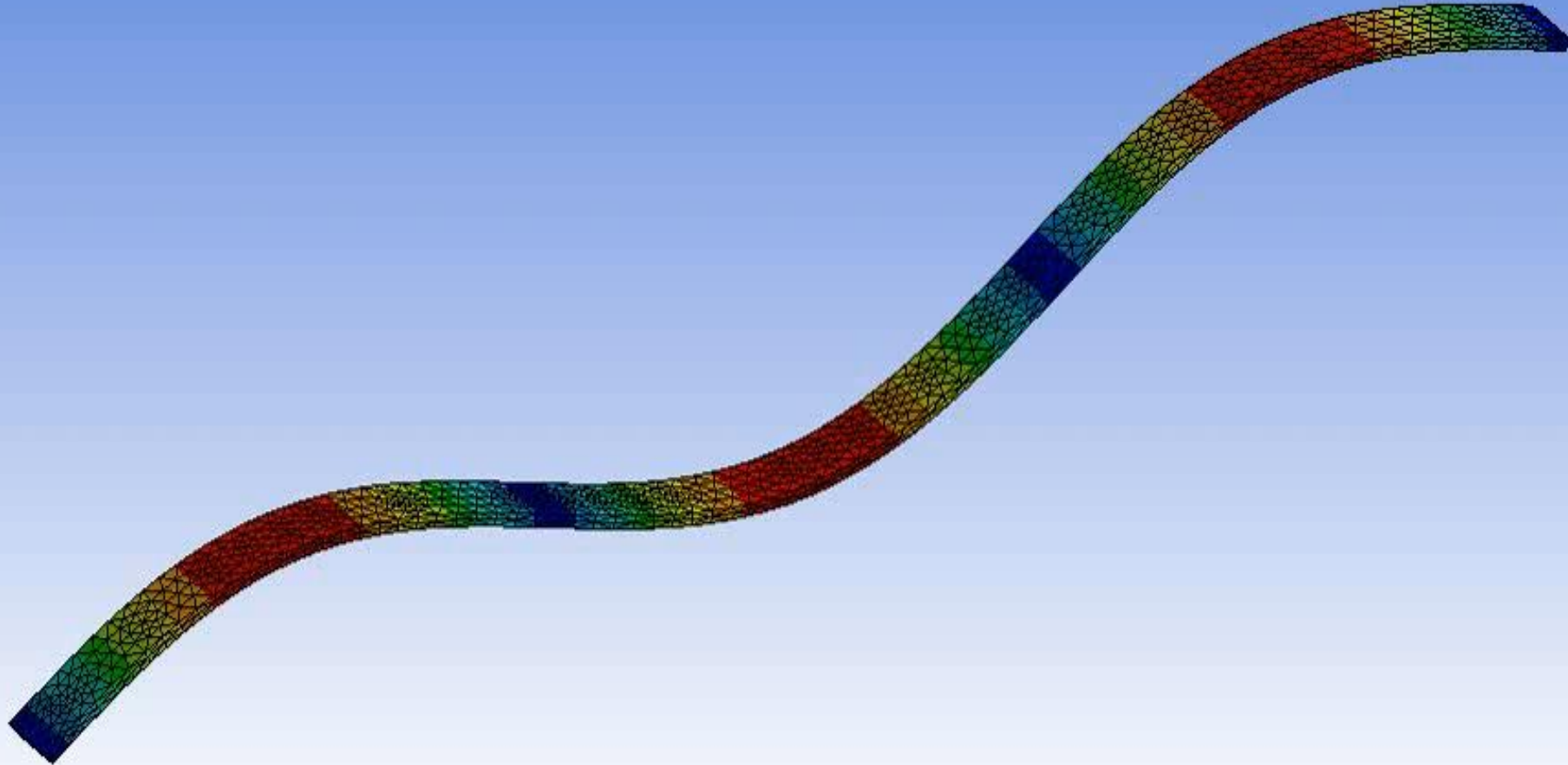
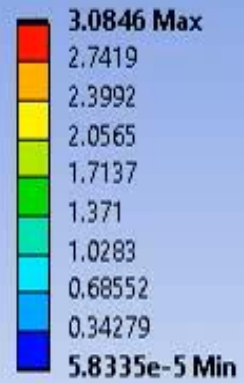
Type: Total Deformation

Frequency: 305.24 Hz

Unit: m

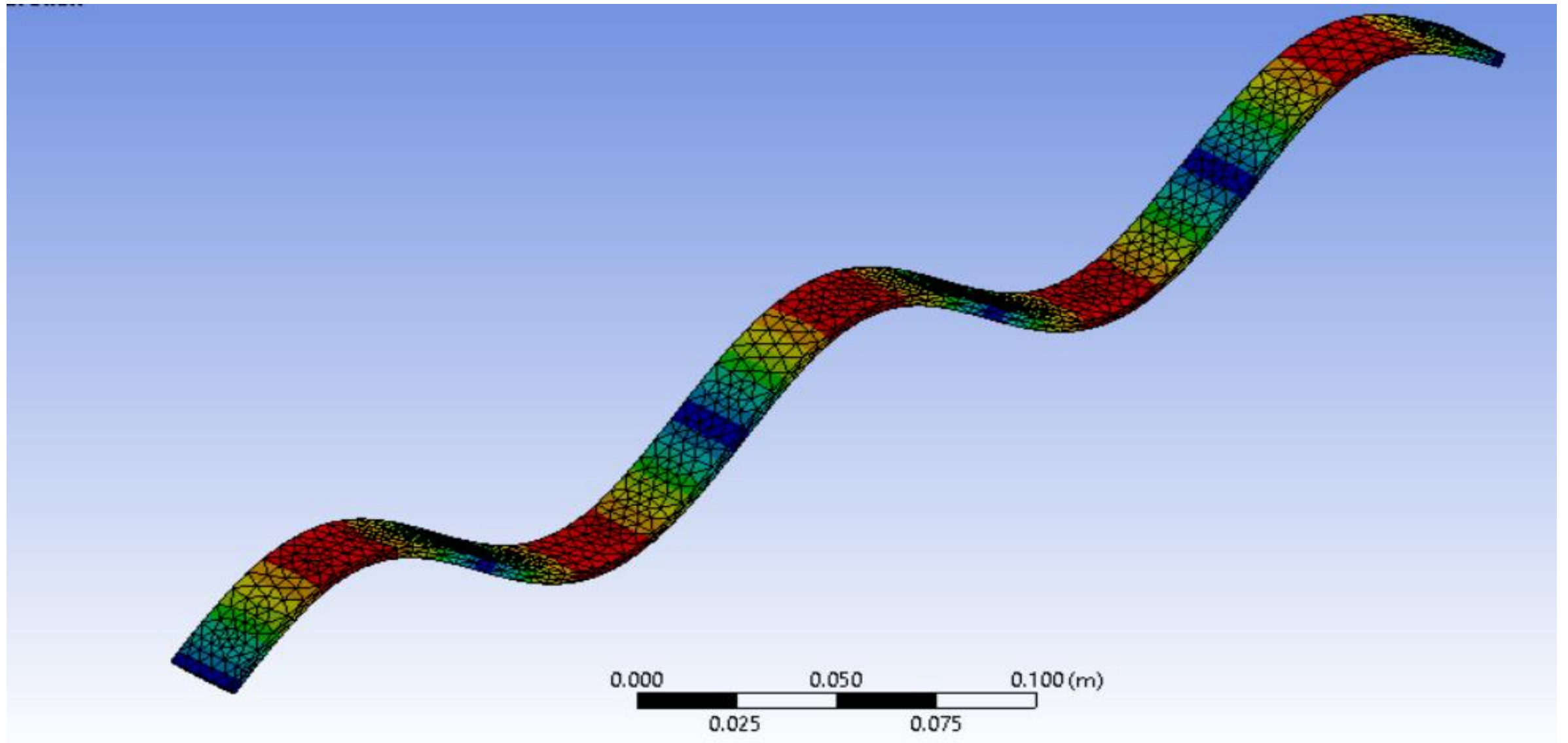
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Mode-4

