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# Static and Harmonic Study of Fishing Stick Using Composite Materials (FGM)

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***Abstract--*** The present work deal with FGM rods. The aim of this paper is to compare the vibration behavior of fishing stick with different composite materials. FGM rods or the fishing stick in our paper is Functionally graded in x-axis. The results show that the functionally graded fishing stick in x-axis with composite materials gives better performance.

***Key words:***-- FGM, Fishing Stick, Composite.

## 1. Introduction and Background [1]-[11]

The fishing rod is a slender flexible rod used by fishermen for fishing. In the simplest terms, a fishing rod is a simple stick or pole attached to a fishing line ending with a hook (previously called a horn, hence the name "fishing"). The length of the pole can vary from 2 to 50 feet (0.5 to 15 m). In order to attract fish, the bait or bait is pierced through one or more hooks attached to the fishing line. Fishing line is usually stored on a reel, which reduces tangles and helps fish to land.

Traditional poles are made of wood, including ash, hickory, and bamboo, while contemporary poles are usually made of glass fiber or carbon fiber. Contrary to nets commonly used for livelihoods and commercial fishing, fishing rods are more commonly used for recreational fishing and competitive casting. Fishing rods come in many sizes, functions, hardness, lengths and structures, depending on whether they are used for small, medium or large fish, or for different fresh or salt water conditions. Various types of fishing rods are designed for specific types of fishing. Fly rods are used for casting artificial flies, rotating rods and bait casting rods are used for casting bait or bait. Ice fishing rods are designed to fish in small holes in snow-covered lakes. The trolling rod is designed to drag the bait or bait behind a moving boat.

Judging by stone inscriptions dating back to 2000 BC, fishing rods go back to ancient Egypt, China, Greece, Trinidad and Tobago, Rome and medieval England.

There are several specifications manufacturers use to delineate rod uses. These include power, action, line weight, lure weight, and number of pieces.

- **Power**

Also called "power value" or "rod weight". Rods can be classified as super light, light, medium light, medium, medium heavy, heavy, overweight or other similar combinations. Power is usually an indicator of what type of fishing, the type of fish, or the size of the fish is most suitable for a particular pole. The ultra-light fishing rod is suitable for catching small bait fish and panfish, or where the response ability of the fishing rod is critical. Overweight fishing rods are used for deep sea fishing, surf fishing or heavy fishing.

- **Action**

"Action" refers to the speed at which the lever returns to its neutral position. The action can be slow, medium, fast, or anything in between (for example, medium speed). Contrary to the usual display, the action does not involve bending curves. A rod with fast acting is as easy to have a gradually curved curve (from the tip to the butt) as with only the top curve. The taper, length and blank material of the rod will affect the action. Generally, rods using glass fiber composite material blanks are slower than rods using carbon fiber composite material blanks.

- **Bending curve and tapering**

The main function of the fishing rod is to bend and provide a certain resistance or strength: when throwing, the fishing rod acts as a catapult: moving the fishing rod forward, the mass of the bait or bait and the inertia of the fishing rod itself will load (bend) the rod, and then lure or Bait. When the bite is bitten and the fisherman strikes, the bending of the fishing rod inhibits the strike, thereby avoiding line failure. When fishing, the bending of the rod not only enables the fisherman to keep the fishing line under tension, but the bending of the rod also keeps the fish under constant pressure, thereby draining the fish and enabling the fisherman to catch the fish. Bending also reduces leverage by shortening the distance of the lever (rod).

A stiff rod requires more power from the fisherman, but actually less power is exerted on the fish. In contrast, a deep curved rod will require the fisherman to reduce power, but will provide more fighting power for the fish. In fact, this leverage

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often misleads fishermen. People usually think that a hard, hard rod gives fish more control and power to fight, but in fact, it is the fish that gives the fisherman power. In commercial fishing practice, large fish can usually be pulled directly onto the fishing line without any effort. This is possible because there is no leverage.

The bending curve determines the way the rod builds and releases power. This will not only affect the performance of casting and fishing, but also affect the sensitivity of the bait when fishing, the ability to set the hook (also related to the quality of the fishing rod), the control of the bait or bait, the way of the joystick and the power on the rod Allocation. On a complete progressive rod, the power is most evenly distributed throughout the rod.

- **Line weight**

Usually fishing rods are also classified according to the optimal weight of the fishing line, or for fishing rods, fishing lines that the fishing rod should handle should be used. The weight of the fishing line is expressed in pounds force before the fishing line component. The line width of the rod is expressed as the range of the rod design support.

- **Lure weight**

The rod can also be described by the weight of the bait or hook that the rod is designed to support. The bait weight is usually expressed in ounces or grams.

- **Number of pieces**

Despite the most natural "feel" of the rod from the head to the tip, many people still like this type of rod, although as the length of the rod increases, it becomes more difficult to transport the rod safely. Two-piece rods connected by ferrules are very common, and if properly designed (especially tubular glass or carbon fiber rods), there is little sacrifice in the natural feel. Some fishermen do have different sensitivity to two-piece fishing rods, but most people do not.

Some poles are connected by metal bus bars. These increase the quality of the rod, help to set the hook, and help activate the rod from the top to the butt during casting, so as to obtain a better casting experience. Some anglers experience that this assembly is superior to a single pole. They can be found on special handmade poles. In addition to increasing the correct quality according to the type of rod, this accessory is also the strongest known accessory, but also the most expensive accessory. Therefore, they can hardly be found on commercial fishing rods.

FIG.1 : FISHING STICK [1]

Functionally graded (FG) material is a compositional gradient of two or more component materials. Materials can be designed for specific applications with the variation of their composition and structure gradually. FG materials can have the desirable properties of each component because of a homogenous mixture of constituents.

