بسم الله الرحمن الرحيم

Department of Mechanical & Chemical Engineering (MCE)

ISLAMIC UNIVERSITY OF TECHNOLOGY
(IUT)

# Effects on Natural frequency of Simply Supported Square Plate due to concentrated masses and Circular Cutout

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November,2014

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An Undergraduate thesis submitted to the department of Mechanical & Chemical engineering of Islamic University of Technology, Board Bazar, Gazipur in partial fulfillment of the requirements for the degree

OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

CANDIDATES DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma

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Dedicated

To

Our Beloved Parents

**ACKNOWLEDGEMENT**

We are grateful to Almighty Allah (Subhanahu-Tala) who made it possible for us to finish the project successfully on time and without any trouble.

Firstly, we would like to express our sincerest appreciation and profound gratitude to our supervisor **DR. MD. ZAHID HOSSAIN**, Professor, Mechanical and Chemical Engineering Department, IUT, for his supervision, encouragement and guidance. It has been privilege for us, working with somebody with such ingenuity, integrity, experience and wittiness.

We would like to thank Md. Shahriar Islam, Lecturer, IUT for his help and insight. We would like to thank the following instructors who provided invaluable collaborative support and made our time at IUT Machine Workshop, exciting, fun and productive.

In particular Md. Matiar Rahman, senior operator, Md. Rajaul Karim, operator (Machine shop). Special thanks to Md Rakibul Hasan (mechanics lab) for his useful suggestions and availability whenever needed.

We would also like to convey gratitude to all other faculty members of the Department for their valuable advice in every stage for successful completion of this project. Their Teaching helped us a lot to start and complete this thesis work.

Of course, any errors are ours alone. We seek excuses if there is any mistake found in this report.

# ABSTRACT

In any operation performed by machine on any structure vibration may occur. This vibration can be devastating when the frequency matches with the natural frequency of that structure. Due to resonance the structure can be failed permanently. So it is always desired to reduce the vibration of the structure or maintain a low level. The natural frequency of a simply supported square plate can be modified by making cutout in the plate or by placing concentrated mass on the plate. In this project, our aim is to devise a way of predicting natural frequency for a simply supported square plate. To do that, we analyze vibration characteristics of a simply supported square plate by using ANSYS MECHANICAL APDL 14.0. Vibration characteristics is investigated by analyzing modal and harmonic analysis for the simply supported square plate. Then the analysis is done due to presence of cutout and concentrated mass. The position of cutout and concentrated masses are also an important factor for the vibration characteristics of the plate. By changing the position of cutout and concentrated masses our investigation is also performed.

# Contents

# CHAPTER 1 : INTRODUCTION

## 1.1 PLATE VIBRATION:

Study of vibration of plates is an extremely important area owing to its wide variety of engineering applications such as in aeronautical, civil, and mechanical engineering. Since the members, viz., beams, plates, and shells, form integral parts of structures, it is essential for a design engineer to have a prior knowledge of the first few modes of vibration characteristics before finalizing the design of a given structure. In particular, plates with different shapes, boundary conditions at edges and various complicating effects have often found applications in different structures such as aerospace, machine design, telephone industries, nuclear reactor technology, naval structures, and earthquake-resistant structures. A plate may be defined as a solid body bounded by two parallel plates, flat surfaces having two dimensions far greater than the third. The vibration of plates is an old topic in which a lot of work has already been done in the past decades. In earlier periods, results were computed for simple cases only where the analytical solution could be found. The lack of good computational facilities made it almost impossible to get reasonable accurate results even in these simple cases. This may be the causes for why in spite of a lot of theoretical developments; numerical results were available only for a few cases. By the aid of fast and efficient algorithms complex plate vibration problems can be solved in a very short time and give comparatively accurate results. Methods like finite element methods, boundary integral equation methods, finite difference methods, and the methods of weighted residuals have made handling any shape and any type of boundary conditions possible. This analysis mainly focuses on numerical analysis. In numerical analysis ANSYS (Mechanical APDL 14.0) was used to find the natural frequencies and extract the mode shapes and to observe the response under external loading (Harmonic analysis) with and without spring-damper. By varying the spring and damper it has been tried to find a suitable means of reducing vibration.

## 1.2 IMPORTANCE OF PLATE VIBRATION

Most human activities involve vibration in one form or other. Most prime have vibration problems due inherent unbalance in the engines. In turbines, vibration cause drastic mechanical failures. Plates are the most commonly used element in mechanical structures and machines such as aircrafts, ships and submarines. In designing a structure, plates are usually specified only to withstand applied static loads. However, this is inadequate for more accurate applications. Dynamic forces and random cyclic loads also threaten the stability of a system. There exist a large number of discrete frequencies at which a rectangular plate will undergo large amplitude vibration by sustained time varying forces of matching frequencies. Thus, the possibility of large displacement and stresses due to this recent type of excitation must be taken into account. By predicting the salient frequencies in which the vibration is maximum for specific plate structure active and appropriate measures, like passive and active methods can be installed adequately in response to the working range of the structure. When resonance occur the deflection of the structure is excessive and it can lead to devastating failures which can incur excessive cost to repair or replace. So it's of great concern to study the structure beforehand and avoid such havoc. Hence vibration analysis of plate is imperative in today's structure designs.

## 1.3 LITERATURE REVIEW

In the recent past, it has been observed that the research in the field of vibration is unceasingly accruing immense importance in the modern science, due to the significant role in every field of applied sciences. As fundamental structural elements, plates of various geometries are widely used in various engineering fields such as, aerospace technology, missile technology, naval ship design and telephone industry etc. Due to the appropriate variation of plate thickness, these plates provide the advantage of reduction in weight and size, and also have significantly greater efficiency for vibrations as compared to the plate of uniform thickness. Thus the vibration characteristics of plates having variable thickness have attracted the interest of researchers.

Amba-Rao analyzed the vibration of a simply supported rectangular plate carrying a concentrated mass using a Fourier sine transform Amba-Rao [1]. Magrab investigated the vibration of a rectangular plate carrying a concentrated mass with two edges supported and the remaining edges either clamped or free. Several other authors discussed and investigated different methods to analyze the linear and non-linear vibration of plates with different geometry and boundary conditions [3-6]. Several work on the effect of spring mass system in the middle and other positions on a plate have been done by some author ,among them recently Ding Zhou [7] analyzed free vibration of rectangular plate with concentrating on the continuously distributed spring mass system. Some papers studied the free vibration of rectangular plates with elastic/rigid concentrated masses by using different methods such as the exact solution [9-10], the optimal Rayleigh-Ritz method [11] and the mode expansion method [12]. McMillan and Keane investigated the possibility of using attached masses to control the vibration of rectangular plates [13-14].

Incredible amount of research has been carried out on the free vibration of plates under various boundary conditions and various shapes of cutout by different analytical method. Moon Kyu applied the Independent Coordinate Coupling Method (ICCM) for a rectangular plate with a circular cutout and verified the results with finite element method [21]. Paramasivam used the finite difference plate with a rectangular hole by the classical Rayleigh-Ritz method [22]. Takahashi used the classical Rayleigh-Ritz method after deriving the total energy by subtracting the energy of the hole from the energy of the whole plate [8]. Lee and Kimcarried out vibration experiments on the rectangular plates with a hole in air and water [18]. Pickett analyzed the vibration behavior of plates with holes [16]. G. Aksu and R. Ali determined the dynamic characteristic of plates with cutouts using Finite Difference Method [17].Kwak, M. K. & Han, S. B. presented a new method of Independent Coordinate Coupling Method (ICCM) for the free vibration analysis of a rectangular plate with a rectangular or a circular hole [19].This method utilizes independent coordinates for the global and local domains and the transformation matrix between the local and global coordinates .In the Rayleigh-Ritz method, the effect of the hole can be considered by the subtraction of the energy for the hole domain in deriving the total energy.

# CHAPTER 2

# BASIC OF VIBRATION

## 2.1 VIBRATION

Vibration is the mechanical oscillation of a particle, member, or a body from its position of equilibrium. It is the study that relates the motion of physical bodies to the forces acting on them. The basic concepts in the mechanics of vibration are space, time, and mass (or forces). When a body is disturbed from its position, then by the elastic property of the material of the body, it tries to come back to its initial position. In general, we may see and feel that nearly everything vibrates in Nature; vibrations may be sometimes. Very weak for identification. On the other hand, there may be large devastating vibrations that occur because of manmade disasters or natural disasters such as earthquakes, winds, and tsunamis. Natural and human activities always involve vibration in one form or the other. Recently, many investigations have been motivated by the engineering applications of vibration, such as the design of machines, foundations, structures, engines, turbines, and many control systems.

