iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** II **Month of publication:** February 2018

DOI: http://doi.org/10.22214/ijraset.2018.2017

Reactions in the Body Subjected to Coplanar Non-Concurrent Forces – Validation using Ansys 10.0

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Abstract*: In this paper an attempt has been made to compare the analytical results with the software results. A simple body subjected to the simple loading has been considered for the purpose of comparison. The body is subjected to coplanar non-concurrent forces. The reactions developed in the body due to the coplanar non-concurrent forces are calculated analytically. The reactions developed are also calculated with the software. Then the results of analytical solution and software solution are compared to validate the results.
Keywords: Coplanar non-concurrent forces, reactions and nodes.

I. INTRODUCTION

If all the forces in a system lie in a single plane and the lines of action of all the forces do not pass through a single point, the system is said to be coplanar non-concurrent force system. The body subjected to coplanar non-concurrent force system experiences moment. Moment of a force about a point is defined as the product of the magnitude of the force and the perpendicular distance of the point from the line of action of the force. Varignon's Theorem is very much essential for the analysis of the body subjected to the coplanar non-concurrent forces. Varignon's Theorem states that, the algebraic sum of moments of a system of coplanar forces about a moment center is equal to the moment of their resultant force about the same moment center. The body subjected to coplanar non-concurrent force system experiences couple. Two parallel forces equal in magnitude and opposite in direction and separated by a definite distance are said to form a couple. The sum of the forces forming a couple in any direction is zero, which means the translator effect of couple is zero. In this paper a simple body subjected to simple forces is considered to obtain the reactions.

II. EQUATIONS OF EQUILIBRIUM

A beam is a structural element which has one dimension considerably larger than the other two dimensions in the cross-section and is supported at few points. It is subjected to lateral loads. Due to applied loads, reaction develop at supports and the system of forces consisting of applied loads, self-weight and reactions keep the beam in equilibrium. The forces constitute a system of coplanar non-concurrent system in equilibrium. If the support reactions can be determined using the equations of equilibrium only, then the beam is said to be statically determinate. Statically determinate beams in which all the reactions can be found using the equation of equilibrium only.

To resist the applied coplanar non-concurrent forces reactions develop at supports of the beam. Reactions are self-adjusting forces which will keep the beams in equilibrium. Hence the equation of equilibrium may be written for the system of forces consisting of reactions and the loads. Solutions of these equations give the unknown reactions.

III. PROBLEM DESCRIPTION

In this paper simple cantilever beam has been considered. The beam is subjected to two point loads. One point load at the end and another point load at distance of 2 meter from the fixed end. The second point load is inclined at 60^0 to the horizontal. The first point load is at a distance of 1 meter from the second load.

The first point load value is 15kN and second point load value is 20kN. The beam is also subjected to the uniformly distributed load of 10 kN/m for a length of 2m from the fixed end. At the end of the uniformly distributed load, the second point load is acting. The beam is made of material of Young's Modulus of 200 GPa. The beam has a rectangular cross section of Width 0.5 meter and height 0.3 meter. The schematic diagram of the body subjected to the above said loads is shown in Fig. 1.