Functionally graded material (FGM) structures have taken great interest of engineer's recent years. They were designed for thermal isolation for aerospace structural applications and fusion reactors, especially. Metal-ceramic functionally graded materials are used in extremely high temperature environments as a structural element.

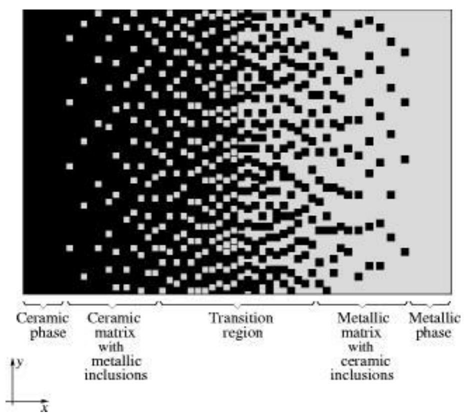


FIG.2 : ILLUSTRATION OF FUNCTIONALLY GRADIENT MATERIAL [12]

The Functionally Gradient Material (FGM) is a pioneering composite material that follows a predetermined law of the microstructure and composition of the material. The change in structure and composition varies over volume either randomly or strategically, which results in changes in the properties of the material for performing certain functions. These properties depend on the spatial position in the structure. FGM can be designed to modify the response of the material to meet the design criteria.

## 2. PROBLEM DEFINITION AND ASSUMPTIONS

First of all, we will draw a line element with 6 m length, after that we will slice it to three regions each region will be 2 m, however these three regions will be slice into 4 region each will be 0.5 m, so, it will be a body congaing 12 part each part 0.5 m. Each 0.5 m will be material. The materials that will use is (Epoxy Carbon UD (395 GPa), Carbon Fiber (395 GPa), S-Glass).

The procedure:

- Solve Static Structural to find the Maximum Combined Stress in (Mpa).
- Solve Modal Structural to find the first 6 mode shapes in (Hz).

- o Solve Harmonic Response to find the frequency response.

- <u>Modeling & Analysis Setup (Static Structural)</u>

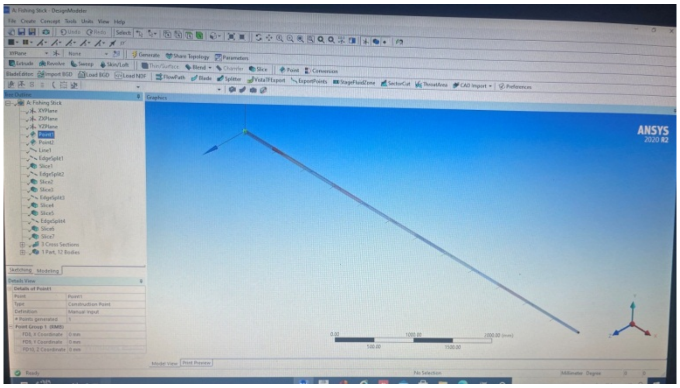

FIG.3 : THE FIRST POINT AT (0,0,0) M

In the above fig.3 we put the first point in order to draw the fishing stick in (0,0,0) m coordinates.

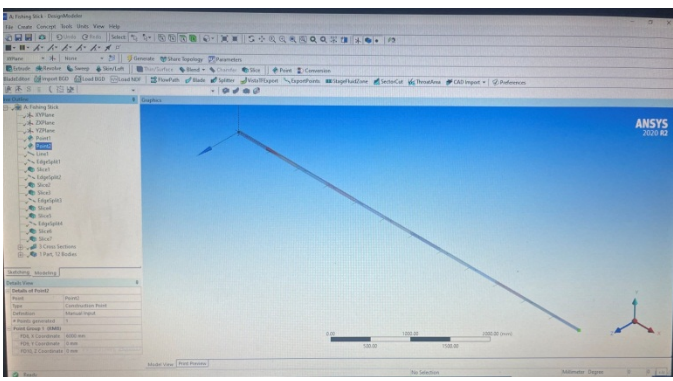

FIG.4 : THE SECOND POINT AT (6,0,0) M

In the above fig.4 we put the second point in order to draw the fishing stick in (6,0,0) m coordinates.

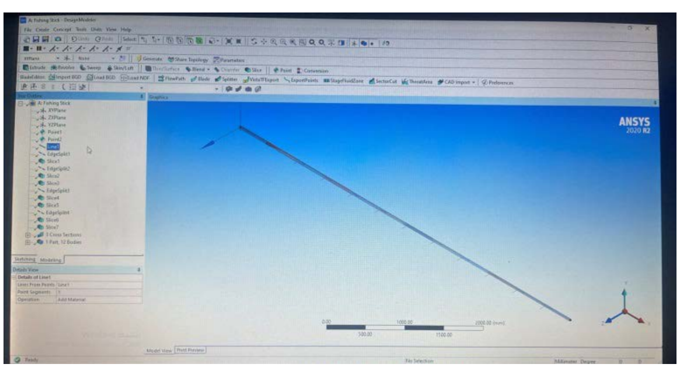

FIG.5 : THE LINE CONNECTED BETWEEN THE TWO POINTS

In the above fig.5 we connected between the two points by a line.