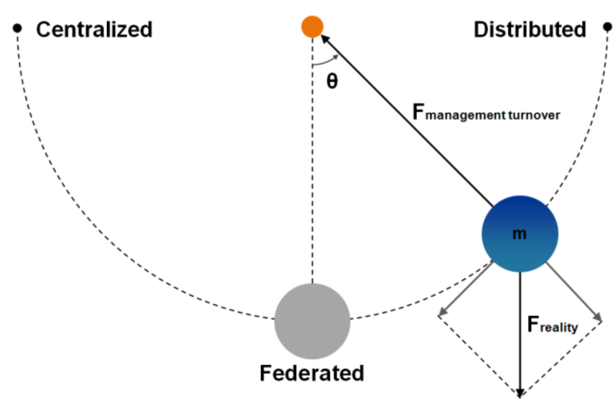



Figure 1:Vibration of a pendulum

## 2.2TYPES OF VIBRATION:

Vibration can be classified in several ways. Some of the important classifications are as follows.

### 2.2.1 FREE VIBRATION AND FORCED VIBRATION

### FREE VIBRATION:

After an initial disturbance, if a system is left to vibrate on its own then it is called free vibration. In free vibration no external force is applied or acted on the system. Oscillation of a simple pendulum is an example of free vibration.

### FORCED VIBRATION:

If a system is subjected to an external force the resulting vibration is known as forced vibration. The oscillation that arises in machine such as diesel engine is an example.

## 2.2.2 LINEAR AND NON LINEAR VIBRATION

### LINEAR VIBRATION:

If all basic components of a vibratory system the spring, the mass and the damper- behave linearly, the resulting vibration is known as the linear vibration. If the vibration is linear then the principle of superposition holds.

### NON LINEAR VIBRATION:

If any of the basic components of vibration behave nonlinearly then the vibration is called nonlinear vibration. For linear vibration the principle of superposition is not valid.

## 2.3 CAUSES OF VIBRATION

The main causes of vibration are as follows:

- Unequal distribution of forces in a moving or rotating machinery
- External forces like wind, tides, blasts, or earthquakes
- Friction between two bodies
- Change of magnetic or electric fields
- Movement of vehicles, etc.

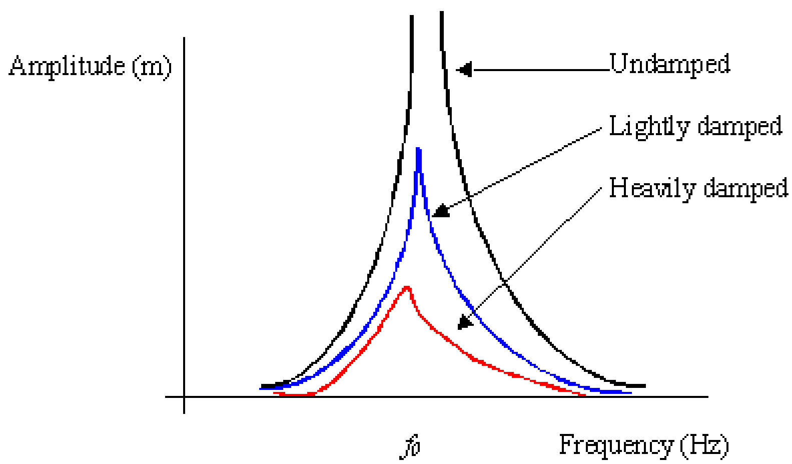
## 2.4 REQUIREMENTS FOR VIBRATION

The main requirements for the vibration are as follows:

- There should be a restoring force.
- The mean position of the body should be in equilibrium.
- There must be inertia (i.e., we must have mass).

## 2.5 RESONANCE

A certain system has more than one natural frequency. If the frequency of the external force coincides with one of the natural frequencies of the system, a condition known as resonance occurs. When resonance happens, the amplitude of vibration will increase without bound and is governed only by the amount of damping present in the system and the system undergoes dangerously large oscillations. Therefore, in order to avoid disastrous effects resulting from very large amplitude of vibration at resonance the natural frequency of a system must be known and properly taken care of. Otherwise failures of such structures as buildings, bridges, turbines and airplane wings maybe occurred.

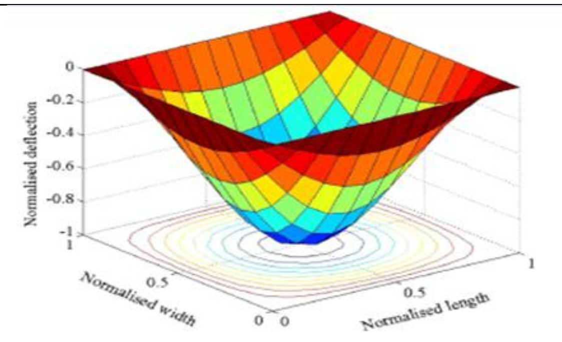
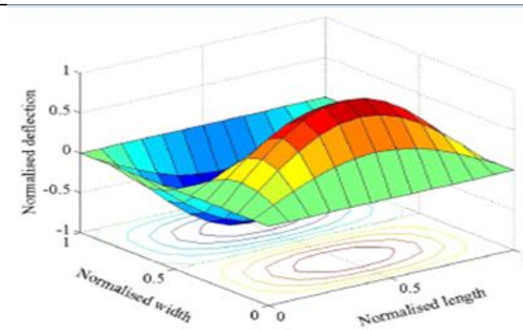
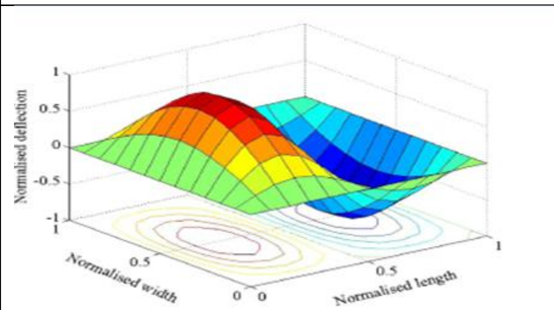


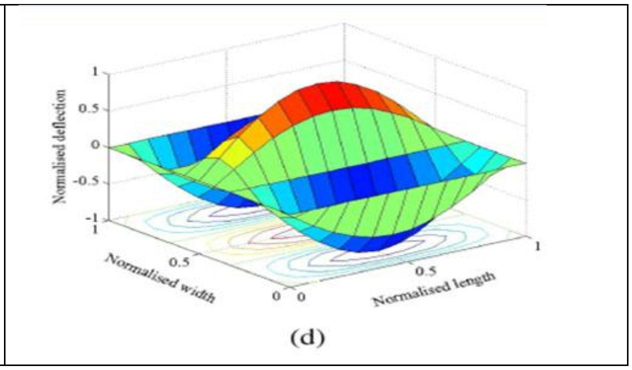

## 2.6 MODAL ANALYSIS:

Modal analysis is a process of obtaining innate dynamic characteristics of a system in the forms of natural frequencies, damping factors and mode shapes and using them to formulate mathematical model for its dynamics behavior. The mathematical model is referred to as the modal mode of the system and the information for the characteristics is known as the modal data. Modal analysis is based upon the fact that the vibration response of the linear time-invariant dynamic system can be expressed as the linear combination of a set of simple harmonic motions called the natural modes of vibration. The natural modes of vibration are inherent to a dynamic system and are determined completely by it physical properties like mass, stiffness, damping and their spatial distribution. Each mode is described by the modal parameters: natural frequency, damping factor and characteristics displacement pattern, which is mode shape. The mode shape corresponds to a natural frequency.