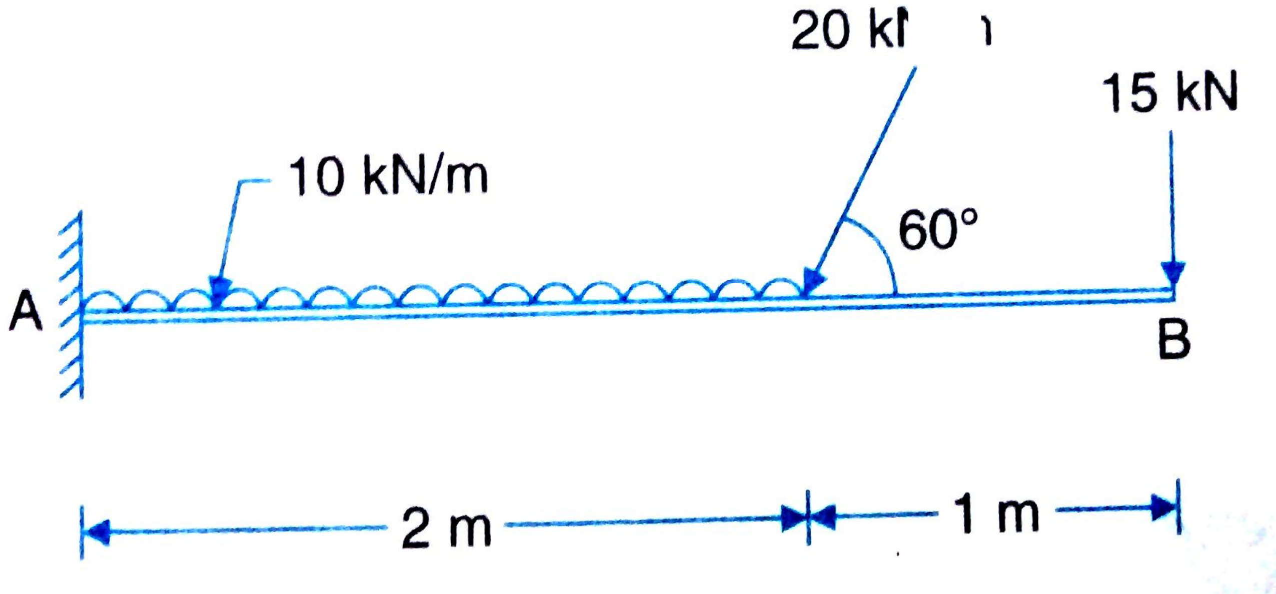

Fig. 1 A schematic diagram of the body subjected coplanar non concurrent forces

IV. ANALYTICAL SOLUTION

Let the reactions developed at fixed support A be V_A, H_A and M_A as shown in Fig. 2. Fig. 2 shows the free body diagram of thebody subjected to coplanar non-concurrent forces.

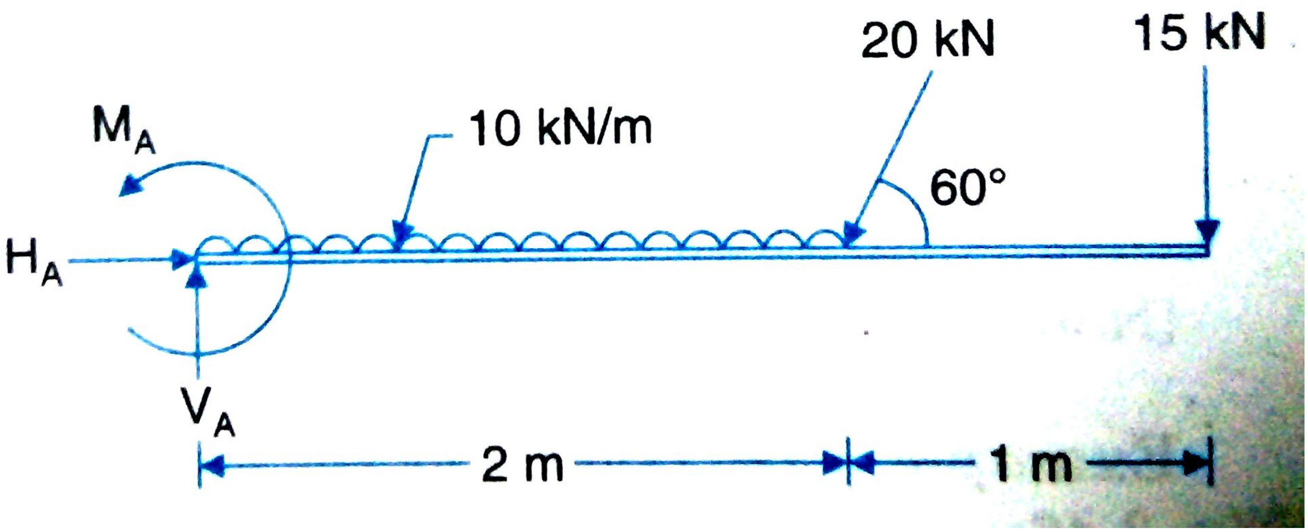

Fig. 2 Free body diagram of the body subjected to coplanar non-concurrent forces

The vertical reaction force at point A is calculated as follows.
Sum of forces in vertical direction = 0
$V_A - 10 \text{ X } 2 - 20 \text{ Sin } (60^0) - 15 = 0$
$V_A = 52.32$ kN
The horizontal reaction force at point A is calculated as follows.
Sum of forces in horizontal direction = 0
$H_A - 20 \text{ Cos } (60^0) - 15 = 0$
$H_A = 10$ kN

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
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The moment reaction at point A is calculated as follows.
Sum of moments about point A = 0
$- M_A + 10 X 2 X 1 + 20 Sin (60^0) X 2 + 15 X 3 = 0$
$M_A = 99.64$ kN-m
There fre, at point P there is vertical reaction of 52.32kN, horizontal reaction of 10 kN and moment reaction of 99.64 kN-m.
These values of reaction are obtained analytically.