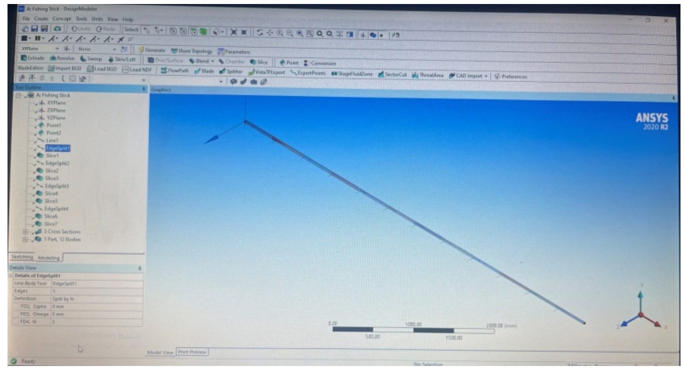

FIG.6 : SPLIT THE LINE INTO 3 PARTS

In fig.6 we split the line into 3 parts so each will be 2 m.

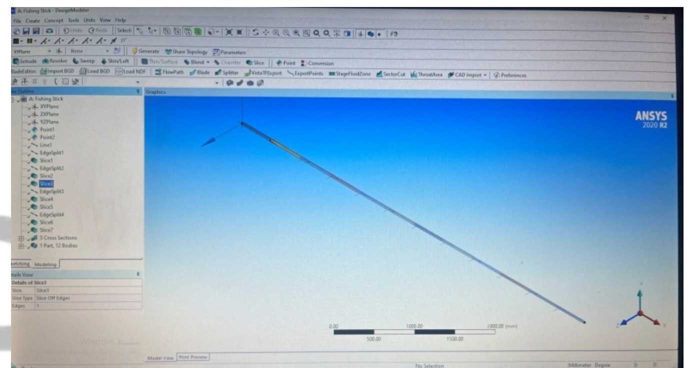

FIG.7 : SLICE THE THREE PARTS

In fig.7 we slice the three parts each into 4 subparts so totally we have 12 different region.

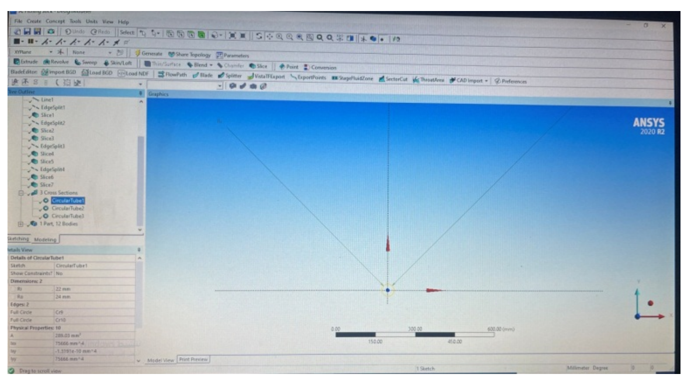

FIG.8 : THE FIRST CROSS SECTION

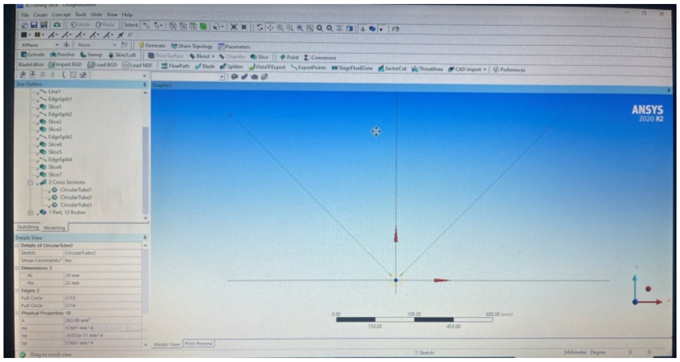

FIG.9 : THE SECOND CROSS SECTION

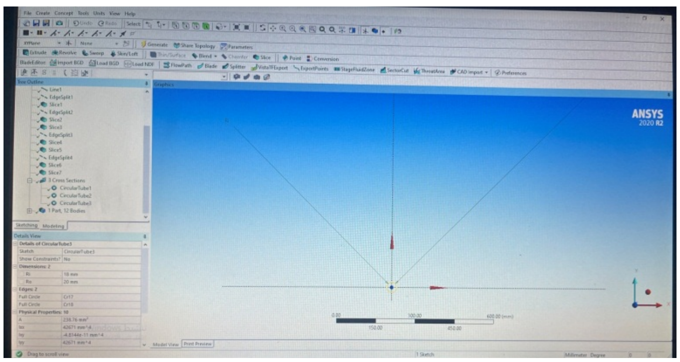

FIG.10 : THE THIRD CROSS SECTION

As we can see form fig.8, fig.9 and fig.10 three circular tube cross sections were made for the three parts that we have in our fishing stick, where the first cross section the inner radius is 22mm while the outer radius is 24mm, while for the second cross section this inner radius is 20mm while the outer radius is 22mm and the third cross section the inner radius is 18mm while the outer radius is 20mm.

TABLE.1: THE 12 PARTS WITH THEIR DETAILS

| *Part No* | *Material* | *Length (m)* | *Inner radius (mm)* | *Outer radius (mm)* |
|---|---|---|---|---|
| *1* | *Epoxy Carbon UD (395 GPa)* | *0.5* | *22* | *24* |
| *2* | *S-Glass* | *0.5* | *22* | *24* |
| *3* | *Epoxy Carbon UD (395 GPa)* | *0.5* | *22* | *24* |
| *4* | *Carbon Fiber* | *0.5* | *22* | *24* |
| *5* | *Epoxy Carbon UD (395 GPa)* | *0.5* | *20* | *22* |
| *6* | *S-Glass* | *0.5* | *20* | *22* |
| *7* | *Epoxy Carbon UD (395 GPa)* | *0.5* | *20* | *22* |
| *8* | *Carbon Fiber* | *0.5* | *20* | *22* |
| *9* | *Epoxy Carbon UD (395 GPa)* | *0.5* | *18* | *20* |
| *10* | *S-Glass* | *0.5* | *18* | *20* |
| *11* | *Epoxy Carbon UD (395 GPa)* | *0.5* | *18* | *20* |
| *12* | *Carbon Fiber* | *0.5* | *18* | *20* |

Above table.1 show us the 12 parts with their dimensions, where each 4 parts have their cross section and with different materials.

