

## Evolution and Revolution of 3D printing in India – Design and Synthesis Analysis Aspects on a Product (Mobile case) Material Selection

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### ABSTRACT

3D printing is a rapid prototyping technology which became popular in the approximate last two years. It builds objects through layer-by-layer printing which is based on digital model files. As a new technology in rapid manufacturing, 3D printing is rapidly emerging and will become an important part of the manufacturing industry in the future. This paper introduces the basic principle of 3D printing technology and the current development trend. The printing model is analyzed in detail from four aspects of saving printing materials, improving the strength, increasing the stability and improving the supporting structure, and the related optimization methods are put forward. Structural optimization can reduce the consumption of printed materials, reduce printing costs and eliminate the structural defects of the 3D model. Through the optimization of 3D model, 3D printing technology can continue to make progress.

### 1. INTRODUCTION

A 3D Printing is a technical process for making a physical object from a three-dimensional digital 2D/3D model, typically by laying down many successive thin layers of a material. It brings a digital 2D/3D object (its CAD representation) into its physical form by adding layer by layer of manufacturing material(s) of particular object Chua, C. K., & Leong, K. F. (2014). A 3D printing technology has now been covered different country areas across many television channels, in mainstream newspapers and across online resources. What really is behind this 3D printing that some have claimed with a practical example will put an end to traditional manufacturing as we aware and know about it, revolutionize design and impose geopolitical, economic, social, demographic and environmental and security insinuations to our everyday lives and living styles.

The most basic differentiating principle behind 3D printing



**Figure 1.** What is 3D Printing?

and traditional manufacturing is that 3D printing is an Additive Manufacturing Process irrespective of Material Removal Manufacturing Process. And this is definitely the key because 3D printing is a superficially different manufacturing method based on advanced technology that builds up parts, additively, in layers at the assistant mm scale. This is fundamentally different from all other existing traditional manufacturing techniques.

### Design & Synthesis Analysis Aspects (Figure 2)

In its simplest term definition, design analysis is a powerful

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and an effective software technology for simulating physical behaviour of a product on the computer. Will it break or deform or get too hot? These are the types of questions for which design analysis provides accurate analysis answers. Instead of building a prototype and developing complex testing treatments to analyze the physical behaviour of a product, engineers can bring out this information quickly and accurately on the computer. Because design analysis can minimize or even eliminate the need for physical prototyping and testing of a product, the technology has gone main stream in the manufacturing world over the past decade as a valuable product development tool and has become ubiquitous in almost all fields of engineering. Design Analysis is just that. It is studying the characteristics (form, structure, construction, features, etc.) of the design of a thing (Attaran, M.2 017).

Design synthesis is creating a design or the discernible characteristics that makeup the design. The first concept focuses on studying and reviewing the details while the second concept deals with the creation of construction of the thing; in this case the design.



**Figure 2.** Design & Synthesis Analysis

Synthesis usually is done through assimilating pieces or patterns to reproduce the functionality seen in other designs. Synthesis can also be done by implementing novel approaches to solve the same or similar problems in alternative ways.

### A. Finite Element Analysis (FEA)

Design Analysis utilizes the finite element analysis (FEA) method to replicate physical behaviour of a product design. The FEA process consists of subdividing all systems into individual components or “elements” whose behaviour is easily understood and then reconstructing the original system from these components. This is a natural way of performing analysis in engineering and even in other analytical fields. For example, a control arm on a car suspension is one single continuous shape. An analysis application will test the control arm by dividing its geometry into ‘elements,’ analyzing them, and then simulating what relationship happens between the different elements. The application displays the results as colour-coded 3D images, red colour usually denoting an area of failure, and blue colour denoting areas to facilitate maintaining their integrity under the load applied.

Design Analysis can be applied to just about anything an Engineer(s) will analyze just about every type of product development alongwith possibility of its research efforts. Analyzing machine designs, injection moulded plastics, cooling systems, products that emit an electromagnetic field, and systems that are influenced by fluid dynamics are just some subjective examples of how companies leverage design analysis (Poli, C. 2001).

In the field of mechanical engineering, design analysis aspect can also solve a wide range of product development problems through product design testing. Engineers can use design analysis aspect to predict the physical behaviour of just about any part or assembly of parts of a product under any loading conditions: from a simple beam under a bending load to a car crash simulations and vibration analysis of an aircraft. The true power of a design analysis is the ability to perform any of these types of studies, as mentioned in above real examples, accurately without either building a single thing or redesigning of existing thing/product. All that above mentioned about design analysis is in a need of a Computer Aided Designing (CAD) model.