V. SOFTWARE SOLUTION

The reaction values for the body subjected to coplanar non concurrent forces shown in Fig. 1 are obtained using the software. The software used for the purpose is Ansys 10.0.

The problem is solved in Ansys by giving structural preference. The element type chosen for the analysis is Beam 188 – 3D finite strain element. The material model chosen are structural, linear, elastic and isotropic with Young's Modulus value of 200 GPa and Poisson's ratio of 0.3. The dimensions of cross section are given by selecting common section with width equal to 0.5 meter and height equal to 0.3 meter.

Then the modelling is done using three nodes. First node is created at the point A to be fixed i.e. resistance for horizontal force, vertical force and moment about Z axis. Second node is created at a distance of 2 meter from the node 1 and is rotated by an angle of -30^0 so that the y can be aligned with load to be applied. The third node is created at distance of 3 meter from node 1 and is at a distance of 1 meter from node 2. The nodes created is shown in Fig. 3

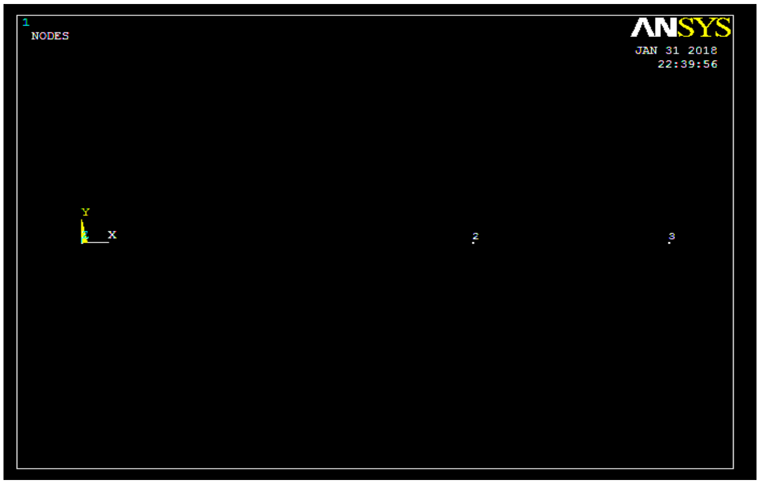

Fig. 3 Creation of model using nodes

The finite element model is generated by creating element between nodes. Element 1 is created using the nodes 1 and 2. Element 2 is created using nodes 2 and 3. The finite element model generated using nodes and elements directly without using key points is shown in Fig. 4.

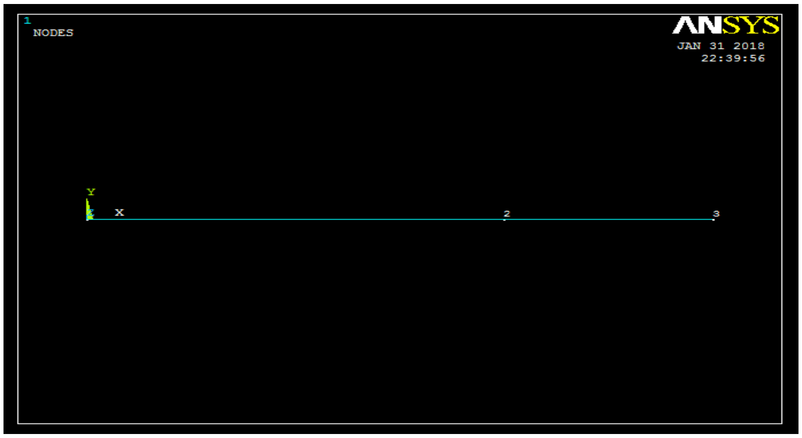

Fig. 4 Finite Element Model using nodes and elements directly

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
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The boundary conditions are given by fixing node 1 by selecting ALLDOF and restricting moment about Z axis by selecting ROTZ. The point loads 15 kN and 20 kN are applied at node 3 and node 2. The load applied node 2 is at 60^0 to horizontal. The uniformly distributed load is applied on element 1 of value 10 kN/m by selecting load key number 2. The applied boundary conditions and loadings are shown in Fig. 5.