# Mode Shape

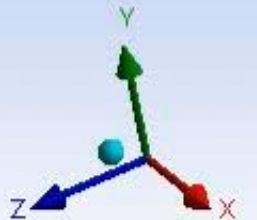
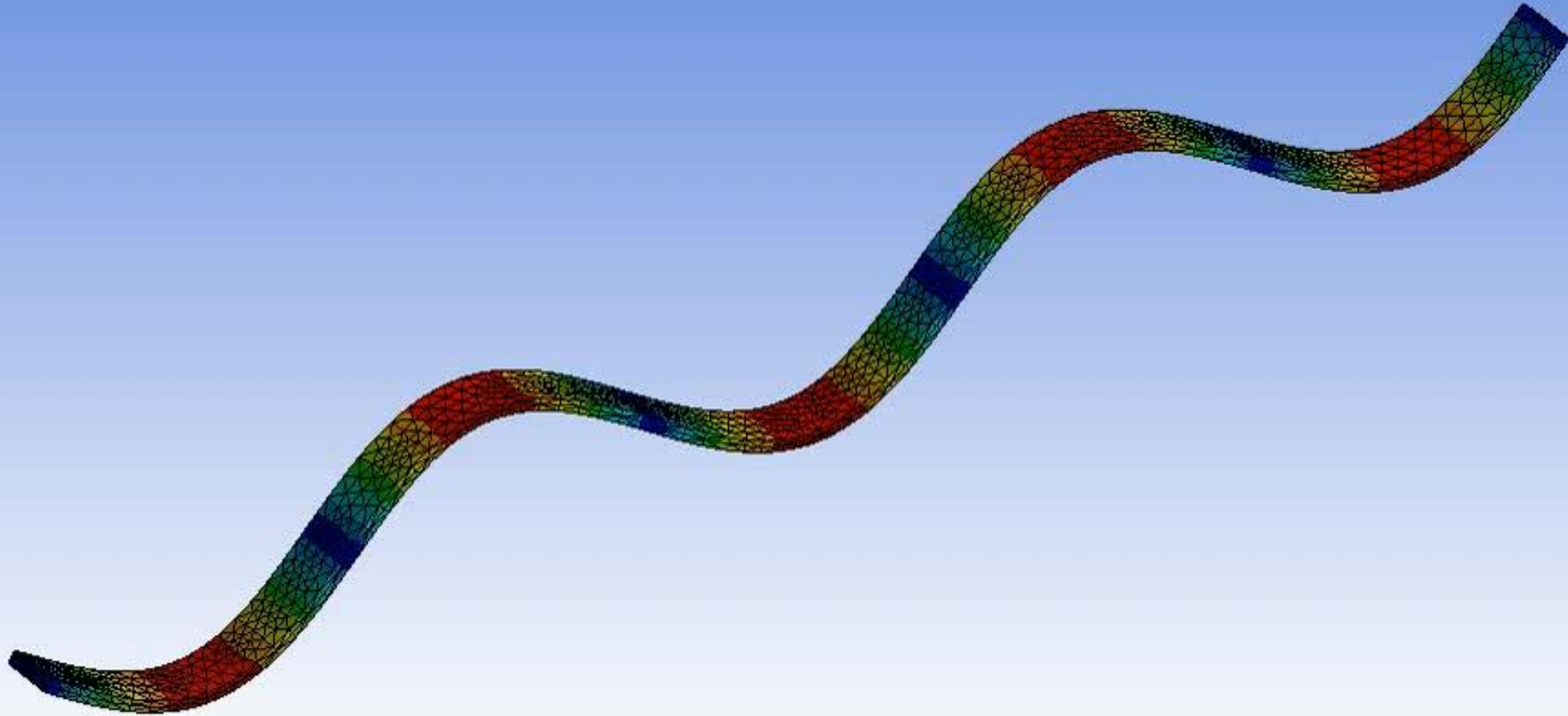


# Animation

**D: Simply supported free vibration**

Total Deformation 4  
Type: Total Deformation  
Frequency: 848.15 Hz  
Unit: m  
5/2/2024 11:20 AM