### B. Stress Analysis

The most common design analysis application scope in the field of mechanical engineering is stress analysis. Engineers can study the stresses (both structural and thermal) on a particular part to determine whether it will fail or not and whether essential design modifications are necessary to overcome potential problems. Design analysis can also be used in a wide variety of fields; here are mentioned just a few examples:

1. Determine the potential for deformation of parts of a product.
2. Measure resonant frequencies and modes of vibration of parts and assemblies of a product.
3. Calculate dynamic and seismic responses within a product.
4. Determine Contact stresses of parts and assemblies of a product.
5. Provide temperature distribution within a product.
6. Analyze fluid flow, whether it is a gas or liquid in a pipeline, the mixture of air and fuel in an engine intake manifold, or molten plastic filling up a mould within a product.

### C. Motion Analysis & Electromagnetism

Besides working very closely with respect to Computer Aided Designing (CAD) packages, the applications of a commercial design analysis also interface with increasingly popular programs for motion analysis to create complete virtual analysis and test systems in a mechanical engineering system. In other engineering disciplines, design analysis is used to study electromagnetic fields, soil mechanics, groundwater flow, bone growth, etc.

### D. Solidworks Simulation Software for Design Analysis.

With powerful and perceptive SOLIDWORKS® Simulation

solutions (Ref [1], Ref [3]), a product engineer can virtually test newly created ideas, quickly and efficiently evaluate regular performance, improve the quality and get the knowledge for any future product innovation.

**E. Working Principle of 3D Printing Technology during its practical application**

The working principle of the 3D printer is actually similar to the principle of an ordinary daily printer. The daily life printer is a two-dimensional planar object, and the 3D printer first draws a virtual 3D model on the computer, and then the virtual 3D is cut into a layer of cross sections, which is slicing process, and finally guides the 3D printer from bottom to top layer by layer model printing. In general, as shown in figure 3, the Printing process of 3D printing is mainly divided into four areas, namely: (a) Building models (b) Slicing (c) Printing and (d) Post-processing.

**1. To Build a Model**

To print the actual model product, it is necessary to draw a corresponding three-dimensional virtual model. Therefore, we must first use the three-dimensional graphics software (such as CAD, Pro/E, etc.) to design the appropriate software model, according to our own ideas.

**2. Layered Slices**

The design of the 3D virtual model input to the computer to go, and then through the 3D printer comes with professional printing software to further print processing, the model cut into layers of sheet, the properties of the print material and the printer's specifications decided the thickness of each sheet.

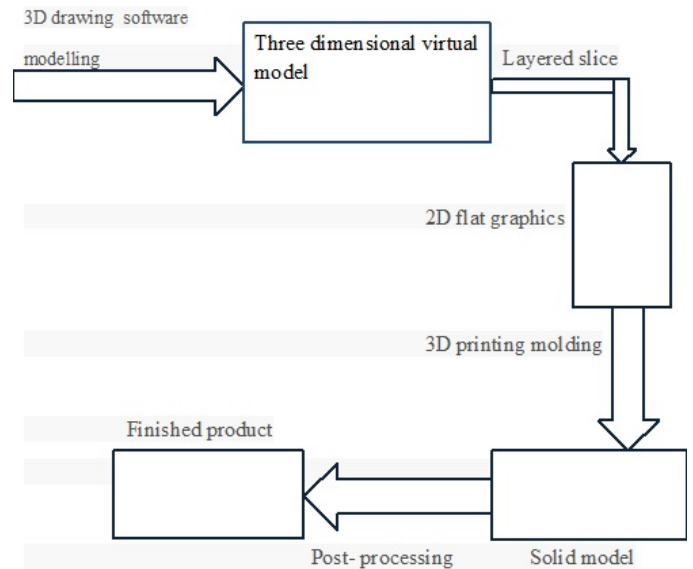
**3. Printing and Forming**

3D printer model printing process is mainly divided into two steps: support the production and the production of parts entities. In the printed area, the printer head travels along the path specified by the programming software to extrude the liquid and support materials and print the model up from the bottom up.

**4. Post-processing**

The post-processing of 3D printing technology includes: stripping excess support material from the model while ensuring the shape of the model surface, preventing large deformation of the model, and processing the surface to meet the accuracy requirements of the model. 3D printing combines the design of the model with the production of the process, and the steps that were previously required to be done separately can now be made in 3D by all means. This greatly reduces the product model in the design of production costs, but also significantly shorten the production time.