## 2.7 SHAPES OF DIFFERENT MODES:

A normal mode of an oscillating system is a pattern of motion in which all parts of the system move sinusoid ally with the same frequency and with a fixed phase relation. The motion described by the normal modes is called resonance. The frequencies of the normal modes of a system are known as its natural frequencies or resonant frequencies. A physical object, such as a building, bridge or molecule, has a set of normal modes that depend on its structure, materials and boundary conditions.

| | |
|---|---|
| **First Mode:**<br>In the first mode all of the plates move upwards or in the downward simultaneously. | <br>(a) |
| **Second Mode:**<br>In the second mode half of the plate moves upward and the rest of the plate move downward. This upward and downward alters simultaneously. | <br>(b) |
| **Third Mode:**<br>In the third mode half of the plate moves upward and the rest of the plate move downward. This upward and downward alters simultaneously. The difference between 2$^{nd}$ mode and 3$^{rd}$ mode is: they are perpendicular to each other. | <br>(c) |

| Fourth Mode: In the fourth mode the middle of the plates move upward and the rest two parts move downwards. |  |
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# CHAPTER 3:

## NUMERICAL ANALYSIS OF A RECTANGULAR PLATE WITHOUT SPRING-DAMPER USING ANSYS 14.0.

## PROBLEM SPECIFICATION:

| | |
| --- | --- |
| Plate | = MILD STEEL |
| Length | =60cm |
| Width | =60cm |
| Thickness | =2mm |
| Density | = 7850kg/m3 |

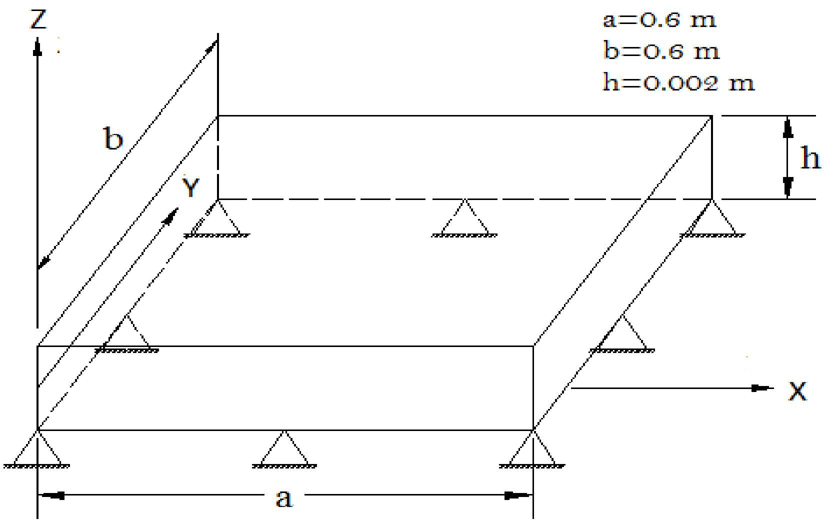




Figure 2:Model Of the Simply supported rectangular plate

We have divided our work on three cases. We have done the analysis based on this three cases.

- Case 1: Analysis of natural frequency and amplitude of the
- Case 2: Analysis of the behavior of vibration of the plate with different cutout and point load.
- Case 3: Behavior of vibration is analyzed in different positions of the plate.

## ANSYS:

ANSYS is engineering simulation software uses FEM to predict system response. Structural mechanics solution from ANSYS provide the ability to simulate every structural aspect of a product, including linear static analysis that simply provides stresses or deformations, modal analysis that determines vibration characteristics; through the advanced transient nonlinear phenomena involving dynamic effects and complex behavior. The ANSYS Mechanical (APDL) software suite is used for both modal and harmonic analysis.

## ANSYS INPUT:

## Modal Analysis:

No of modes to extract: 10

No of modes to expand:10

## NUMERICAL WORK:

The material of the plate was chosen to have the mechanical properties defined by

| | |
|---|---|
| Youngs Modulus | : $210e^{09}Nm^{-2}$ |
| Poisions Ratio | : 0.3 |
| Density | : $7850kg/m^3$ |

The element used for 3-D modeling of solid structures is SOLID 185. It is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, stress stiffening, creep, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials.

# BUILDING THE MODEL IN MECHANICAL APDL:

## Plate with concentrated mass:

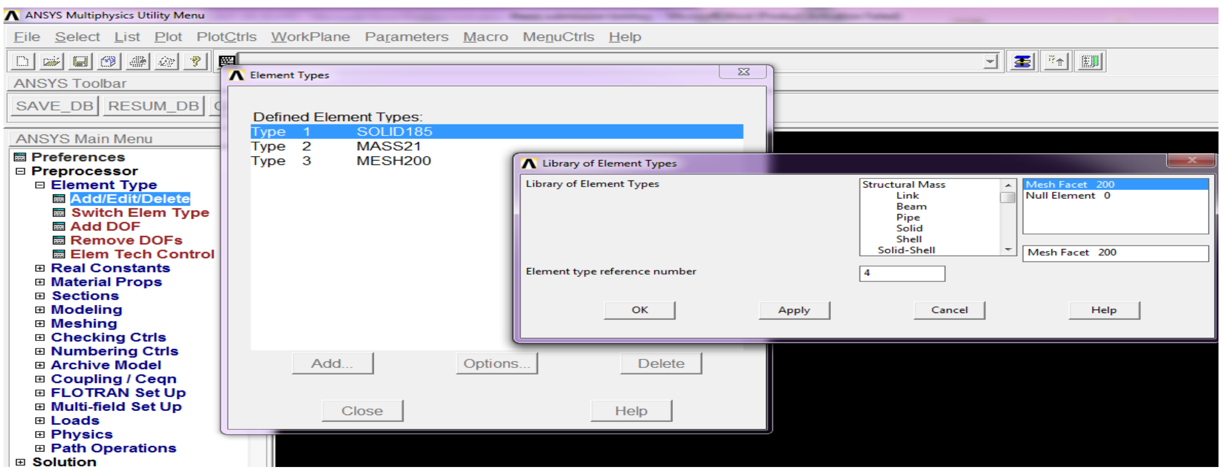
The steps followed in ANSYS APDL14, are given bellow:

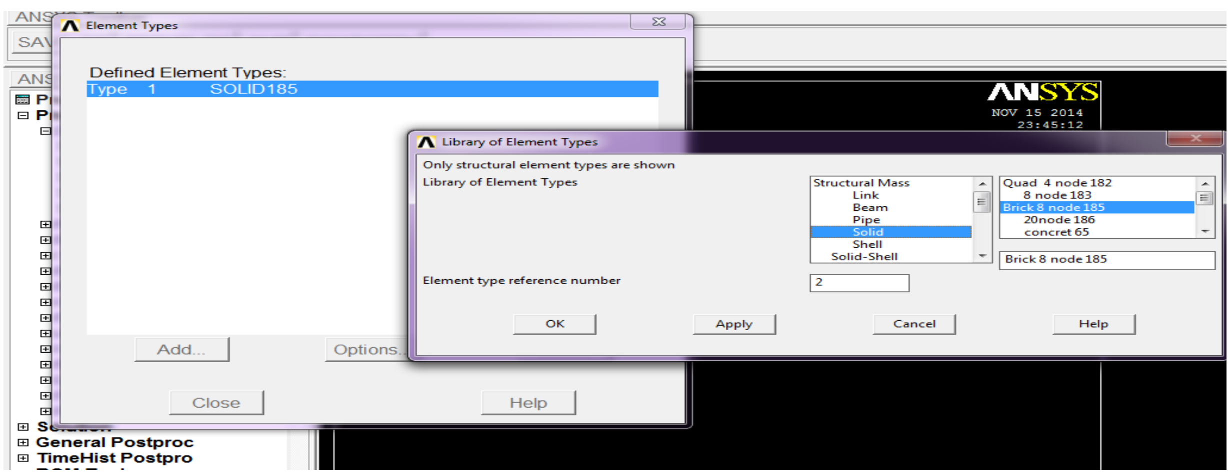
GUI>Preferences>Structural

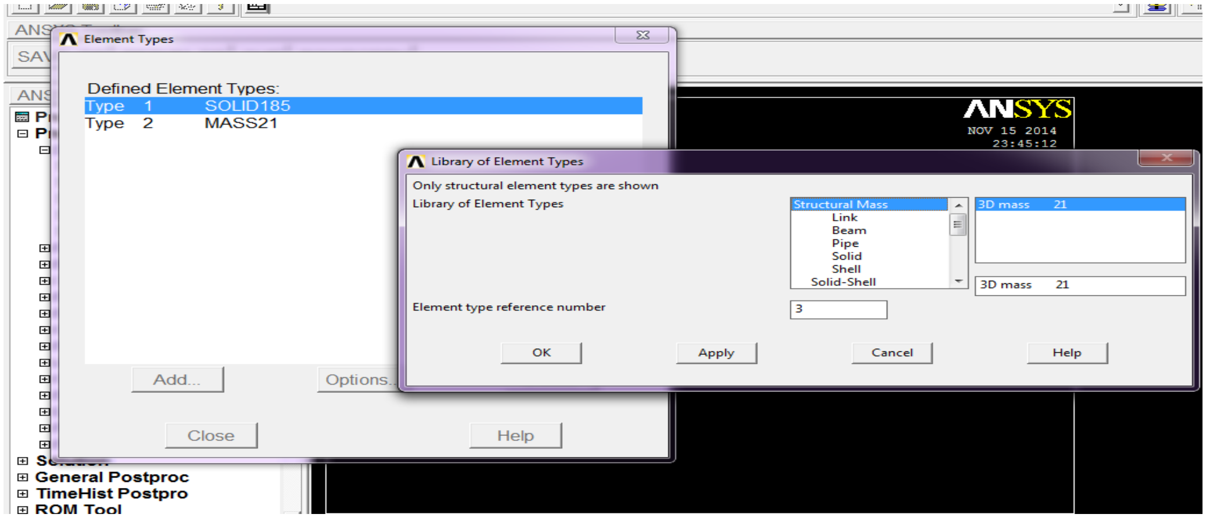
Main Menu>Preprocessor>Element Type>Add/Edit/Delete //select the element//