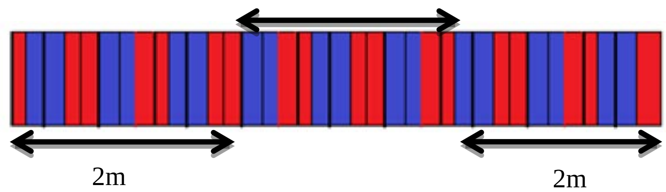


FIG.11 : FUNCTIONALLY GRADED IN X-AXIS OF FISHING STICK

TABLE.2: MECHANICAL PROPERTIES OF MATERIALS

| **Property** | **Material** | | | **Unit** |
|---|---|---|---|---|
| | **Epoxy Carbon UD** | **S-Glass** | **Carbon Fiber** | |
| **Density (ρ)** | 1540 | 2500 | 1800 | Kg/ m3 |
| **Tensile yield strength (σ)** | 1979 | 4800 | 4600 | MPa |
| **Young's modulus (E)** | 2.09e+05 | 90000 | 395 GPa | MPa |
| **Possion ratio (ν)** | 0.27 | 0.22 | 0.2 | |
| **Compression Yield strength** | -893 | 5000 | 5200 | MPa |
| **Shear Modulus** | 5500 | 36885 | 8000 | MPa |
| **Thermal Expansion** | -4e-07 | 2.95 10-6/K | -4e-07 | 1/ c |

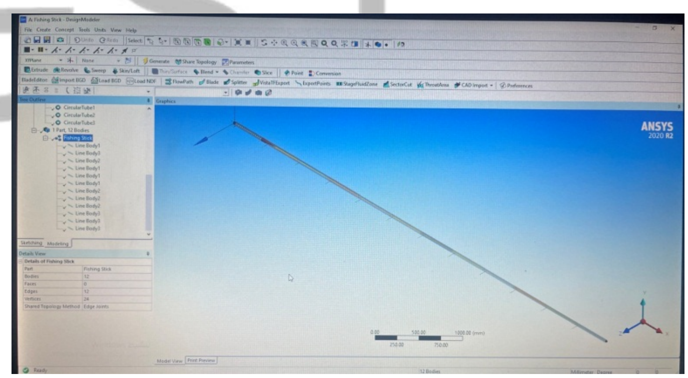

FIG.12 : THE FISHING STICK DIVIDED INTO 12 DIFFERENT PARTS

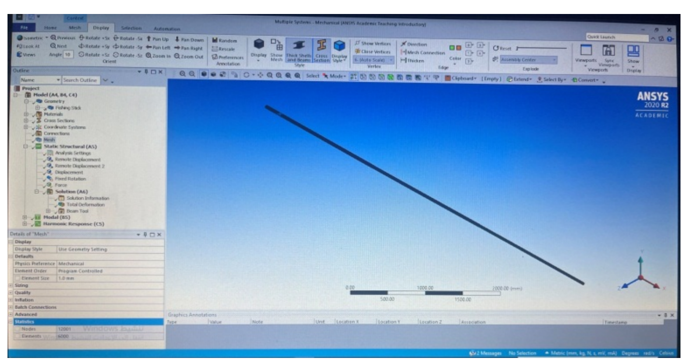

FIG.13 : THE MESHING FOR THE FISHING STICK

Fig. 13 show us the meshing size for the fishing stick which is 1mm with 12001 nodes and 6000 elements.

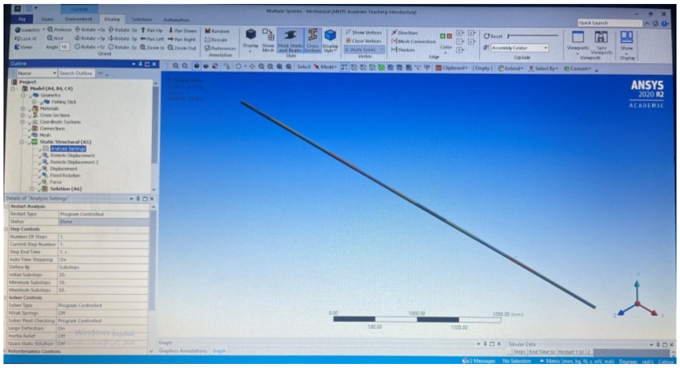

FIG.14 : THE ANALYSIS SETTINGS FOR THE STATIC STRUCTURAL

In Fig.14 we can see that we used sub steps with initial sub steps 20, minimum sub steps 10 and maximum sub steps 50, the large deflection is on in order to solve it as a nonlinear behavior.

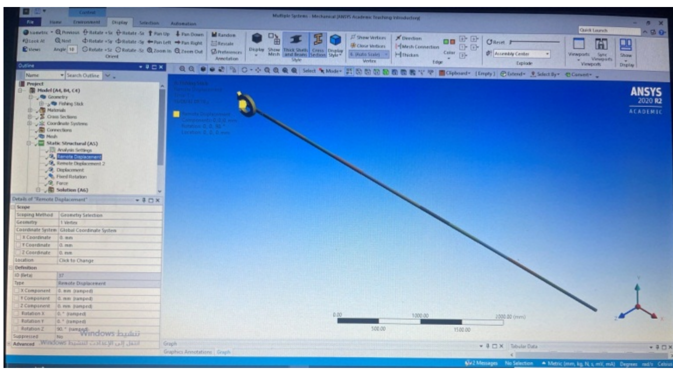

FIG.15 : THE REMOTE DISPLACEMENT FOR THE ORIGINAL POINT

Fig. 15 show us the remote displacement for the original point (0,0,0) m and not allowed to move in X,Y and Z directions with 90 degree rotation around Z axis and 0 around X and Y.