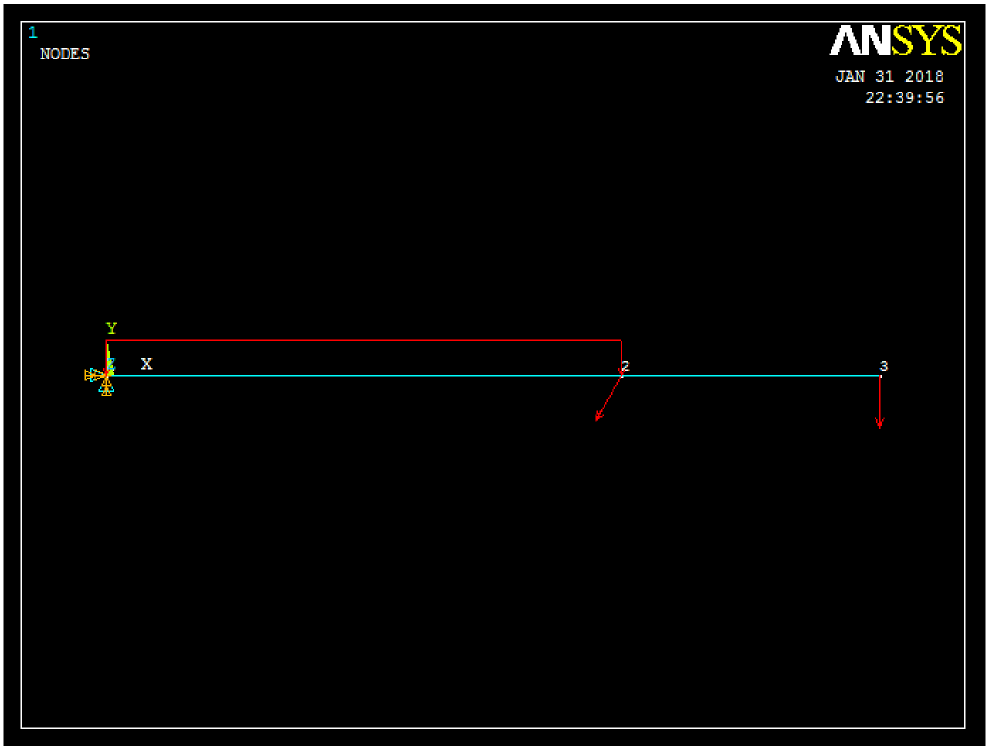

Fig. 5 Applied boundary conditions and loadings

For the applied loads and boundary conditions is solved in Ansys software and final reaction values are obtained in the general post processor. The listed reactions at nodes obtained from Ansys is shown in Fig. 6. The deformed and undeformed shape of the body is shown in Fig. 7.