Add>solid>brick 8 node 185

Add>structural mass>3d mass21




Element Types
Defined Element Types:
Type 1 SOLID185
Type 2 MASS21
Library of Element Types
Only structural element types are shown
Library of Element Types
Structural Mass
Link
Beam
Pipe
Solid
Shell
Solid-Shell
3D mass 21
3D mass 21
Element type reference number
3
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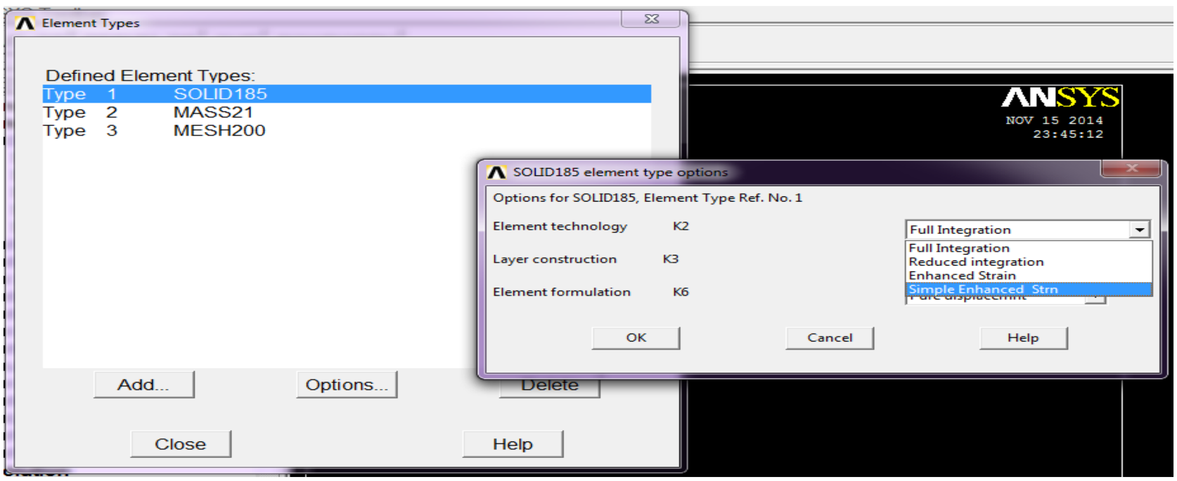
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Type 1 SOLID185
Type 2 MASS21
Type 3 MESH200
SOLID185 element type options
Options for SOLID185, Element Type Ref. No. 1
Element technology K2
Layer construction K3
Element formulation K6
Full Integration
Full Integration
Reduced integration
Enhanced Strain
Simple Enhanced Strn
OK
Cancel
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Add...
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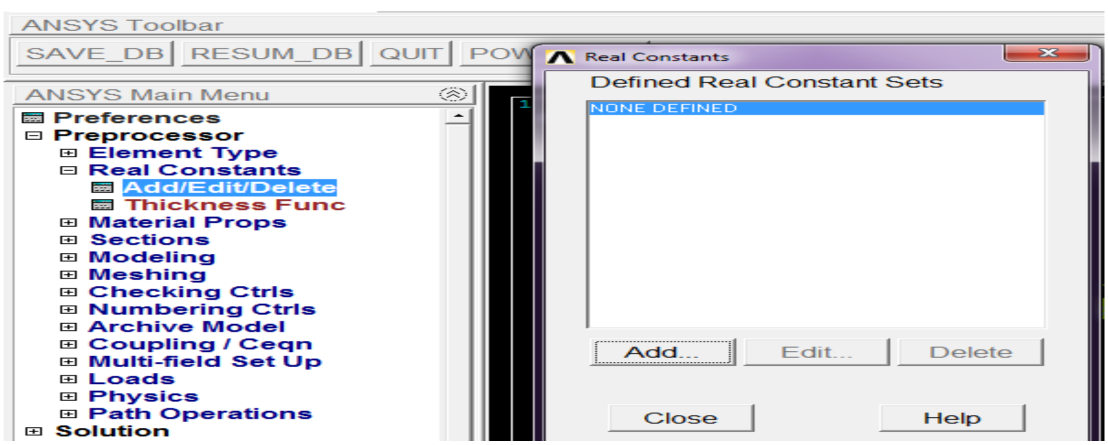
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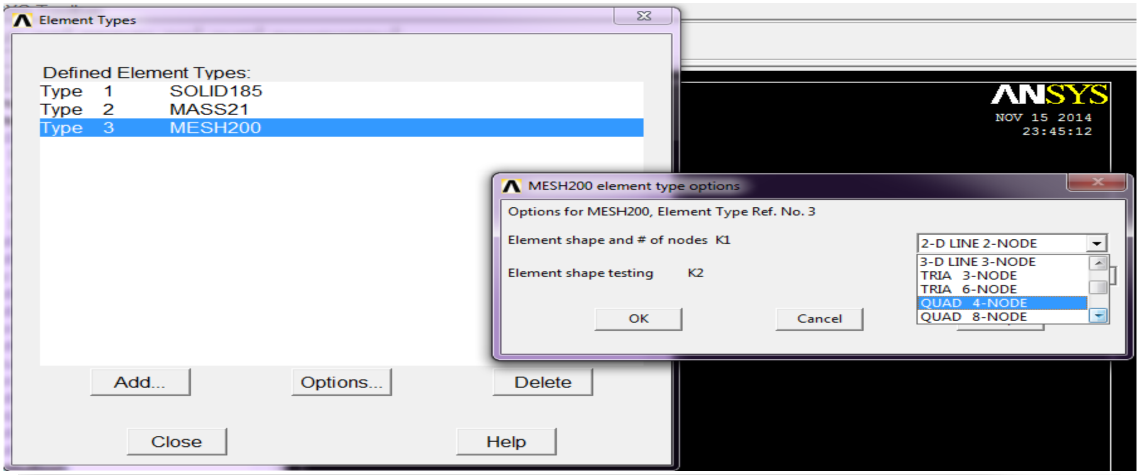
Element Types
Defined Element Types:
Type 1 SOLID185
Type 2 MASS21
Type 3 MESH200
Add...
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Help
ANSYS
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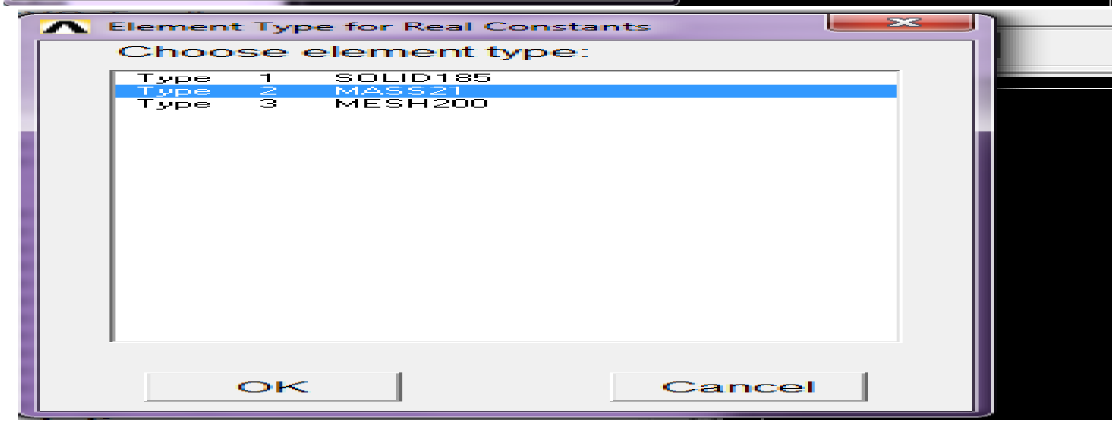
23:45:12
MESH200 element type options
Options for MESH200, Element Type Ref. No. 3
Element shape and # of nodes K1
Element shape testing K2
2-D LINE 2-NODE
3-D LINE 3-NODE
TRIA 3-NODE
TRIA 6-NODE
QUAD 4-NODE
QUAD 8-NODE
OK
Cancel