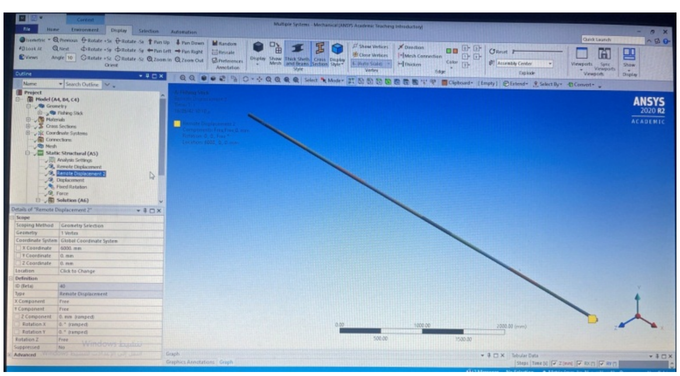

FIG.16 : THE REMOTE DISPLACEMENT FOR THE SECOND POINT (6,0,0) M

As we can see from above fig. 16 remote displacement for the second point (6,0,0) m and free to move in X,Y and not allowed to move in Z directions with free rotation around Z axis and 0 around X and Y.

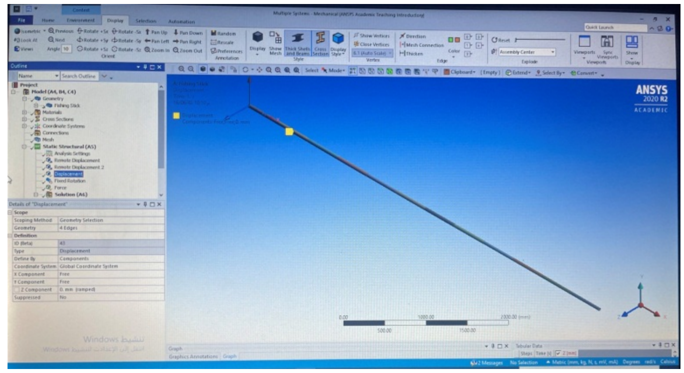

FIG.17 : THE DISPLACEMENT FOR THE FIRST 4 ELEMENTS

In Fig.17 we put a displacement for the first 4 elements in the fishing stick, which is free to move in X and Y direction while no allowed to move in the Z direction.

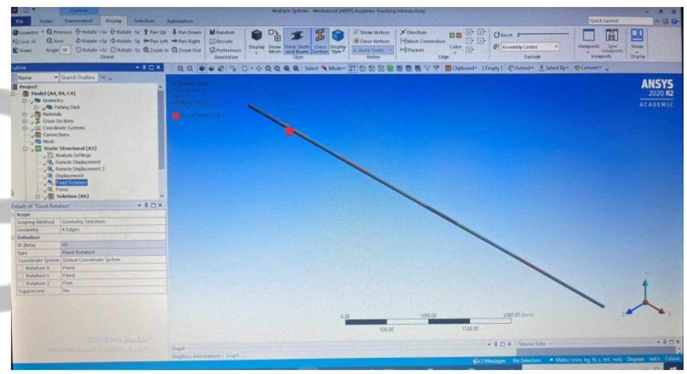

FIG.18 : THE FIXED ROTATION FOR THE FIRST 4 ELEMENTS

In Fig.18 we put a fixed rotation for the first 4 elements in the fishing stick, which is fixed to rotate around X and Y while free to rotate around Z.

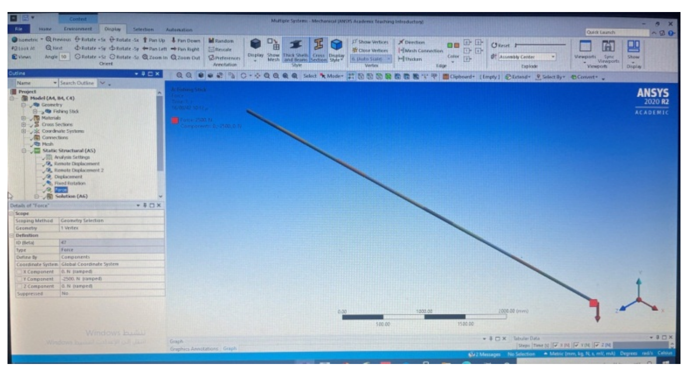

FIG.19 : THE FORCE APPLIED TO THE END OF THE FISHING STICK

As we can see from above fig.19 we put the applied force with 2500 N in the –ve Y direction in the end point of the fishing stick.

- <u>Results and Discussion (Static Structural)</u>

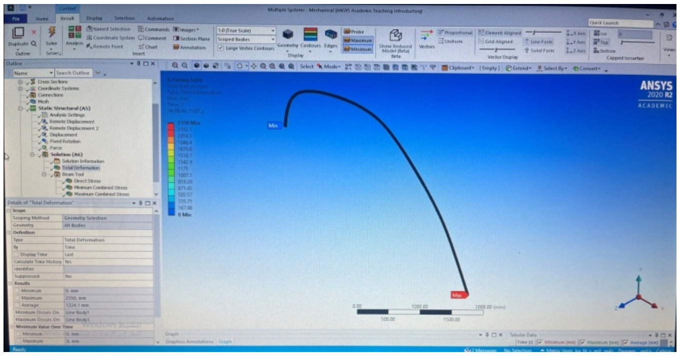

FIG.20 : THE TOTAL DEFORMATION OF THE FISHING STICK

Fig. 20 show us the total deformation of the fishing stick which is 2350 mm.