3D printing is a green manufacturing model, Great savings in the processing of materials [2]. There is no doubt that 3D printing will change the mode of industrial manufacturing in the past and eventually develop into a new type of manufacturing system.



**Figure 3.** Process of 3D

**Material Selection & Properties For Selected Product**

There are basically three types of plastics, as below mentioned, used in making cases.

1. Hard plastic cases- Made up of either polycarbonate or hard polyurethane or polypropylene.
2. Soft plastic covers- Manufactured from regular polyurethane or thermoplastic polyurethane.
3. Hybrid plastic cases- Made from a combination of the aforementioned compounds.

The properties of Polyurethanes are greatly depending on the structure of the polymer backbone. They can be adapted to have high strength, high rigidity or high flexibility and toughness. Most of these urethanes have good resistance to oil, hydrocarbons, oxygen, and ozone.

**Table I.** Properties Of Polyurethane (Pu) Thermoplastic Elastomer

Polymer	Tensile strength (MPa)	Flexural modulus / (modulus of elasticity) (GPa)	Elongation at break (%)	Strain at yield (%)	Notched Izod impact strength (kJ/m)	Surface hardness
Nitrogen-containing Polymers						
Polyurethane (PU) Thermo-plastic Elastomer	24	0.003	700	N/Y	1.064	SA 70

**An Experimental Practical Case Study On A Mobile Case**

Mobile Cases, are designed to attach to support or otherwise hold a smart mobile, are popular accessories. Case measures

are based on the display inches (e.g. 5 inch display) of a mobile. There are different types of mobile cases:

- Pouches and sleeves
- Holsters
- Shells
- Skins
- Bumpers
- Flip cases and wallets
- Screen protection and body films
- Drop and shock protection
- Leather case

Today, there are more mobile devices than there are existing people within the world. That means there's sufficient opportunity for you to grab a slice of the growing market for accessories of a smart mobile. Mobile cases, in particular, are easy to provide source and appeal to people for looking to inject some individuality or extra functionality into their necessity device for whom they can't live without.

**A. Too Much Reliance on Plastic**

The popular and cheapest 3D printers generally use layers of plastic filaments. Although using raw plastic reduces waste generation, the machines still leave unused or excess plastic in the alternative print beds. The plastic by product ends up in landfills negatively affecting the surrounding of an environment. Furthermore, plastic limits the type of utilized products that can be created from the plastic material. Future 3D printers will need to use other materials such as metals (as some currently do) or carbon composites to become more useful to both manufacturers and consumers alike.

**B. Designing Steps Of Mobile Case Using Solidworks**

**1). Introduction And Applications Of Solidworks.**

The SOLIDWORKS® CAD software is a mechanical design automation application that allows designers quickly sketch out the ideas, experiment with features and dimensions, and produce models and detailed drawings of a product.

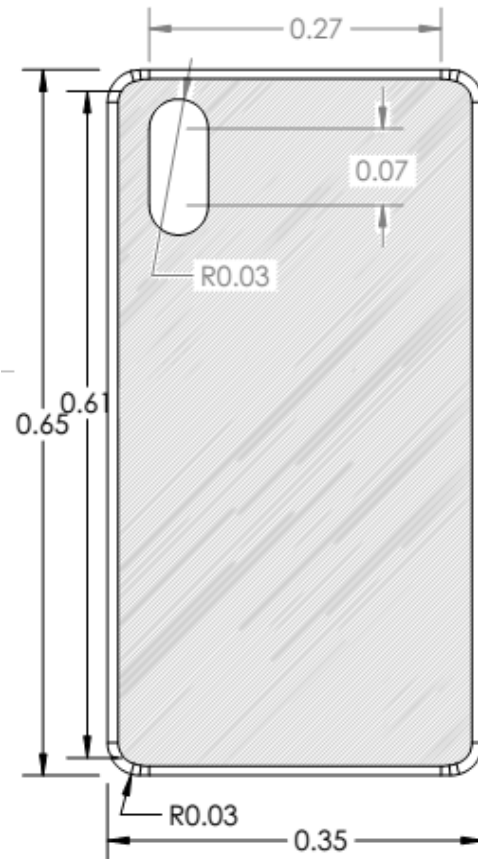
The SolidWorks have wide range of applications in industries such as:

- a. Aerospace
- b. Automotive
- c. Consumer products
- d. Defence
- e. Electronics
- f. Heavy equipment
- g. Machinery
- h. Medical tool
- i. Process plant
- j. Sheet metal work

**k. Transportation**

Now are applying the concept of above software on our predefined product as below mentioned:

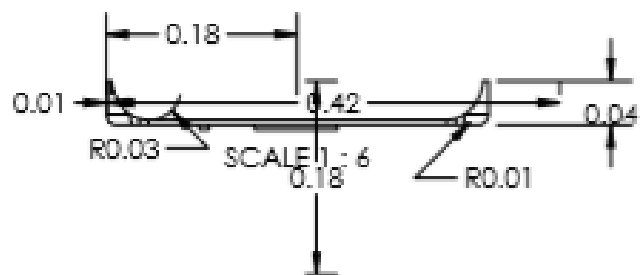
1. Firstly select rectangle from the sketch layout and draw the rectangle of dimension 0.35m\* 0.65m.
2. Then apply fillet at its corners of radius 0.01 m.
3. For the camera, select dome from the sketch bar and make a dome as shown in Figure 4.



SCALE 1 : 6

**Figure 4.** Dome Drawing of Mobile Case

4. Then exit the sketch and use extrude command of 0.04 m.
5. Then use shell command to it, to hollow fill its thickness in command bar, 0.01m.
6. Then select the front view of it, and apply fillet at all its inward corners of radius 0.03 m as shown in Figure 5.

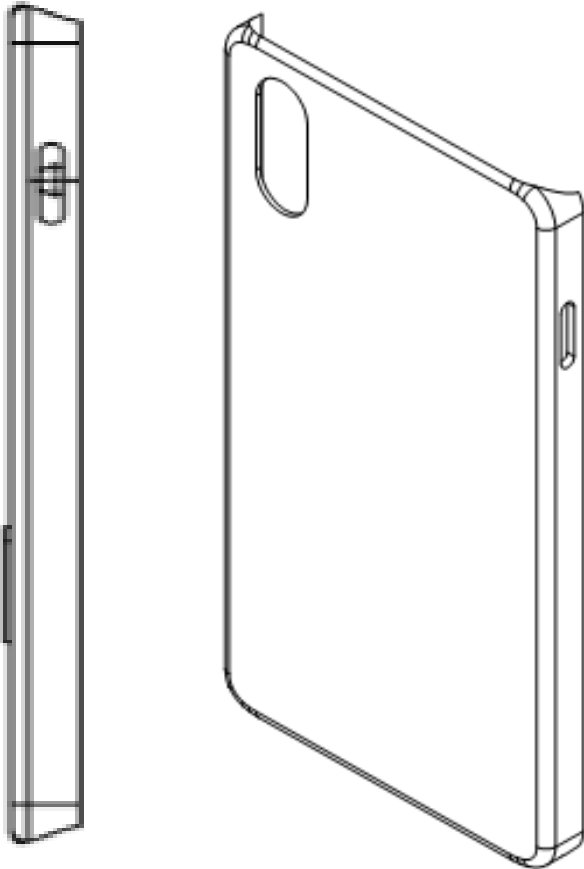


**Figure 5.** Fillets used in Mobile Case

7. Then select its side view and dome in it, as shown in Figure 6 for the lock button.
8. Similarly on the other side of it make another dome of dimension 0.06m for the volume space.
9. Then to make it attractive, we extrude it 0.01m, as

shown in Figure 6.