Element Type for Real Constants
Choose element type:
Type 1 SOLID185
Type 2 MASS21
Type 3 MESH200
OK
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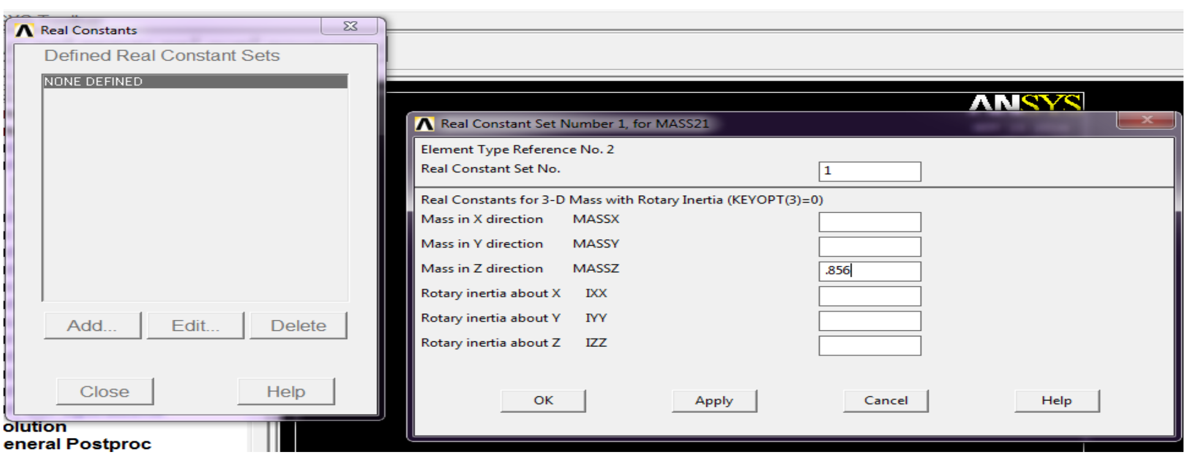
Real Constants
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Real Constant Set Number 1, for MASS21
Element Type Reference No. 2
Real Constant Set No.
1
Real Constants for 3-D Mass with Rotary Inertia (KEYOPT(3)=0)
Mass in X direction MASSX
Mass in Y direction MASSY
Mass in Z direction MASSZ
.856
Rotary inertia about X IXX
Rotary inertia about Y IYY
Rotary inertia about Z IZZ
OK
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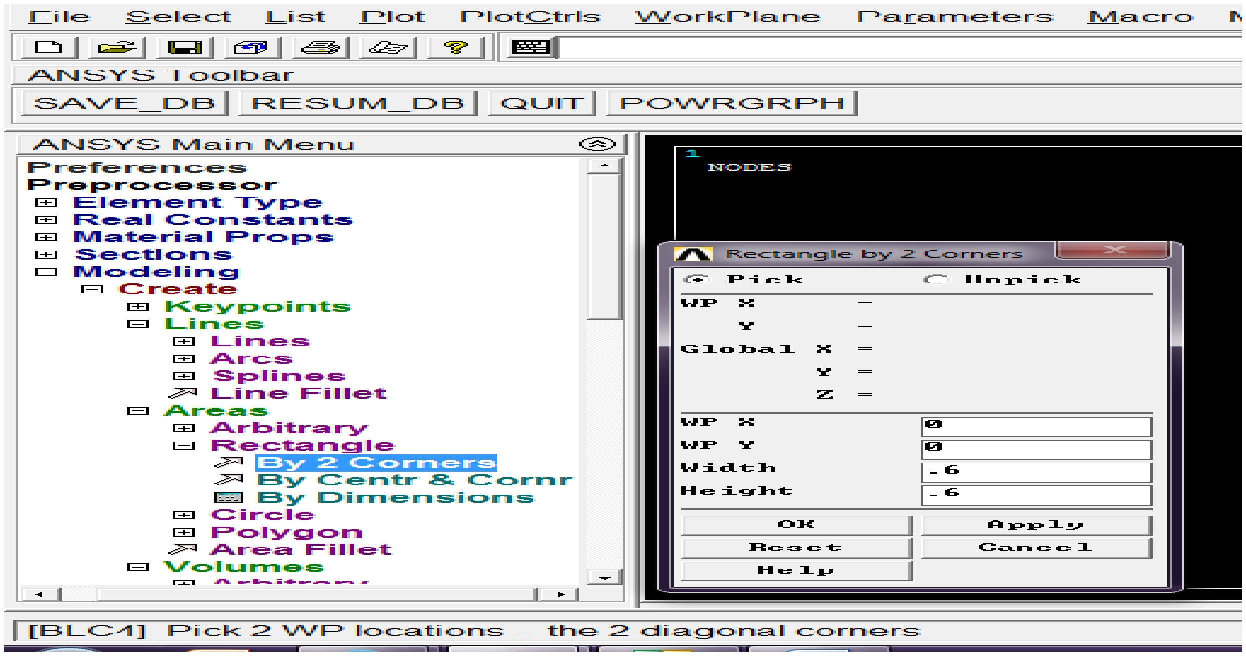
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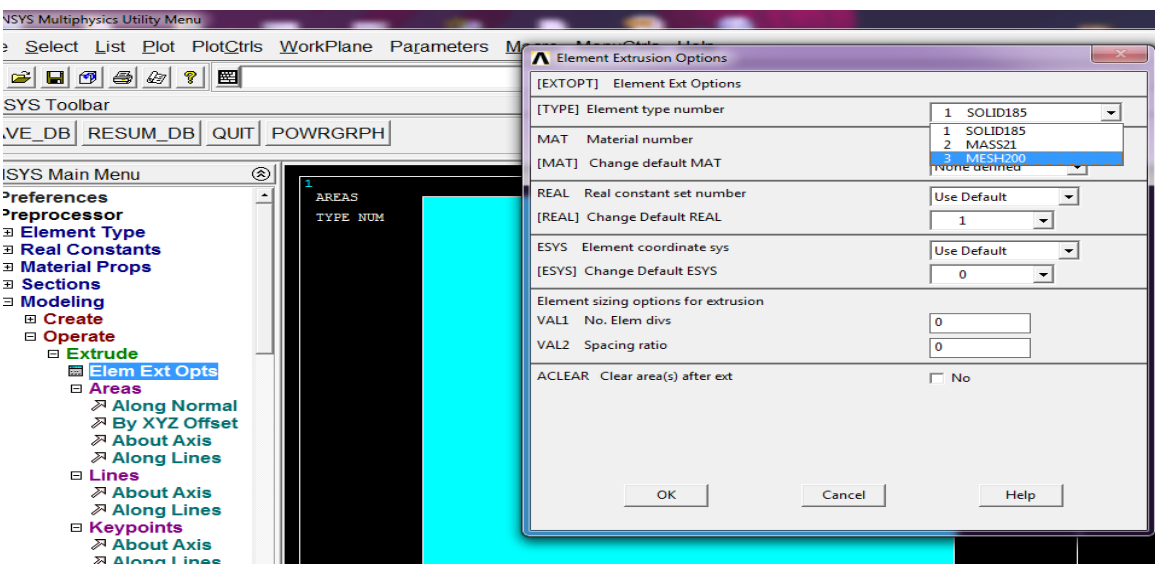
By Centr & Cornr
By Dimensions
Circle
Polygon
Area Fillet
Volumes
NODES
Rectangle by 2 Corners
Pick
Unpick
WP X =
Y =
Global X =
Y =
Z =
WP X 0
WP Y 0
Width .6
Height .6
OK
Apply
Reset
Cancel
Help
[BLC4] Pick 2 WP locations -- the 2 diagonal corners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About Axis
Along Lines
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AREAS
TYPE NUM
Element Extrusion Options
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[TYPE] Element type number
1 SOLID185
1 SOLID185
2 MASS21
3 MESH200