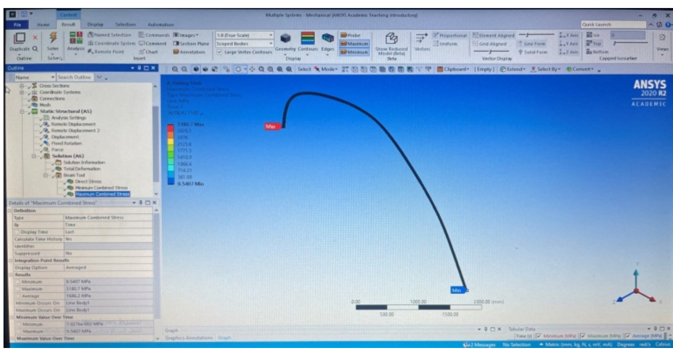

FIG.21 : THE MAXIMUM COMBINED STRESS OF THE FISHING STICK

In fig.21 we can see the maximum combined stress for the fishing stick which is 3180.7 MPa.

- <u>Modeling & Analysis Setup (Modal)</u>

For the Modal study we are interesting in the first 6 mode shapes for the fishing stick.

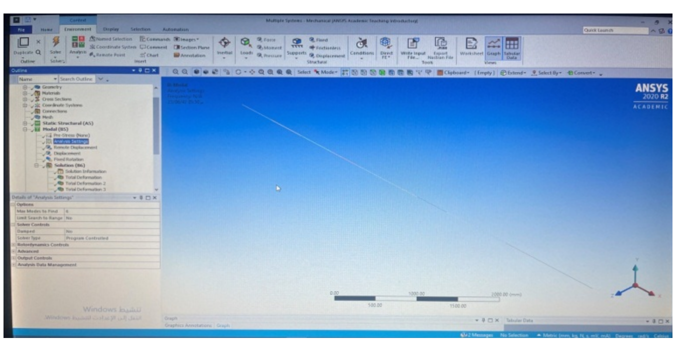

FIG.22 : THE ANALYSIS SETTINGS FOR THE MODAL STUDY

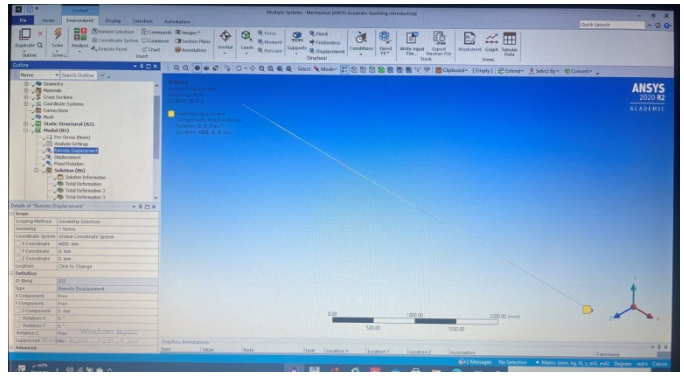

FIG.23 : THE REMOTE DISPLACEMENT FOR THE FISHING STICK

As we can see from above fig. 23 remote displacement for the second point (6,0,0) m and free to move in X,Y and not allowed to move in Z directions with free rotation around Z axis and 0 around X and Y.

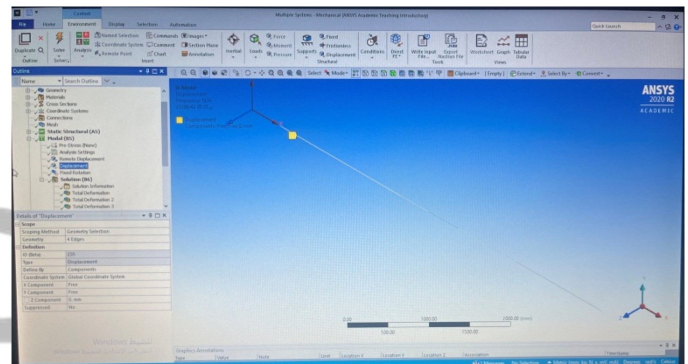

FIG.24 : THE DISPLACEMENT FOR THE FISHING STICK

In Fig.24 we put a displacement for the first 4 elements in the fishing stick, which is free to move in X and Y direction while no allowed to move in the Z direction.

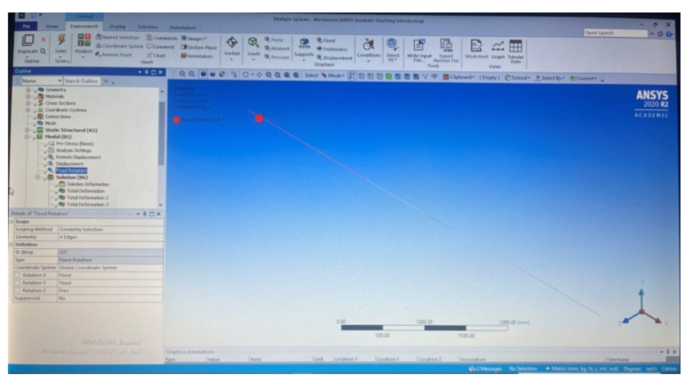

FIG.25 : THE FIXED ROTATION FOR THE FISHING STICK

In Fig.25 we put a fixed rotation for the first 4 elements in the fishing stick, which is fixed to rotate around X and Y while free to rotate around Z.