10. Hence this is our final product design of predefined and preselected mobile case.



**Figure 6.** Side views of Mobile Case

### C. Synthesis Analysis Steps Of Mobile Case Using Ansys

#### 1). Introduction and application of ANSYS

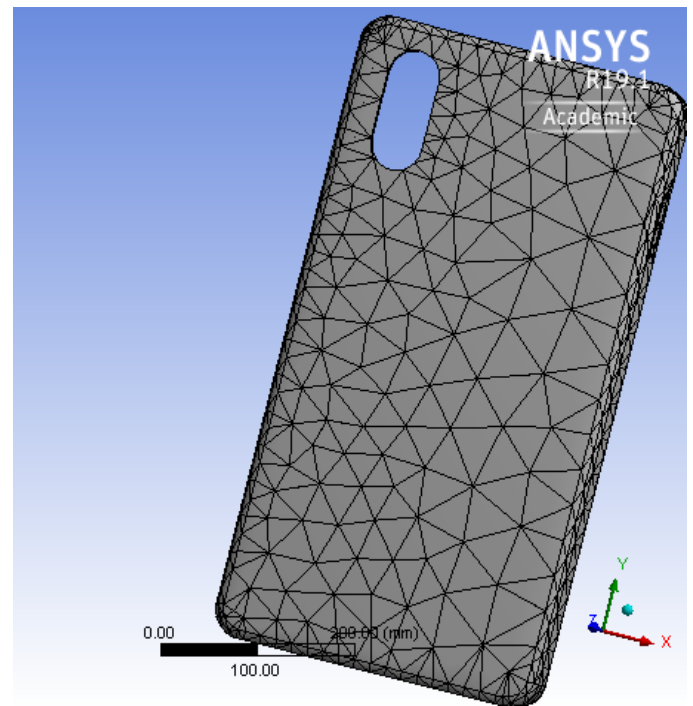
The ANSYS Workbench (Ref [2], Ref [4]) environment is a sensitive up-front finite element analysis tool that is used in combination with CAD systems and/or Design Modeler. ANSYS Workbench is a software environment for performing structural, thermal and electromagnetic analyses. The class focuses on geometry creation and optimization, attaching existing geometry, setting up the finite element model, solving and reviewing results. The class will describe how to use the code as well as basic finite element simulation concepts and results explanation (Zhou, W. X. (1997).

The ANSYS structural analysis software suite enables anyone to solve the complex structural engineering problems and make better, faster design decisions. With Finite Element Analysis (FEA) tools, anyone can customize and automate simulations and parameterize them to analyze multiple design scenarios. ANSYS structural mechanics software easily connects to other physics analysis tools by providing even greater realism in predicting the behaviour and performance character of complex products.

The ANSYS have wide range of applications in industries such as:

- a. Composites
- b. Durability

- c. Fluid-structure interaction



**Figure 7.** Modeling of Mobile Case

- d. Impact
- e. Optimization
- f. Rigid body dynamics
- g. Strength analysis
- h. Thermal analysis
- i. Vibrations

Now are applying the concept of above software with its basic and general concept commands on our predefined product as below mentioned:

**Step 1** - Launching ANSYS Workbench. The Workbench Project Window will open.

**Step 2** - ANSYS Main Menu - Preferences (Select -STRUCTURAL- ok)

**Step 3** - Pre-processor

**Element Type**- selects type of element from the table and the required options.

**Real constants**- Give the details such as Thickness, Areas, Moment of Inertia etc. required depending on the nature of the problem.

**Material Properties**- Select units and choose one of the following types of unit.

**USER**- User-defined system (default).

**SI International system**- SI or MKS (m, kg, s, K).

**CGS**- CGS system (cm, g, s, °C).

**MPA**- MPA system (mm, Mg, s, °C).

**BFT**- British system using feet (ft, slug, s, °F).

**BIN**- British system using inches (in, lbf\*s<sup>2</sup>/in, s, °F).

**Material properties** Give the details such as Young's

Modulus, Poisson's ratio etc. required depending on the nature of the problem

**Step 4 - Modeling** (See Figure 7)

**Modeling** – Create – Nodes – in active CS– apply (first node is created) – x, y, z location in CS -300 (x value w.r.t first node) – ok Create – elements – Auto numbered – thru node – pick 1&2 – ok (elements are created through nodes).

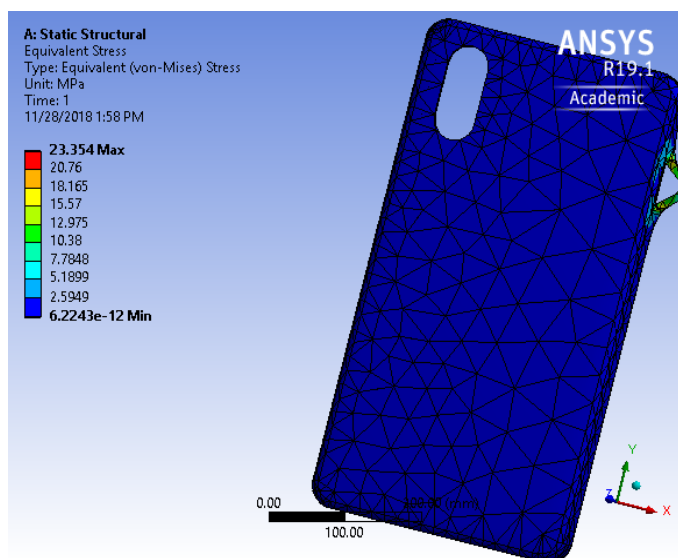
NODES: 7116  
ELEMENTS: 3181

**Step 5 - Apply the Boundary conditions/ loads** – Such as DOF constraints, Force/ Momentum, Pressure etc. (See Figure 8)