MAT Material number
[MAT] Change default MAT
REAL Real constant set number
Use Default
[REAL] Change Default REAL
1
ESYS Element coordinate sys
Use Default
[ESYS] Change Default ESYS
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VAL2 Spacing ratio
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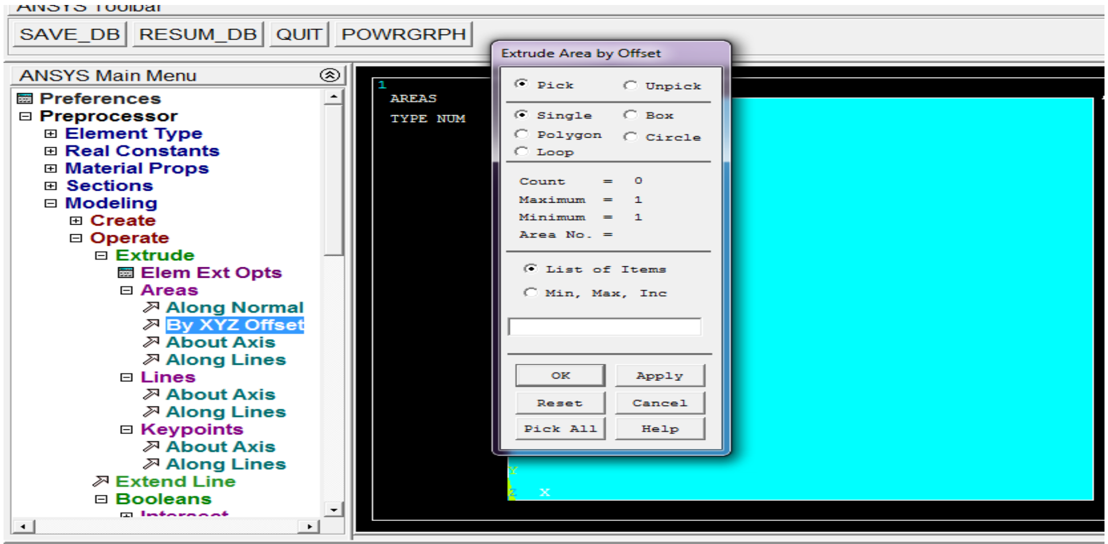
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Single
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Minimum = 1
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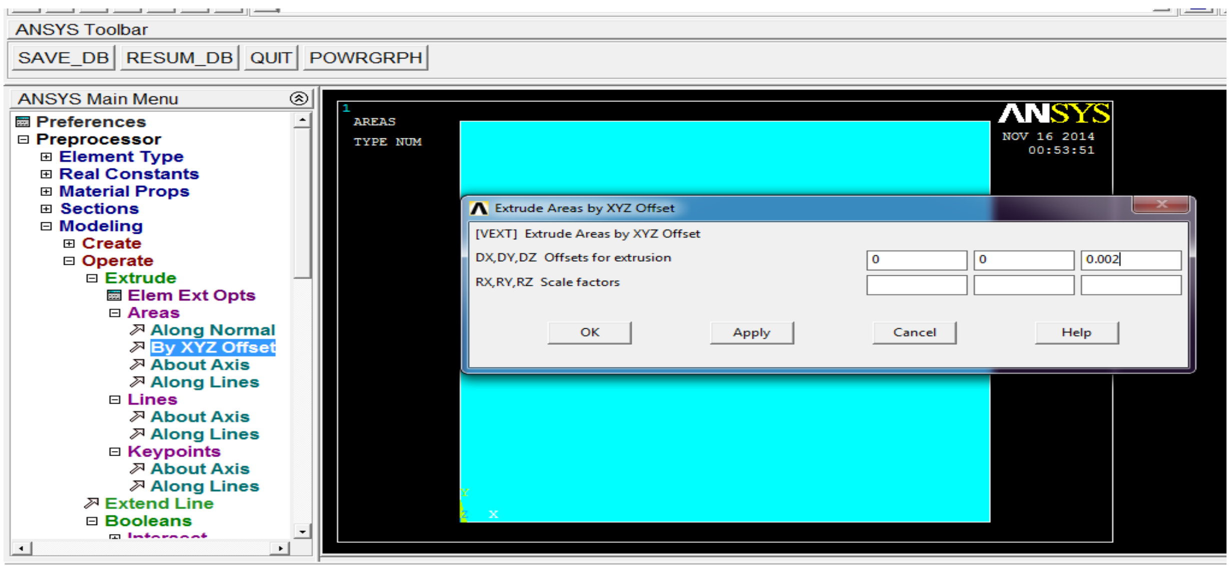
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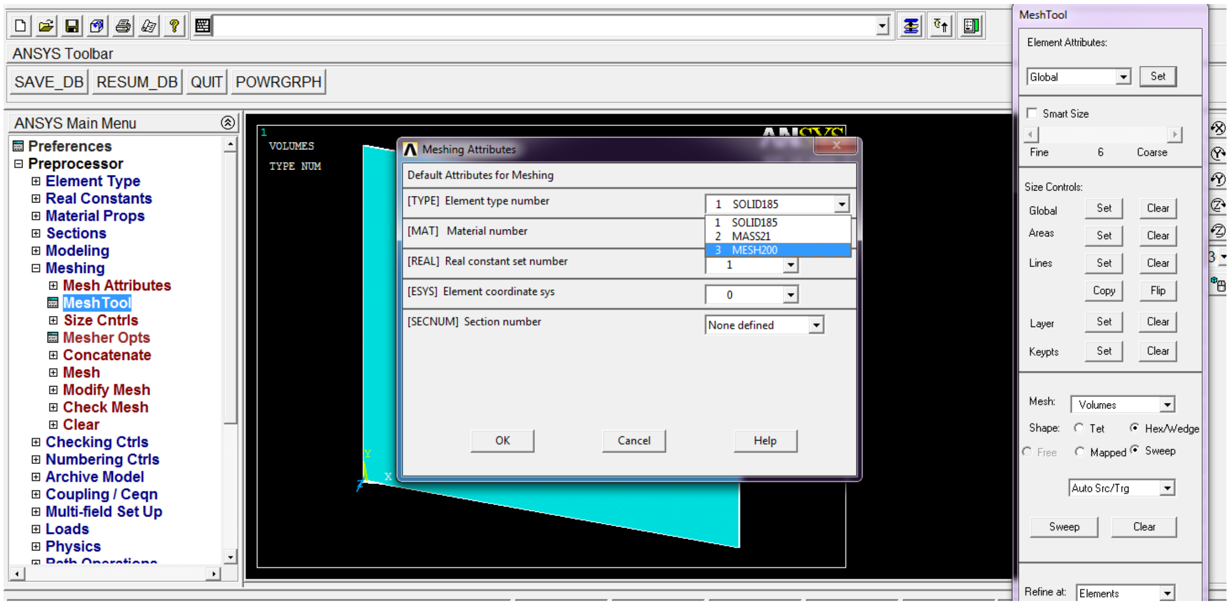
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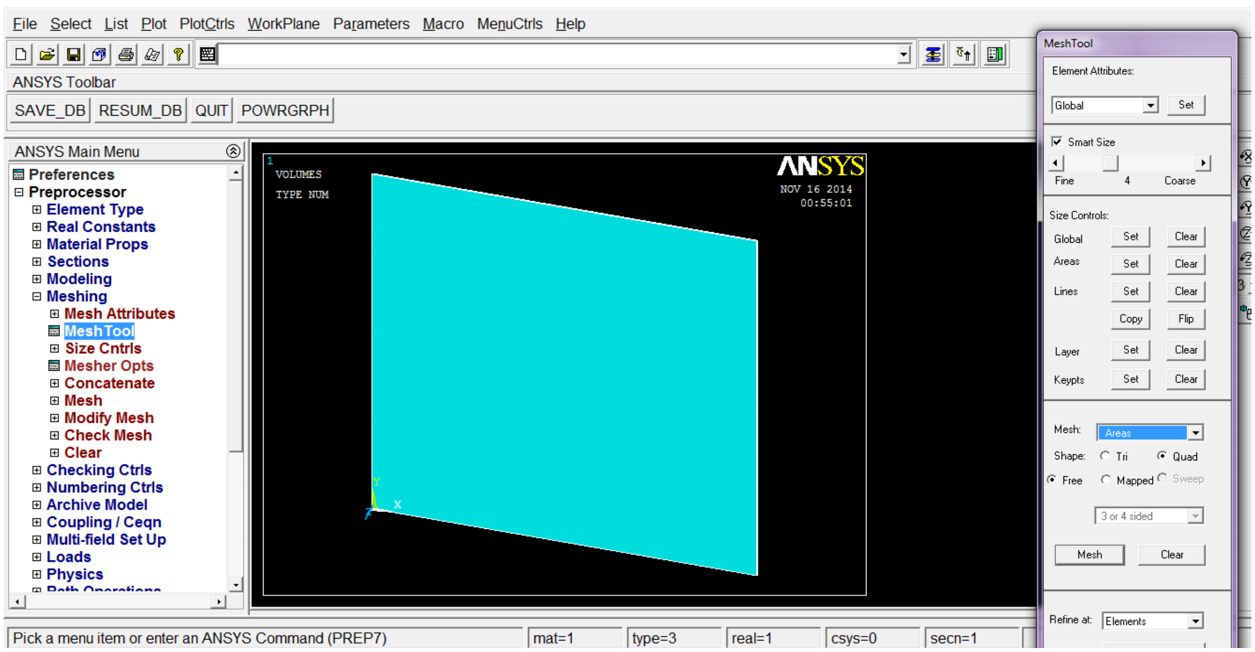
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
VOLUMES
TYPE NUM
Meshing Attributes
Default Attributes for Meshing
[TYPE] Element type number
1 SOLID185
1 SOLID185
2 MASS21
3 MESH200
[MAT] Material number
[REAL] Real constant set number
1
[ESYS] Element coordinate sys
0
[SECNUM] Section number
None defined
OK
Cancel
Help
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
6
Coarse
Size Controls:
Global
Areas
Lines
Layer
Keypts
Set
Clear
Copy
Flip
Mesh:
Volumes
Shape:
Tet
Hex/Wedge
Free
Mapped
Sweep
Auto Src/Trg
Sweep
Clear
Refine at:
Elements