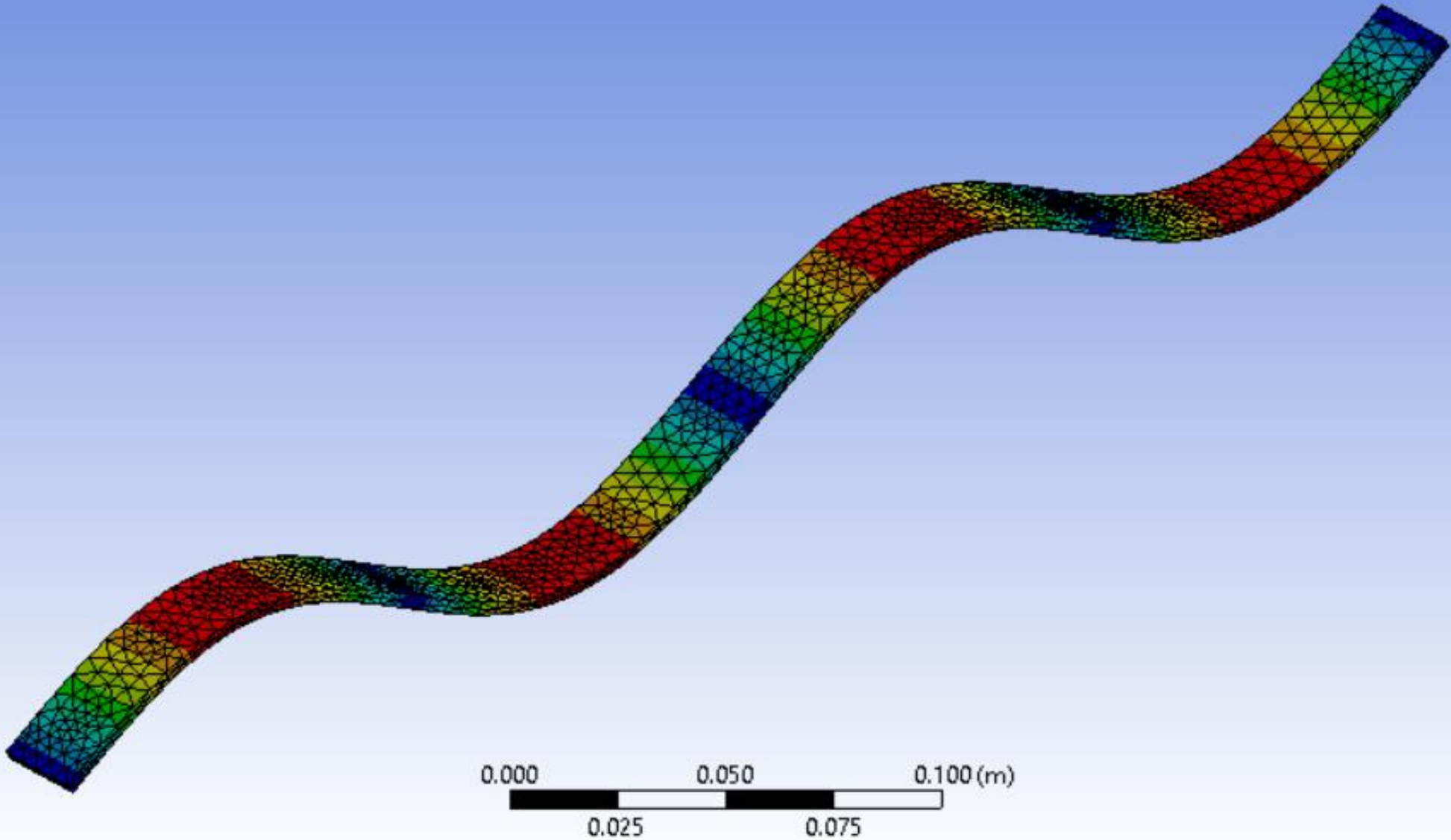
**ANSYS**  
2021 R1



Mode-5



# Mode Shape



# Animation

D: Simply supported free vibration

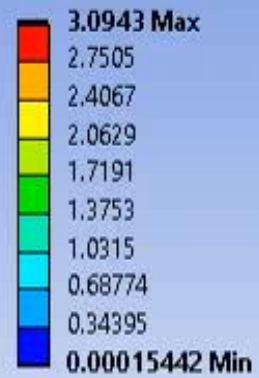
Total Deformation 5

Type: Total Deformation

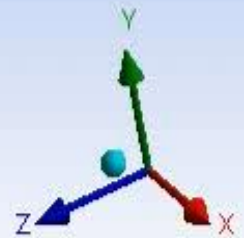
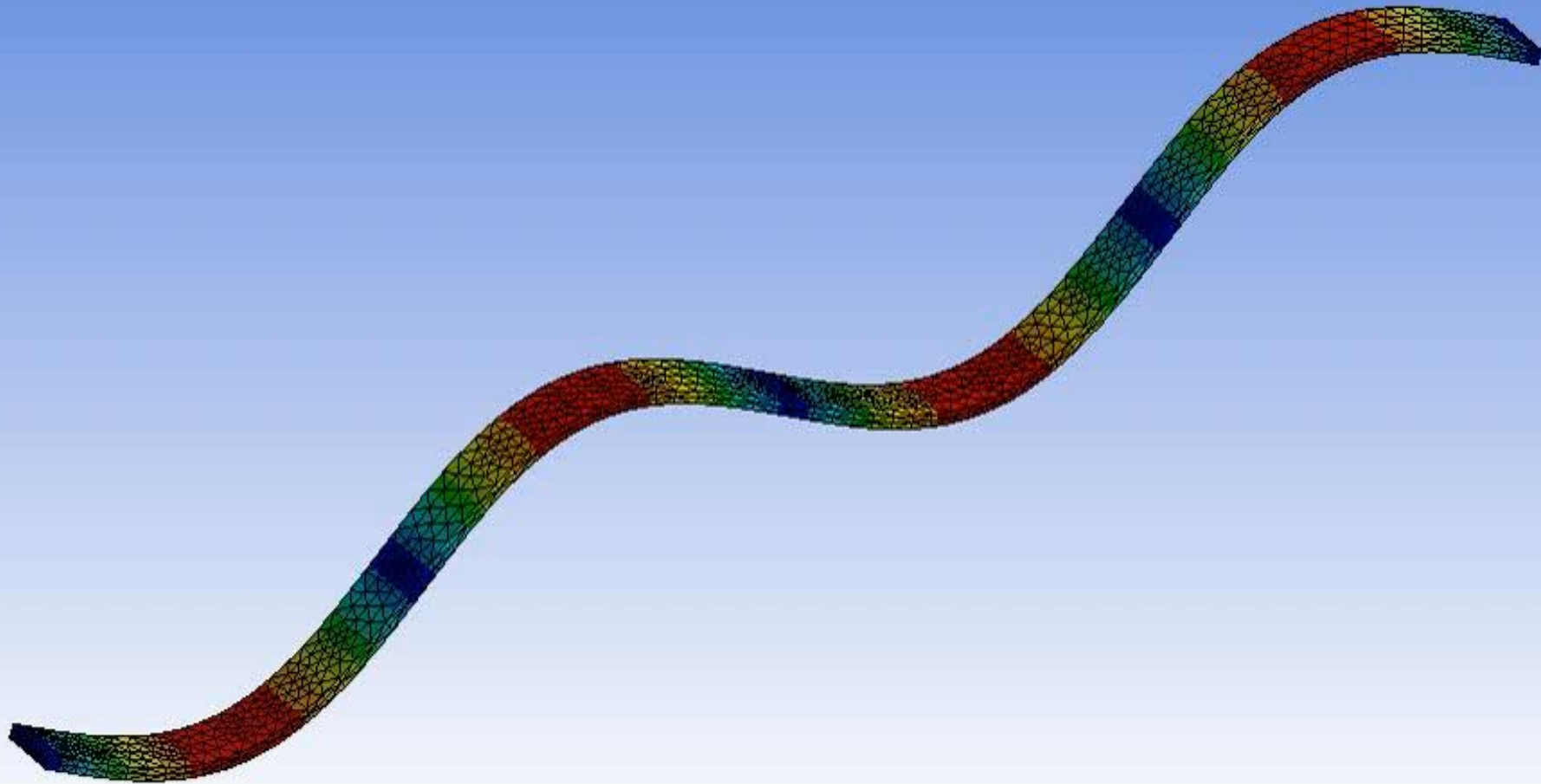
Frequency: 542.73 Hz

Unit: m

5/2/2024 11:20 AM



ANSYS  
2021 R1





# Eigen frequency comparison (Analytical vs Ansys )

Mode	Analytical (Hz)	Ansys (Hz)
1	33.95	33.909
2	135.79	135.65
3	305.577	305.24
4	505.77	505.77
5	543.189	542.73
6	848.789	848.15

Used formula for analytical result:-

$$f_n = \frac{(\beta_n l)^2}{2\pi l^2} \sqrt{\left(\frac{EI}{\rho A}\right)}$$

Case	$\beta_0 l$	$\beta_1 l$	$\beta_2 l$	$\beta_3 l$	$\beta_4 l$	$\beta_5 l$
		3.142	6.283	9.425	12.566	15.708

## **4. CANTILEVER BEAM**

*(Point Mass At one end\_LANCZOS ITERATION )*

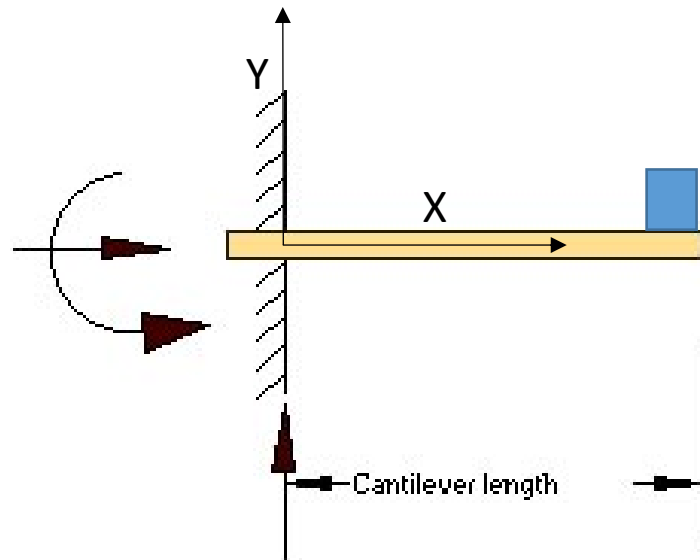
# Geometry

Attributes	Values
Length	0.4064 <i>m</i>
Width	0.003175 <i>m</i>
Height	0.0254 <i>m</i>
Moment Of Inertia	$6.7746 \times 10^{11} \text{ m}^4$

# Material

Attributes	Values
Material Name	Structural Steel
Young Modulus (E)	$2.1 \times 10^{11} Pa$
Poisson ratio (Mue)	0.3 <i>micron</i>
Density	$7850 \frac{Kg}{m^3}$