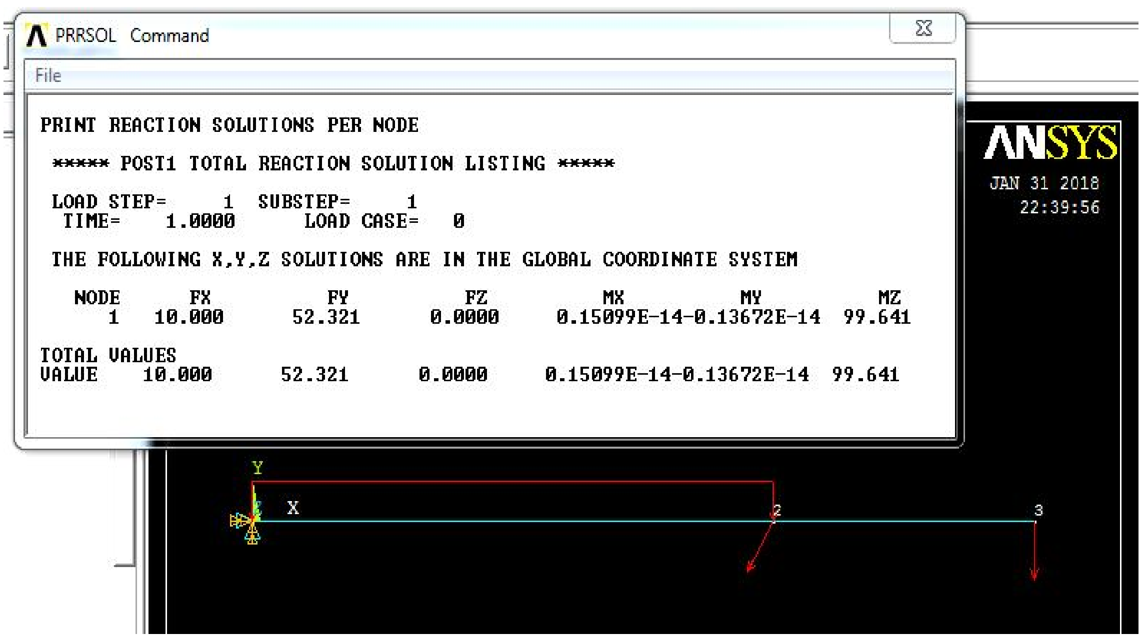

Fig. 6 The reaction solution in general post processor

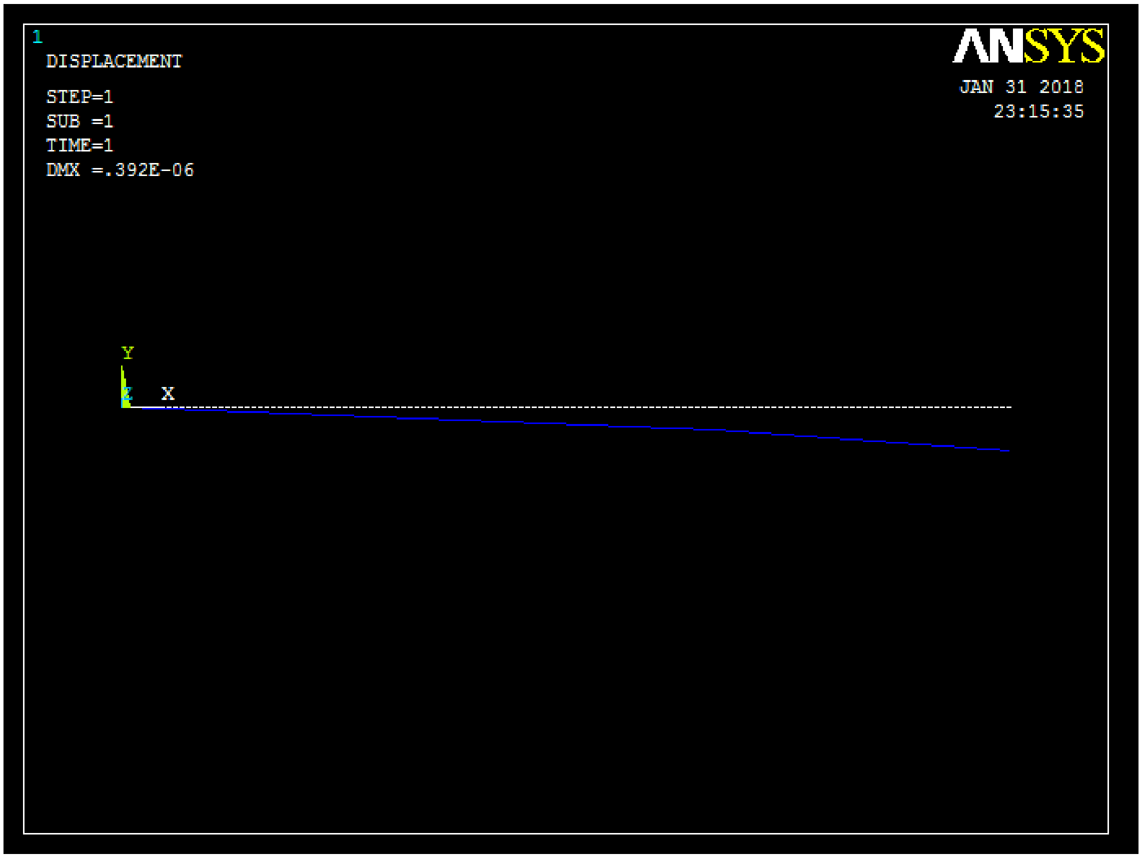

Fig. 7 The deformed and undeformed shape of the body

The results of the analytical solution and Ansys solution are tabulated in TABLE I.