File
Select
List
Plot
PlotCtrls
WorkPlane
Parameters
Macro
MenuCtrls
Help
ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
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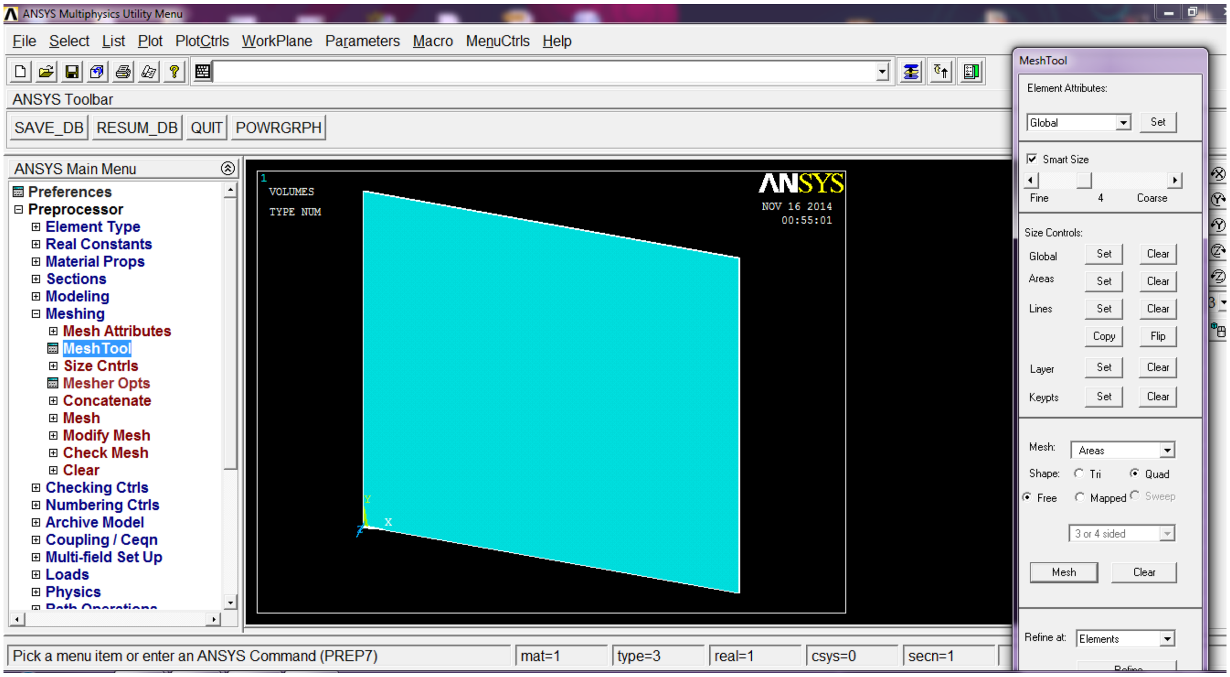
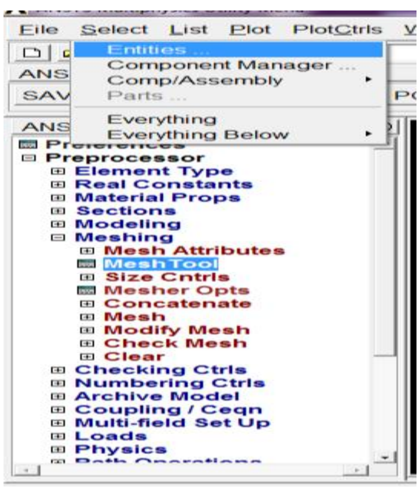
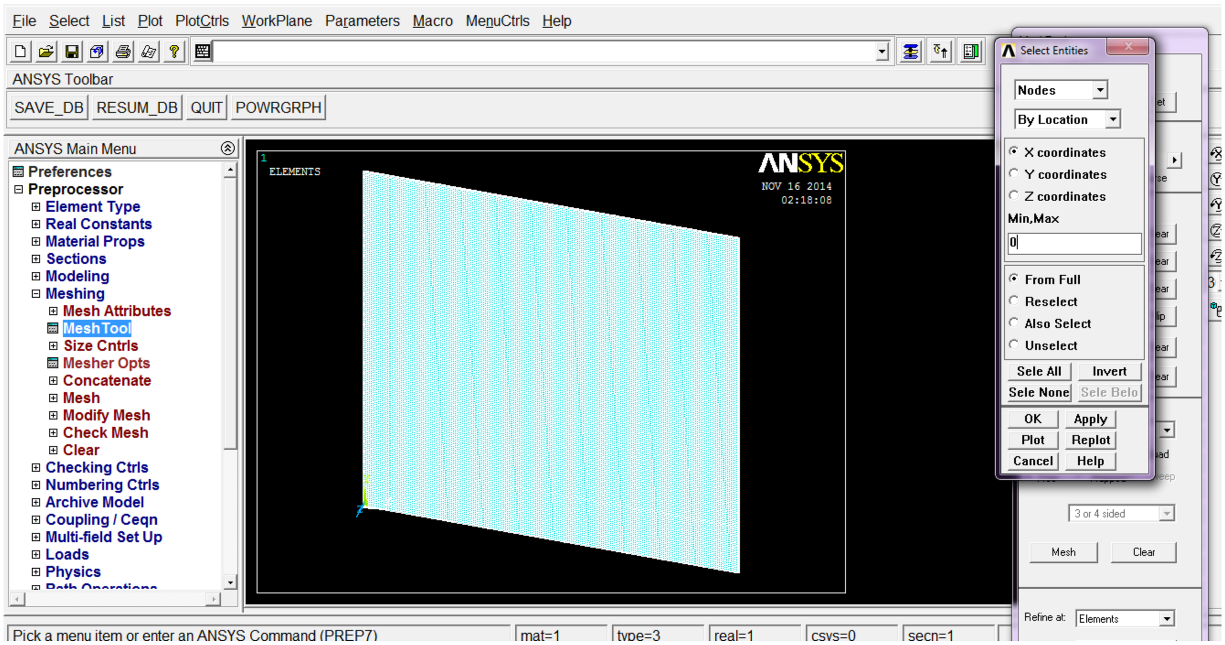
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
VOLUMES
TYPE NUM
ANSYS
NOV 16 2014
00:55:01
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
4
Coarse
Size Controls:
Global
Areas
Lines
Layer
Keypts
Set
Clear
Copy
Flip
Mesh:
Areas
Shape:
Tri
Quad
Free
Mapped
Sweep
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=3
real=1
csys=0
secn=1