# Boundary Condition



(a) Cantilever beam

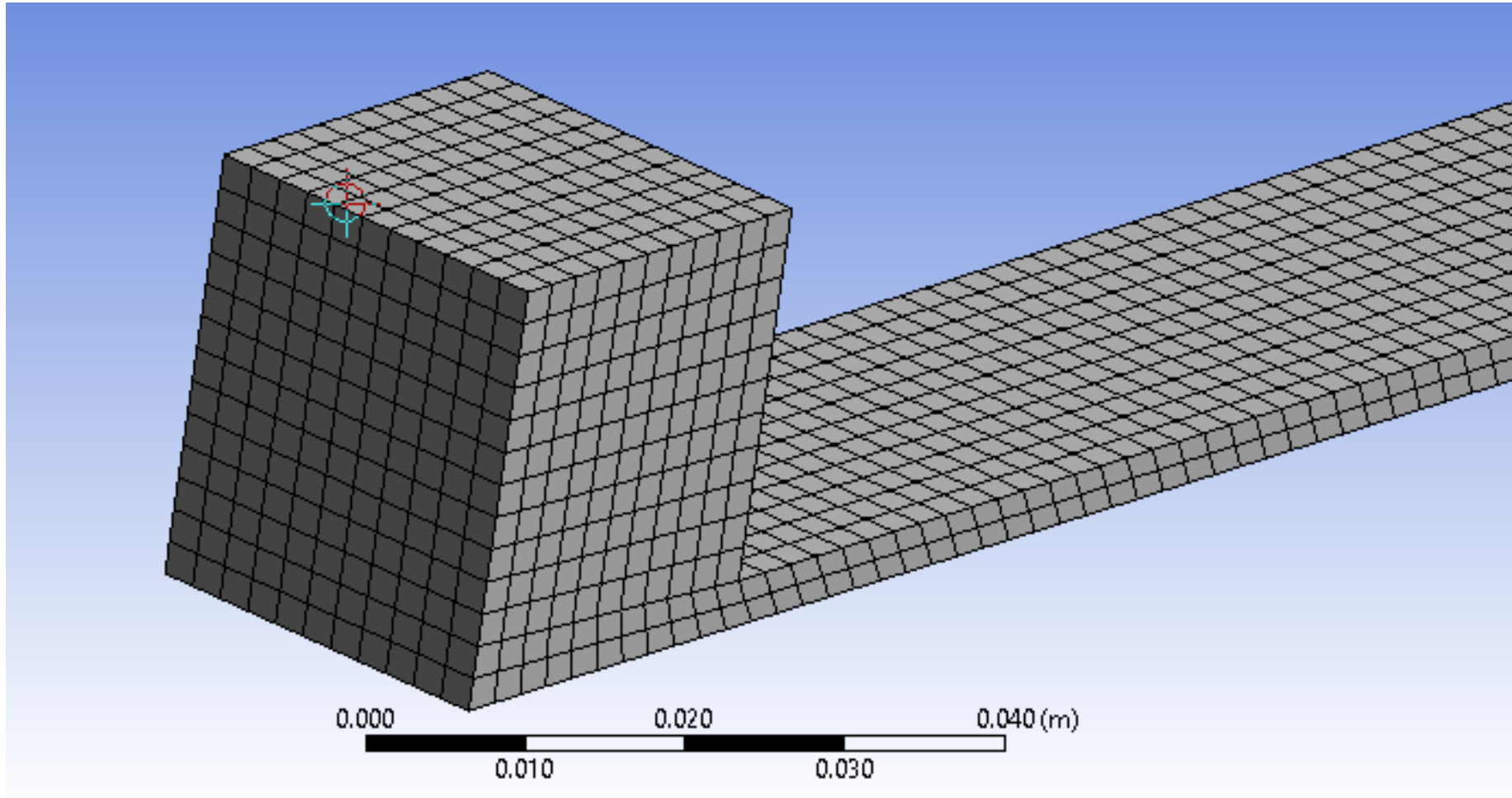
$$y = 0 \quad @ \quad x = 0$$

$$\frac{dy}{dx} = 0 \quad @ \quad x = 0$$

$$y = \delta \quad @ \quad x = L$$

$$\text{Shear Force} = Mg \quad @ \quad x = L$$

# Meshing (Size = 0.25 mm)

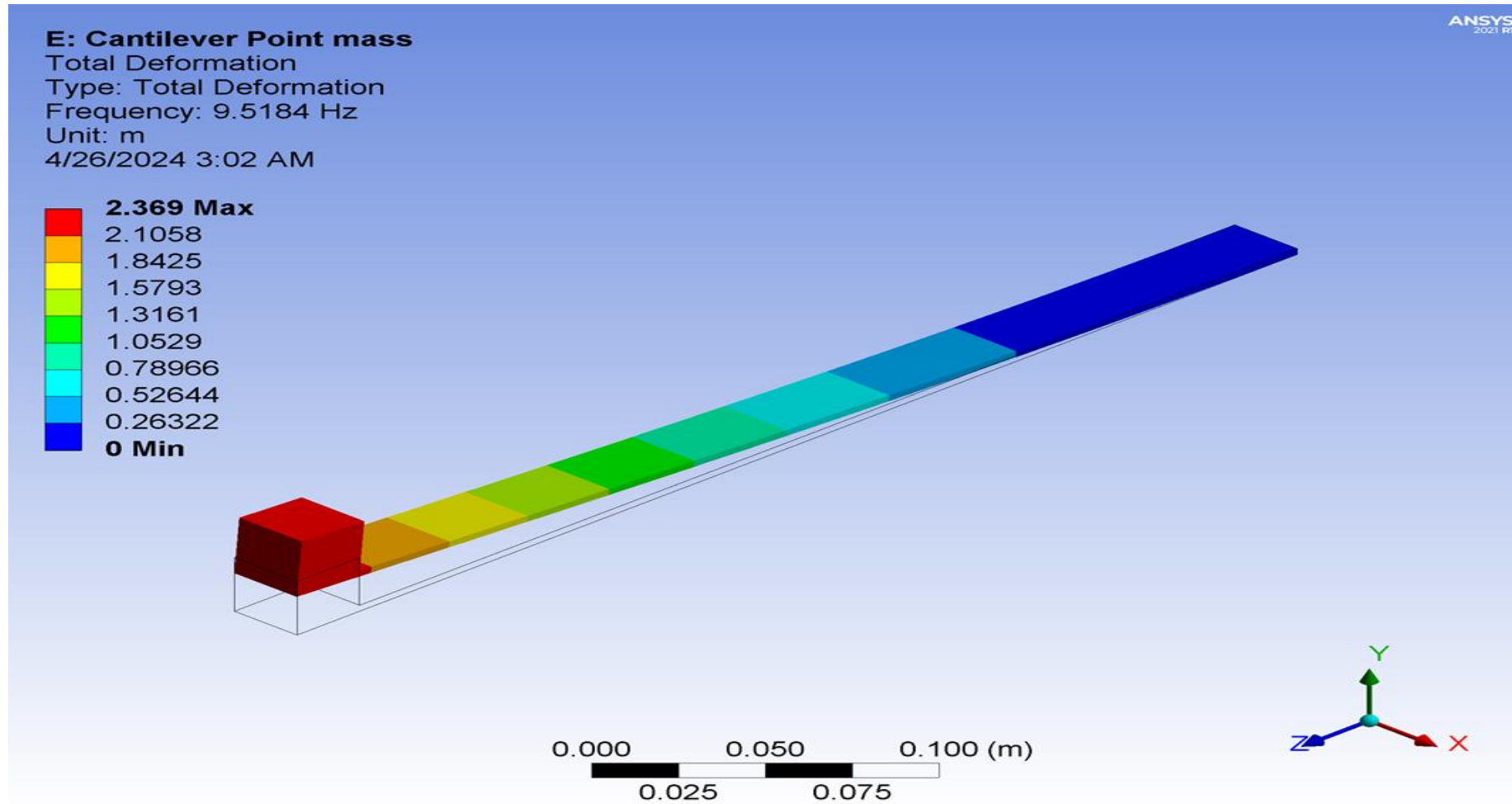


# **Mode Shapes & Animation**



Mode-1

# Mode Shape



# Animation

E: Cantilever Point mass

Total Deformation 2

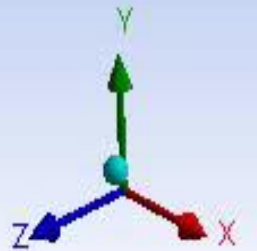
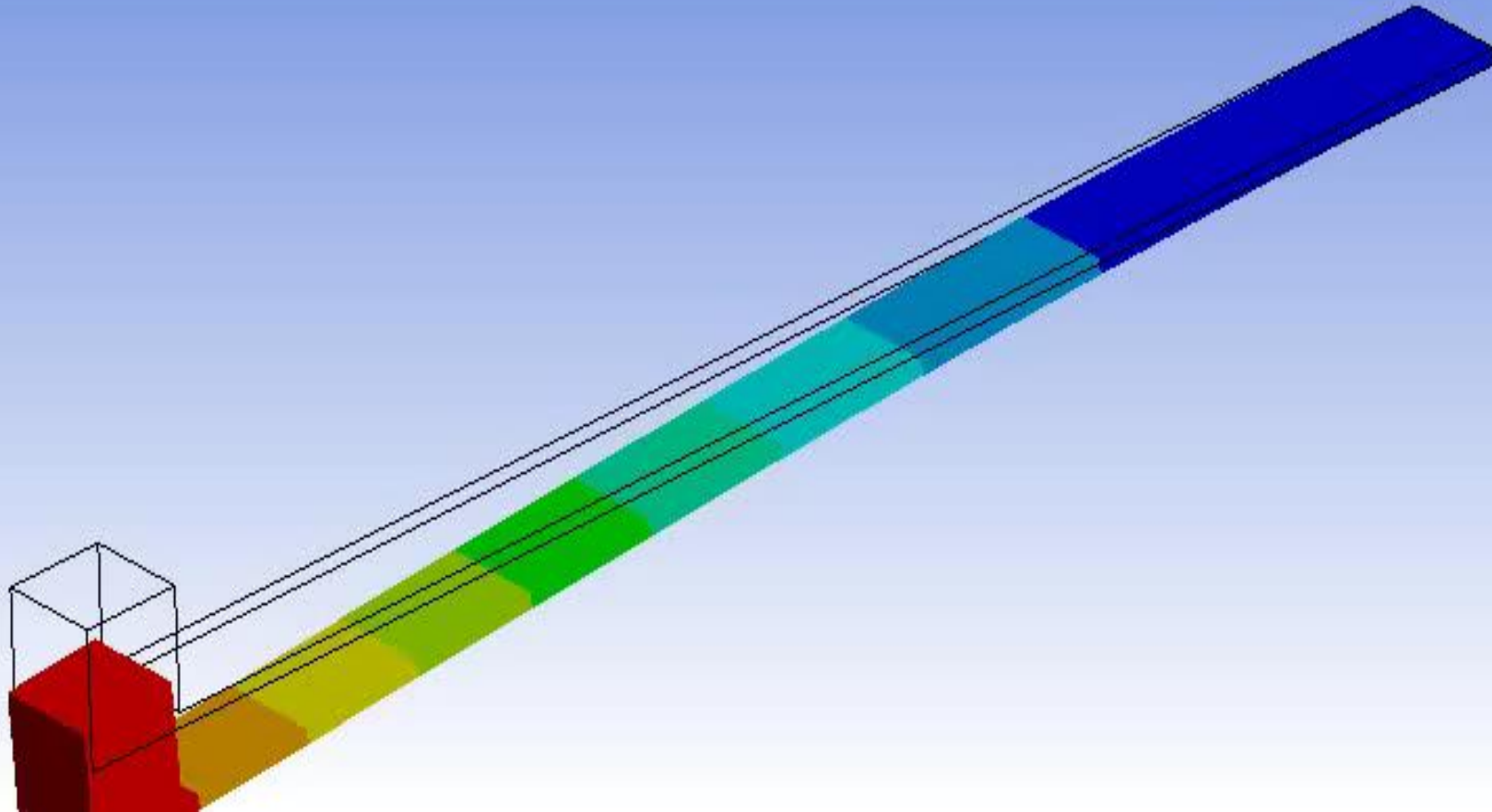