TABLE I
COMPARISON OF RESULTS

	Reaction Solutions		
	Reaction force - FX	Reaction force - FY	Moment - MZ
Ansys Solution	10.000	52.321	99.641
Analytical Solution	10 kN	52.32 kN	99.64 kN-m

VI. CONCLUSIONS

The analytical and Ansys solution for the reaction forces are successfully obtained. The comparison of analytical solution with Ansys solution from TABLE I it clear that the analytical solution close match with software solution. The Ansys solution is successfully used for the validation of the analytical solution to find reaction forces. Hence the Ansys can be used for obtaining the reaction forces for any complicated problems in future whose analytical solution is difficult or impossible to obtain.

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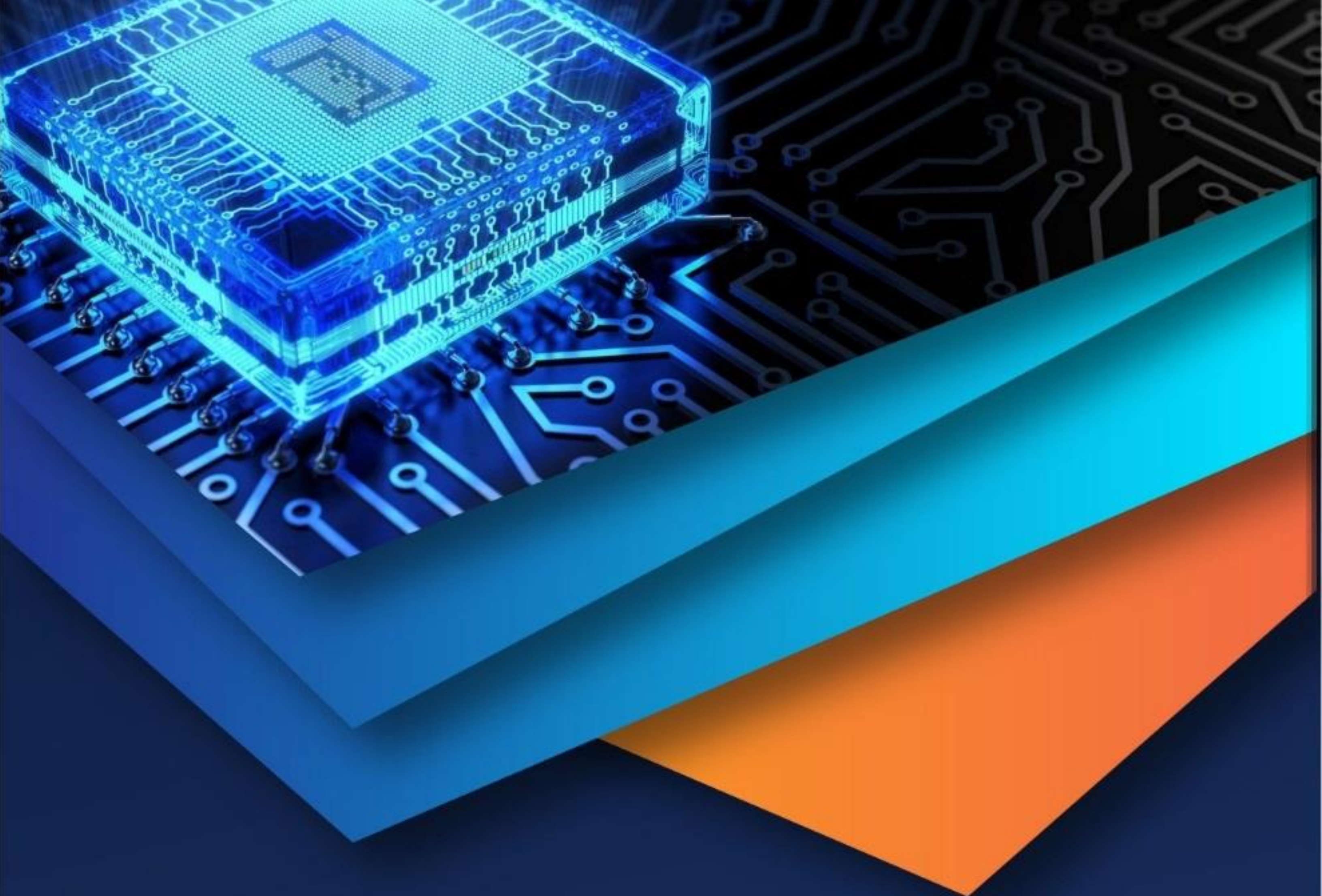

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