- <u>Results and Discussion (Modal)</u>

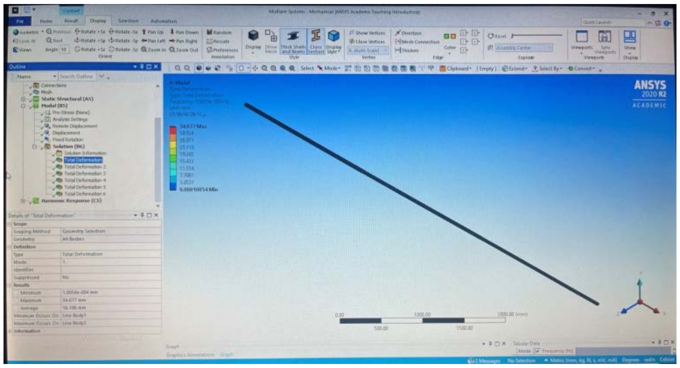

FIG.26 : THE FIRST MODE SHAPE

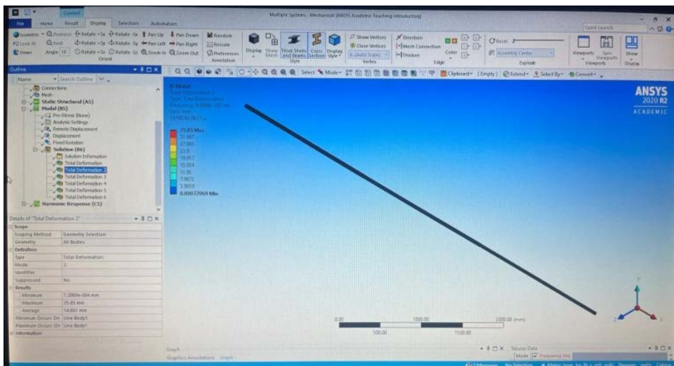

FIG.27 : THE SECOND MODE SHAPE

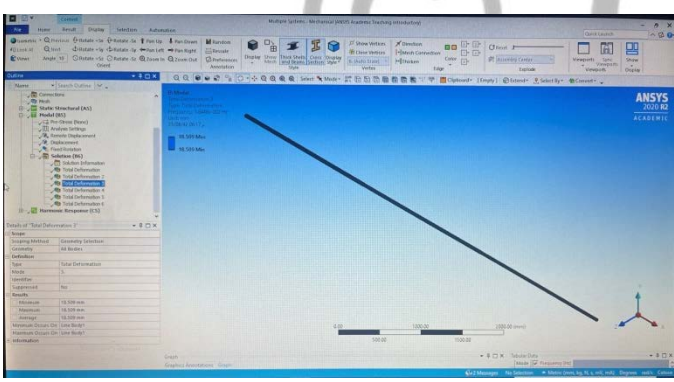

FIG.28 : THE THIRD MODE SHAPE

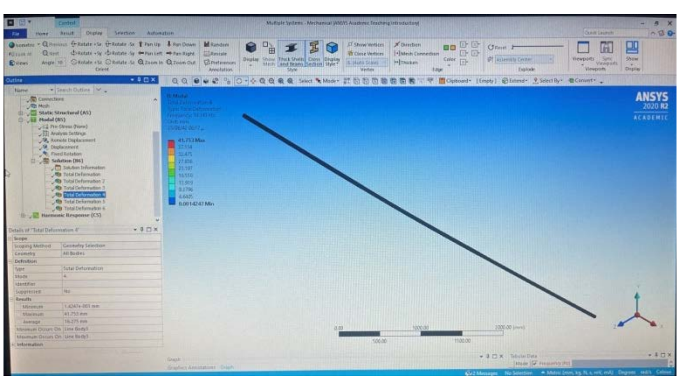

FIG.29 : THE FORTH MODE SHAPE

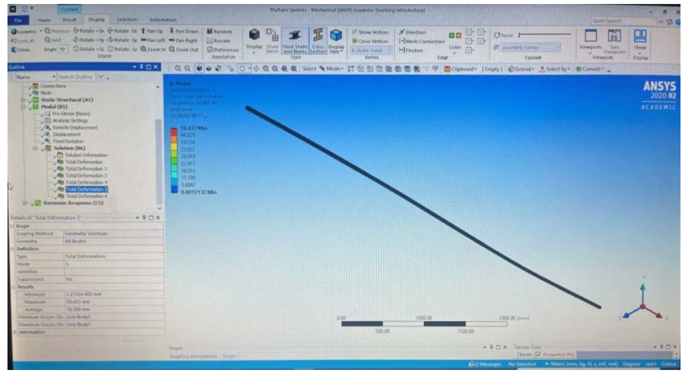

FIG.30 : THE FIFTH MODE SHAPE

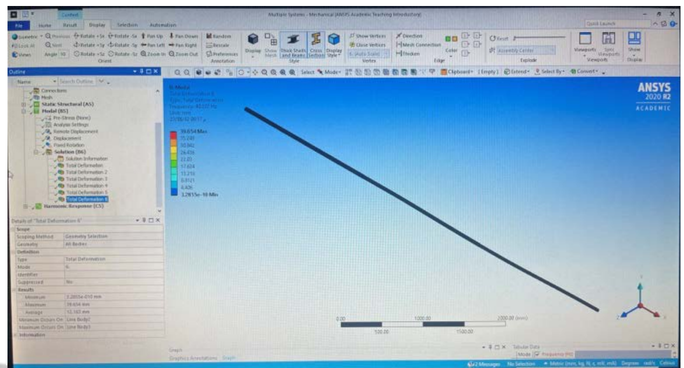

FIG.31 : THE SIXTH MODE SHAPE

TABLE.3: THE 6 MODE SHAPES

| ***Mode Shape*** | ***Total Deformation (mm)*** |
|---|---|
| **1** | *34.677* |
| **2** | *35.85* |
| **3** | *18.509* |
| **4** | *41.753* |
| **5** | *50.433* |
| **6** | *39.654* |