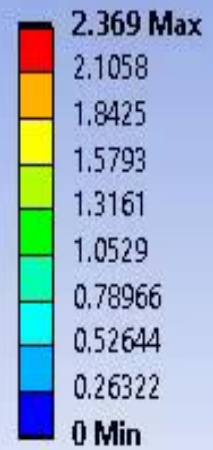
Type: Total Deformation

Frequency: 9.5184 Hz

Unit: m

4/26/2024 3:10 AM

ANSYS  
2021 R1



Mode-2

# Mode Shape

ANSYS  
2021 R1

## E: Cantilever Point mass

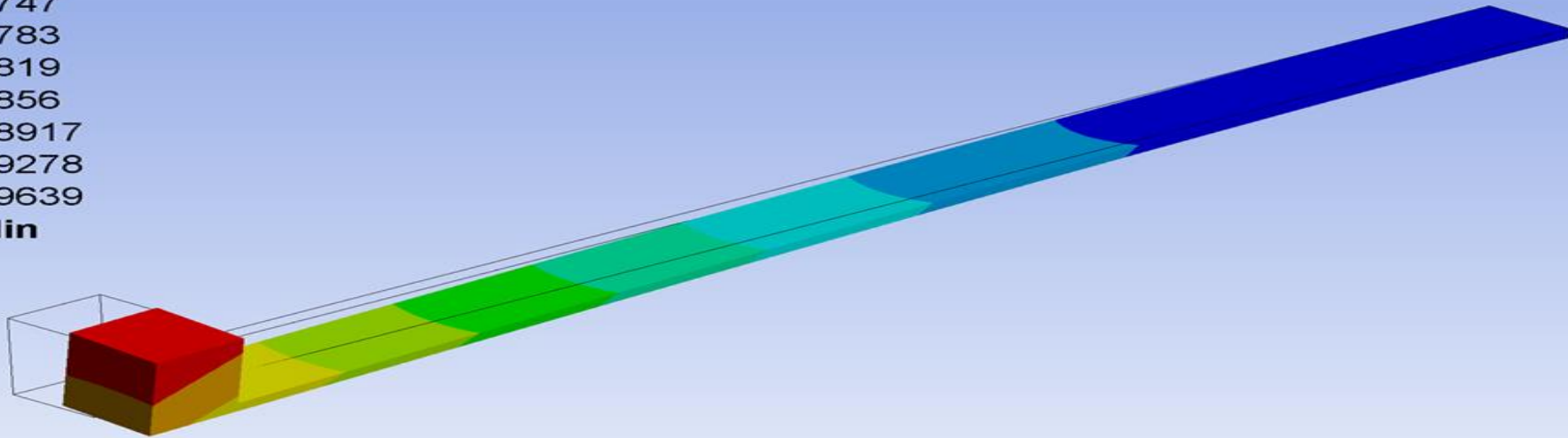
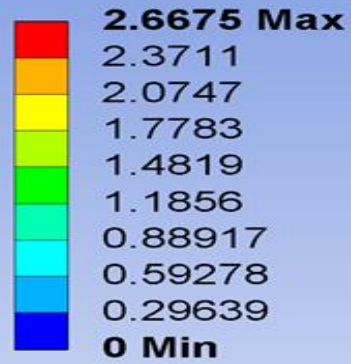
Total Deformation 3

Type: Total Deformation

Frequency: 73. Hz

Unit: m

4/26/2024 3:14 AM



0.000 0.025 0.050 0.075 0.100 (m)

A horizontal scale bar with tick marks at 0.000, 0.025, 0.050, 0.075, and 0.100 meters.