**Figure 8.** Applied Force on Mobile Case

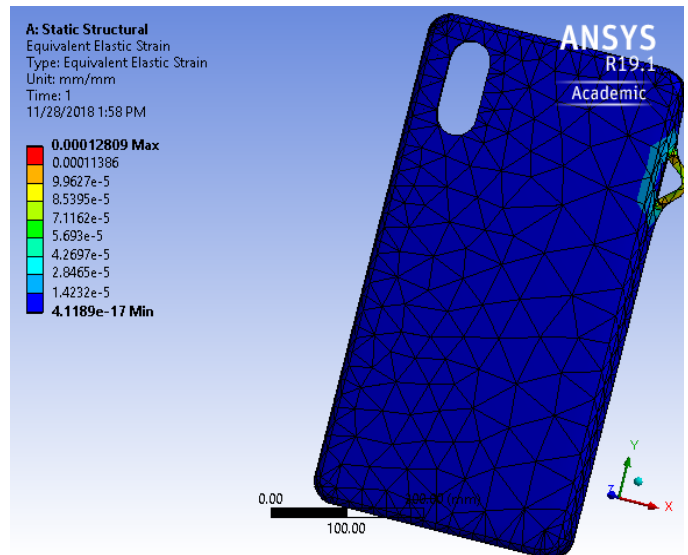
1. On both holes of Camera and Power button firstly, we applied force of 250 N that gives 4.98 MPA of stress.



**Figure 9.** Stress Analysis on Mobile Case

2. Then, in second observation, we applied force of 500 N on both holes, it results 9.34 MPA of stress.
3. Then, in next observation, we applied force of 1000 N on both holes, we discovered 18.64 MPA of stress.
4. Then, in third observation, we insist force of 1200 N on both holes which results in 22.42 MPA of stress.
5. Then in last observation, we applied 1250N of force on

both holes which results in 23.54 MPA of stress which was below then Tensile Strength of 24 MPa of selected material for our research purpose.



**Figure 10.** Strain Analysis on Mobile Case

**Step 6 - Solution** - Solve the problem.

**Step 7 - General Post Processor** - Plot / List the required results.

**Step 8 - Plot ctrls-animate** - deformed shape-def+ undeformed-ok

**Step 9 - After that note the maximum stress** (Figure 9) and maximum strain values (Figure 10).

**Step 10 - To save the solution / geometry etc.** – ANSYS tool bar-Save-DB-File-Save as-zzz.db-ok

**CONCLUSION**

A 3D printing technology, like modeling or 3D scanning, is a creation tool among other creation things, but what most distinguishes it is its potential to create an almost unlimited number of shapes and size of a product. As with every tool, firstly need to master it, to take advantage of its abilities, but must also know its limits before its practical applications. Prototyping is not the ultimate solution for each and every manufacturing need. Techniques, that are hundreds or thousands of years old, such as casting, machining, and blowing, will still remain stay in our industrial landscape for future long time depending upon our present conception necessity needs.

**COMPLIANCE WITH ETHICAL STANDARDS**

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This research collaborated study article was facilitated in terms of province of ANSYS Software either in CAD Lab of Campus or in Laptop by Hon'ble Campus Director of IITM Group of Institutions. Never financial necessity needs developed at any stage, from initial to final steps, during this whole software analysis article as this article will come into existence in nearby future time period(s) depending upon expectational practical time needs of technical studies

of all technical students for making their mind a technical conscious mind regarding that why there is necessity neediness of ANSYS Software to designers that always allows them quickly sketch out their ideas, experiment with features and dimensions, and produce models and detailed drawings of a product for its effectively utilization by a customer in minimum / nominal production + purchasing + maintenance costs on his/her self pocket money with respect to his/her monthly/yearly pre-planned budget.

### **CONFLICT OF INTEREST**

Both, Author 1 & Author 2, individually declares that they have no & even will never individual conflict of interest regarding their this collaborated article.

### **ETHICAL APPROVAL**

This collaborated article does not contain any studies with human participants or animals performed at any stage, from starting to its final steps, by any one of the authors.

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