- <u>Modeling & Analysis Setup (Harmonic Response)</u>

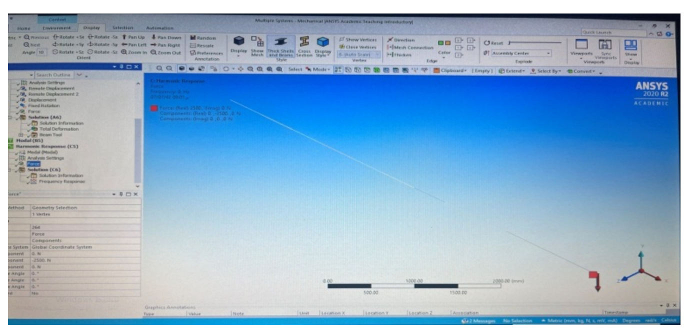

FIG.32 : THE FORCE IN THE HARMONIC RESPONSE

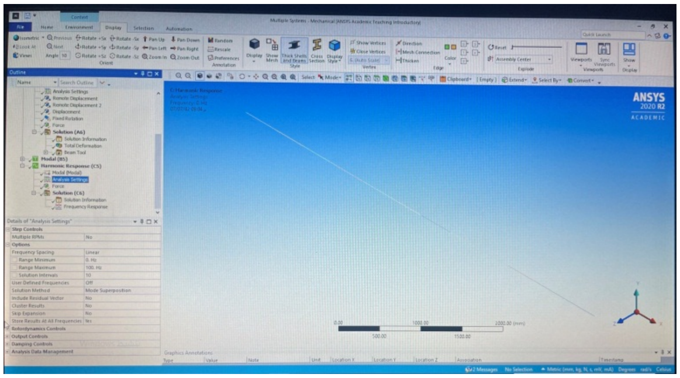


FIG.33 : THE ANALYSIS SETTING IN THE HARMONIC RESPONSE

- <u>Results and Discussion (Harmonic Response)</u>

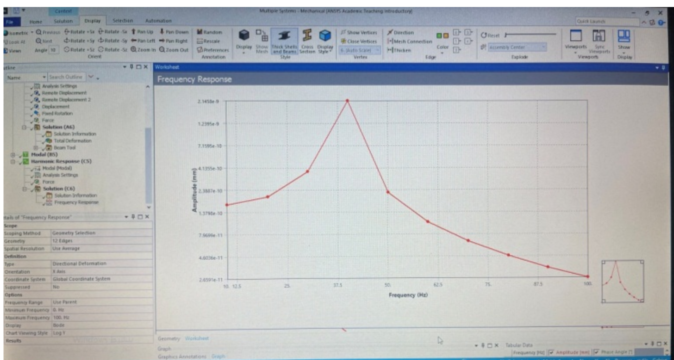


FIG.34 : THE FREQUENCY RESPONSE

As we can see from fig.34 the highest amplitude is 2.1458 X10-9 mm at frequency 40.625 Hz.

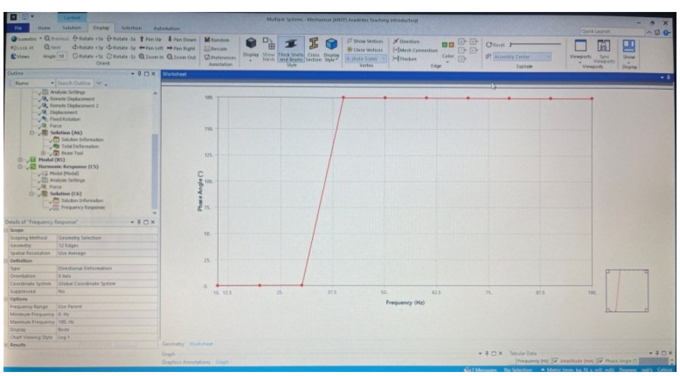

FIG.35 : THE PHASE ANGLE

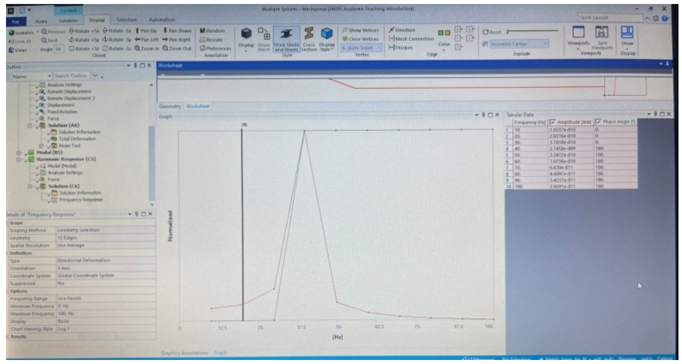

FIG.36 : TABULAR DATA OF FREQUENCY RESPONSE

## 3 DISCUSSION & CONCLUSION

Closing up, is a necessity as it makes everything easy for the reader to go through. Therefore, the project from beginning to end is to be concluded in this section. Starting from providing a background of fishing stick, one can understand their concepts. Secondly, the project is titled as “Static and Harmonic Study of Fishing Stick Using Composite Materials (FGM)”. The objective is Solve Static Structural to find the Maximum Combined Stress in (Mpa), Solve Modal Structural to find the first 6 mode shapes in (Hz), and Solve Harmonic Response to find the frequency response. Therefore, the project was divided into three stages, each stage has its own modeling, analysis and results discussion. On the other hand, we suggests other recommendations for further study such as that redesigning the portion of the fishing stick using other materials which reduces vibration over millions of cycles without degrading.

## 4 REFERENCES

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