# Animation

E: Cantilever Point mass

Total Deformation 3

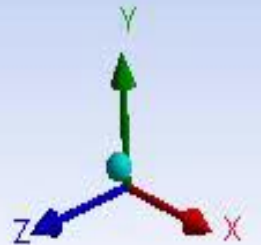
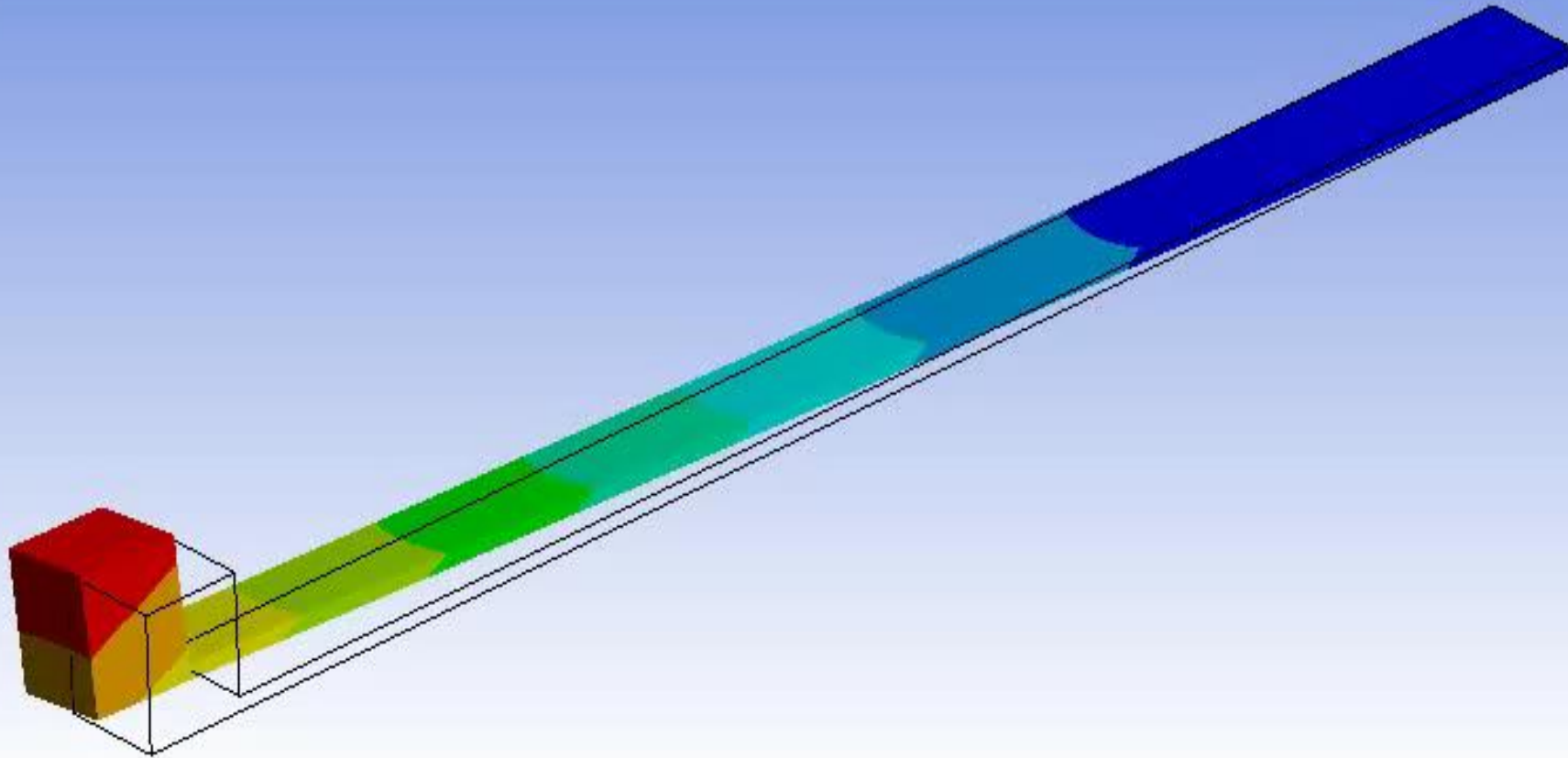
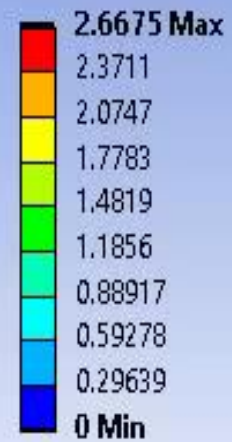
Type: Total Deformation

Frequency: 73. Hz

Unit: m

4/26/2024 3:09 AM

ANSYS  
2021 R1



**Mode-3**

# Mode Shape

## E: Cantilever Point mass

Total Deformation 4

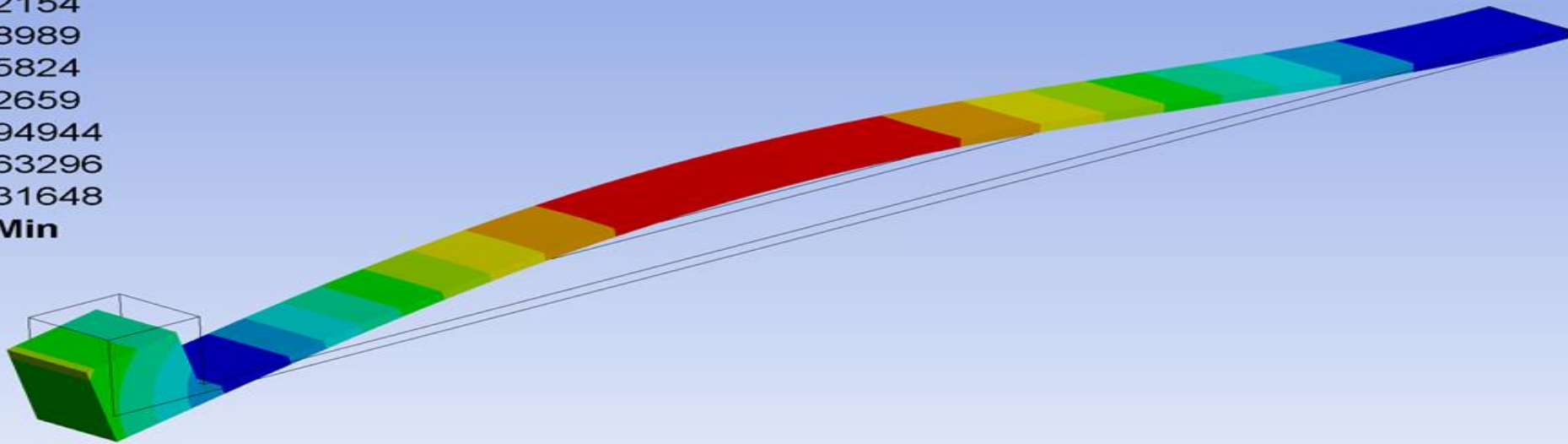
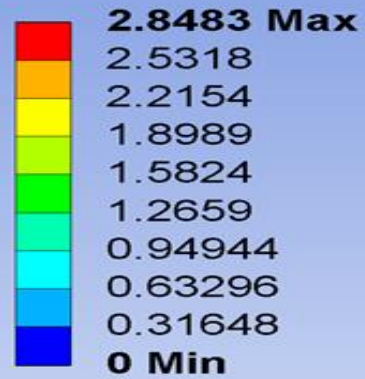
Type: Total Deformation

Frequency: 79.995 Hz

Unit: m

4/26/2024 3:20 AM

ANSYS  
2021 R1





# Animation

**E: Cantilever Point mass**

Total Deformation 4

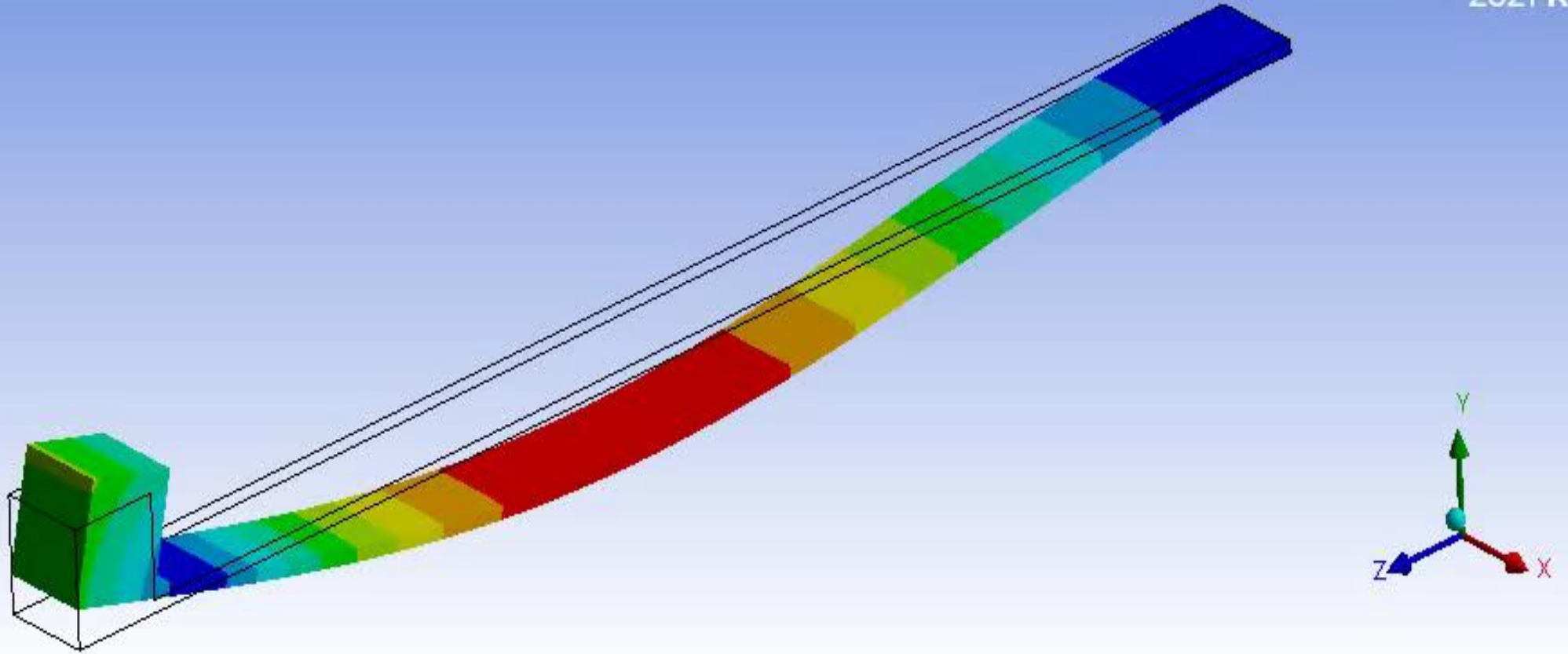
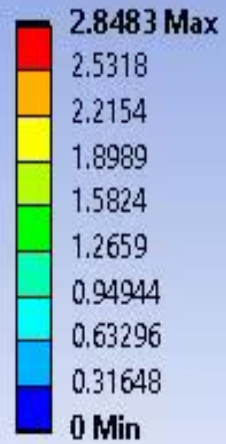
Type: Total Deformation

Frequency: 79.995 Hz

Unit: m

4/26/2024 3:09 AM

**ANSYS**  
2021 R1



Mode-4

# Mode Shape

## E: Cantilever Point mass

Total Deformation 5

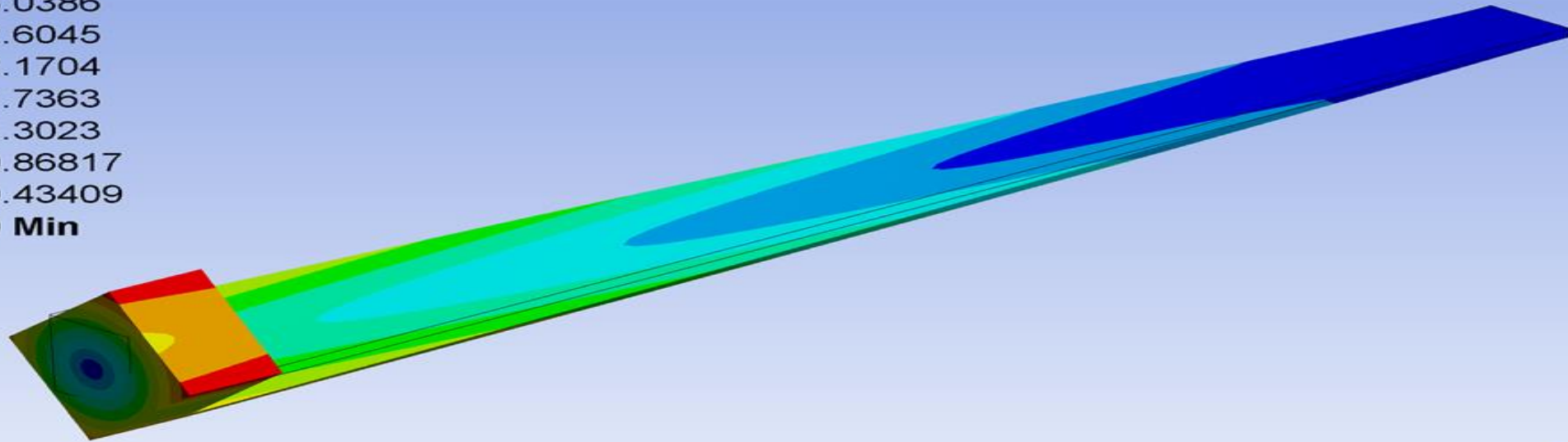
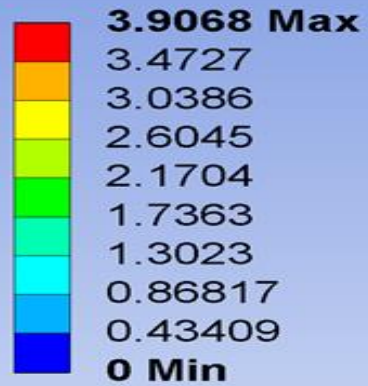
Type: Total Deformation

Frequency: 227.14 Hz

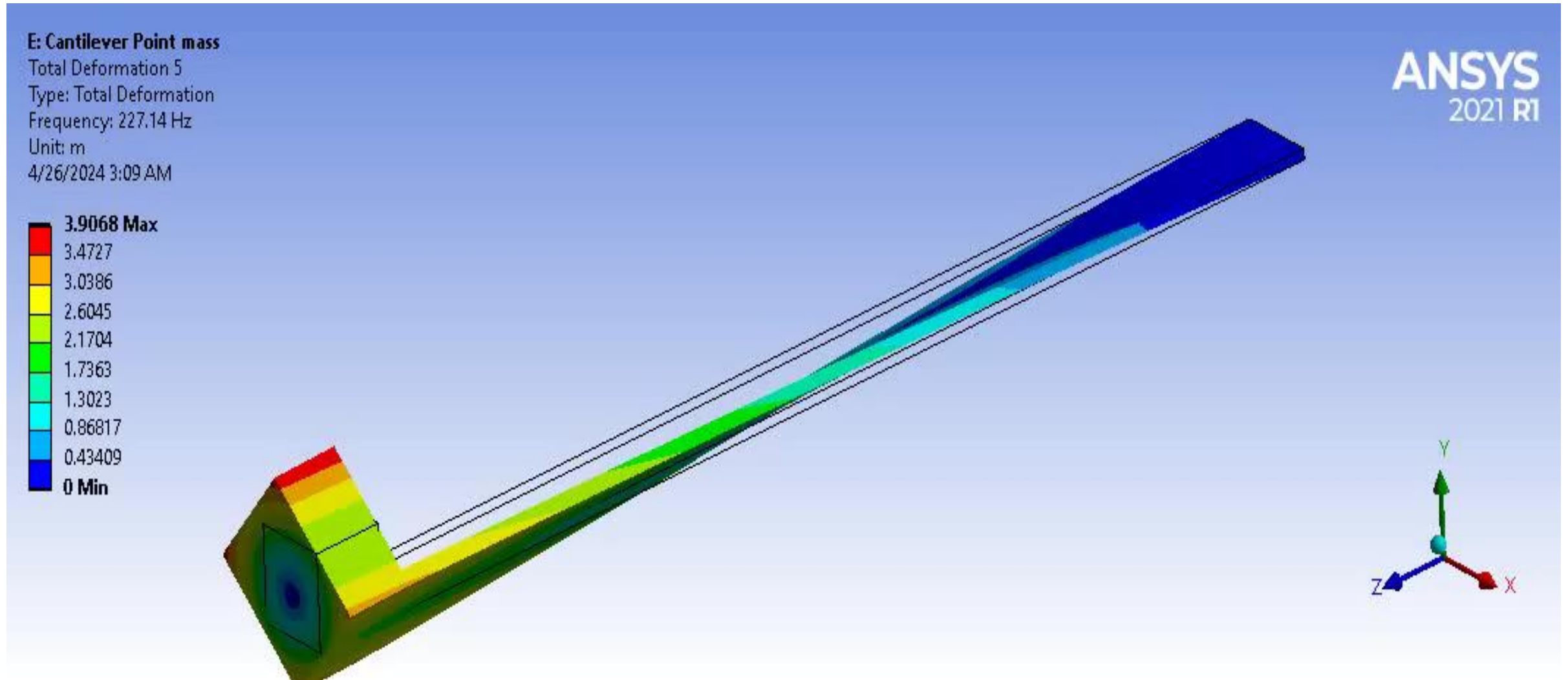
Unit: m

4/26/2024 3:21 AM

ANSYS  
2021 R1



# Animation



Mode-5

# Mode Shape

ANSYS  
2021 R1

## E: Cantilever Point mass

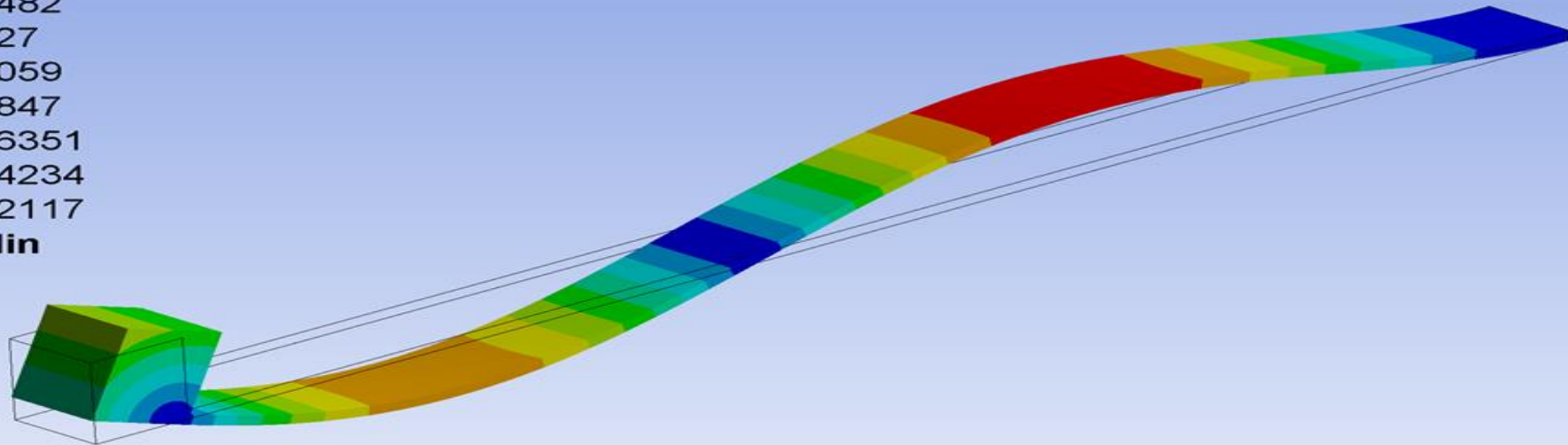
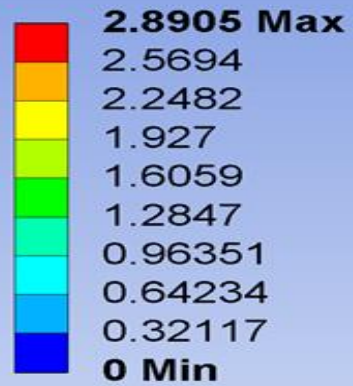
Total Deformation 6

Type: Total Deformation

Frequency: 235.78 Hz

Unit: m

4/26/2024 3:22 AM



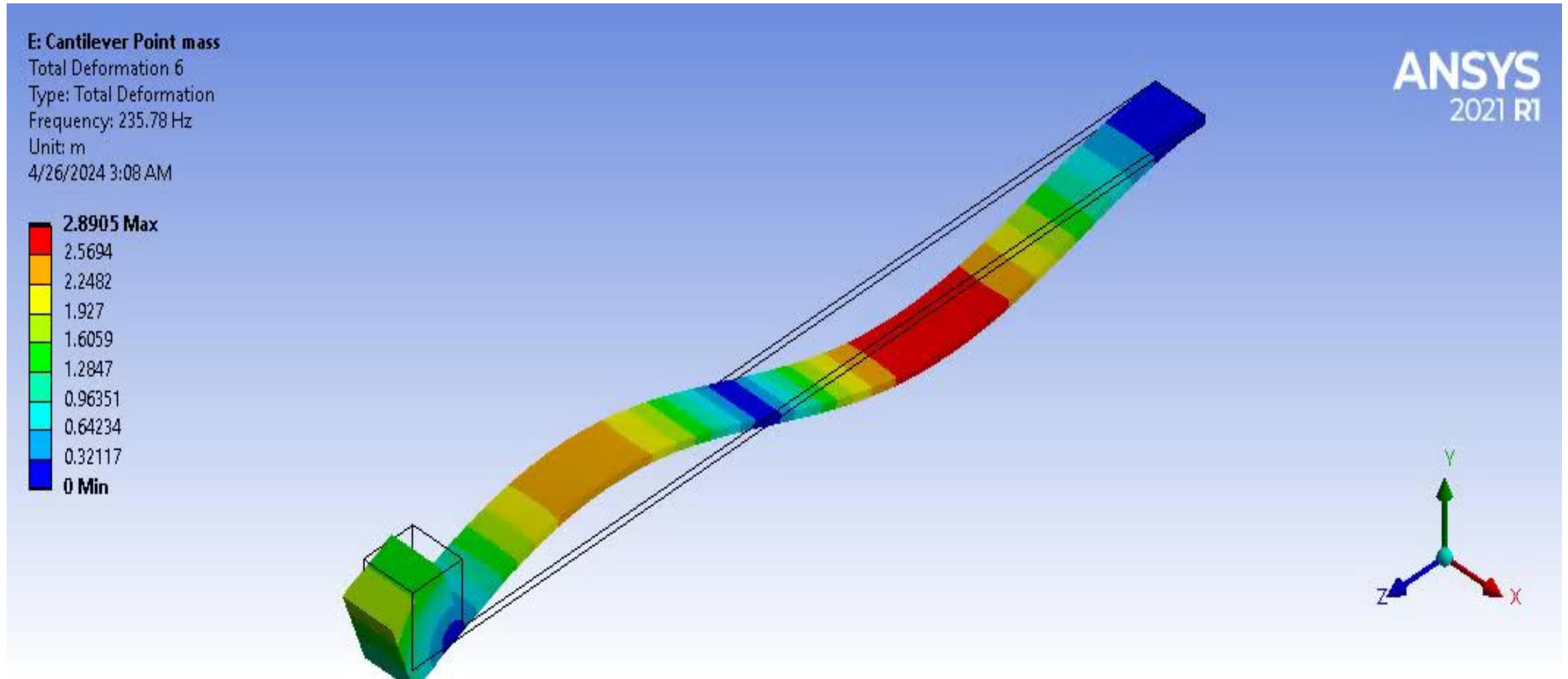
0.000 0.025 0.050 0.075 0.100 (m)



A horizontal scale bar with five segments, labeled with values 0.000, 0.025, 0.050, 0.075, and 0.100 (m).



# Animation



# Eigen frequency comparison (Analytical vs Ansys )

Mode	Analytical (Hz)	Ansys (Hz)
1 (Bending Along X-axis)	9.2108	9.5184
2 (Bending Along Y-axis)	73.37	73
3 (Bending Along X-axis)	77.2083	79.995
4 (Twisting)		227.14
5 (Bending Along X-axis)	236.1777	235.78

Used formula for analytical result:-

$$\omega_r = \lambda_r^2 \sqrt{\frac{YI}{mL^4}}$$

Mode	Frequency parameter ( $\lambda_r$ )
1	1.87510407
2	4.69409113
3	7.85475744
4	10.9955407
5	14.1371684