Apply constraints to the model. Constraints will be applied to all nodes according to the end condition. Select all nodes at x =0, then apply the displacement constraints. In the same way the nodes at the other end are also selected and constraints are applied.


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
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Preprocessor
Element Type
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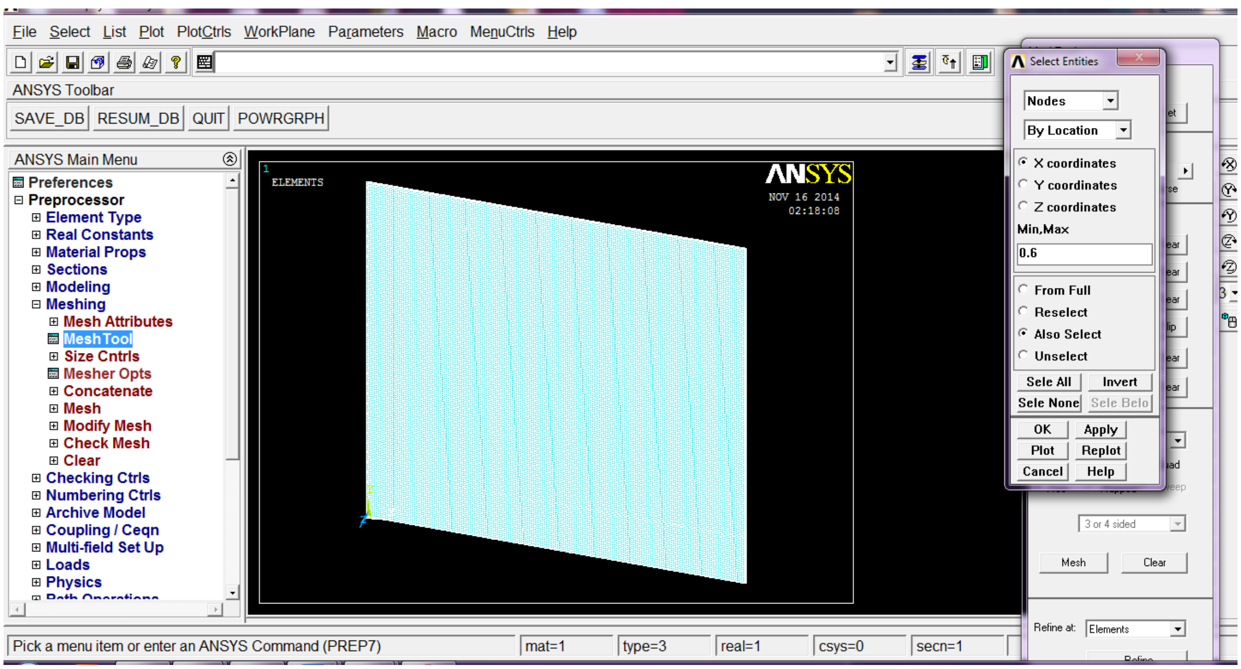
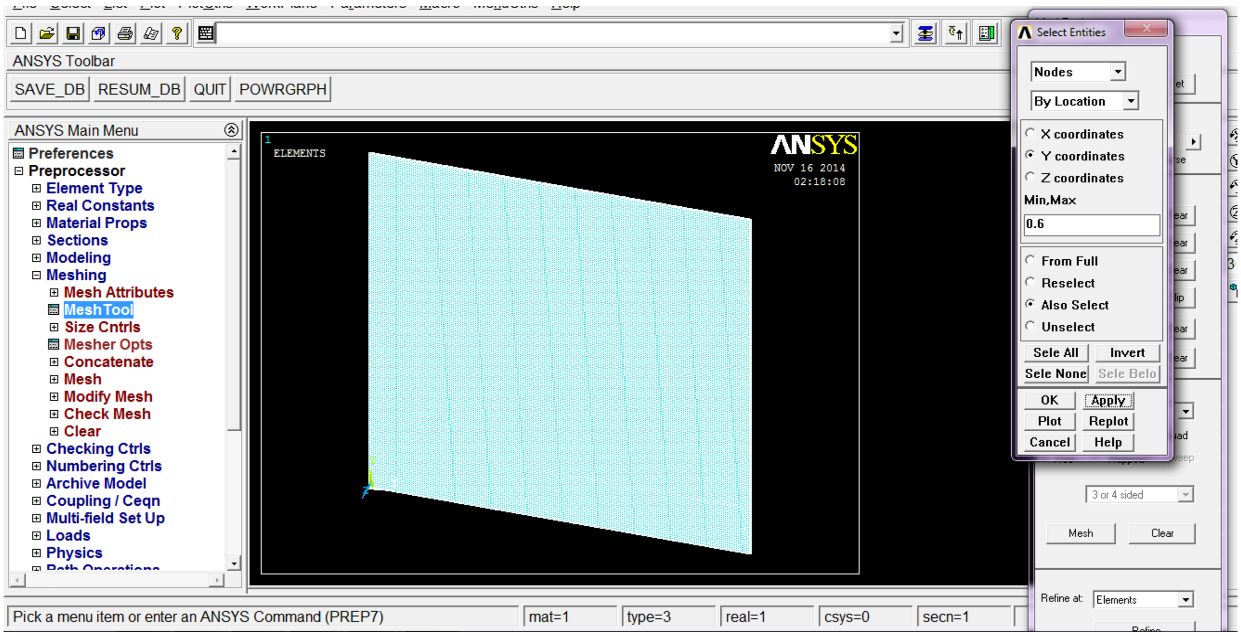
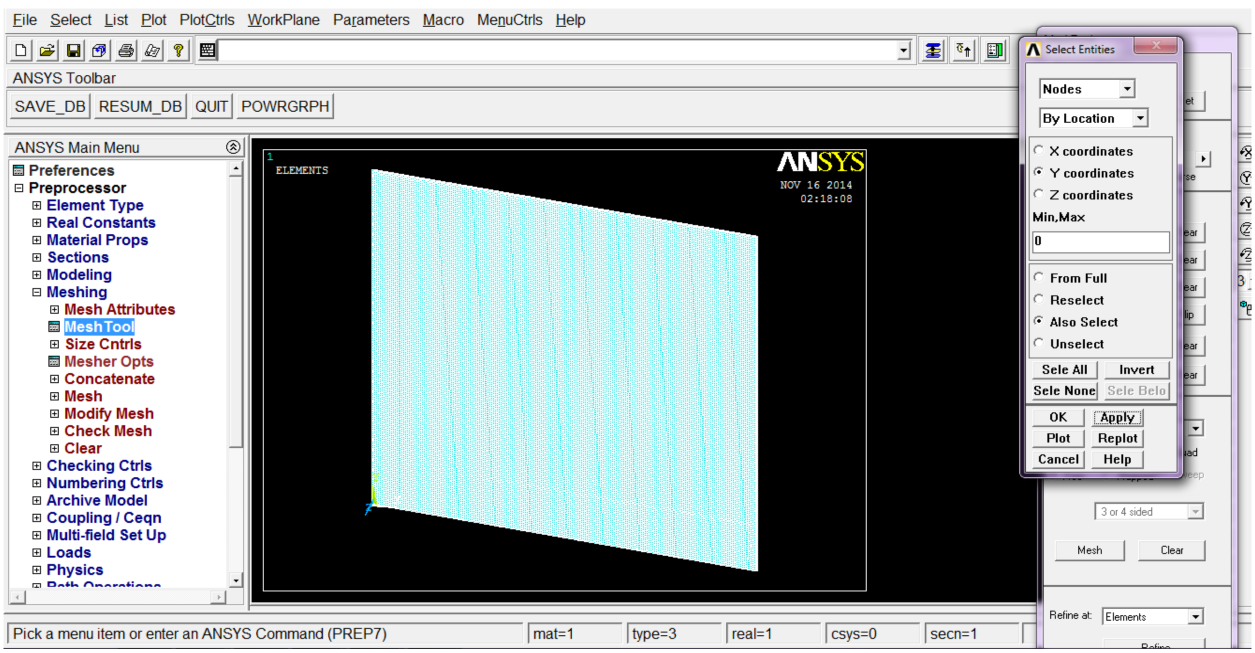
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
ELEMENTS
ANSYS
NOV 16 2014
02:18:08
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=3
real=1
csys=0
secn=1


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
ELEMENTS
ANSYS
NOV 16 2014
02:18:08
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0.6
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=3
real=1
csys=0
secn=1


ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
ELEMENTS
ANSYS
NOV 16 2014
02:18:08
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0.6
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=3
real=1
csys=0
secn=1


File
Select
List
Plot
PlotCtrls
WorkPlane
Parameters
Macro
MenuCtrls
Help
ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
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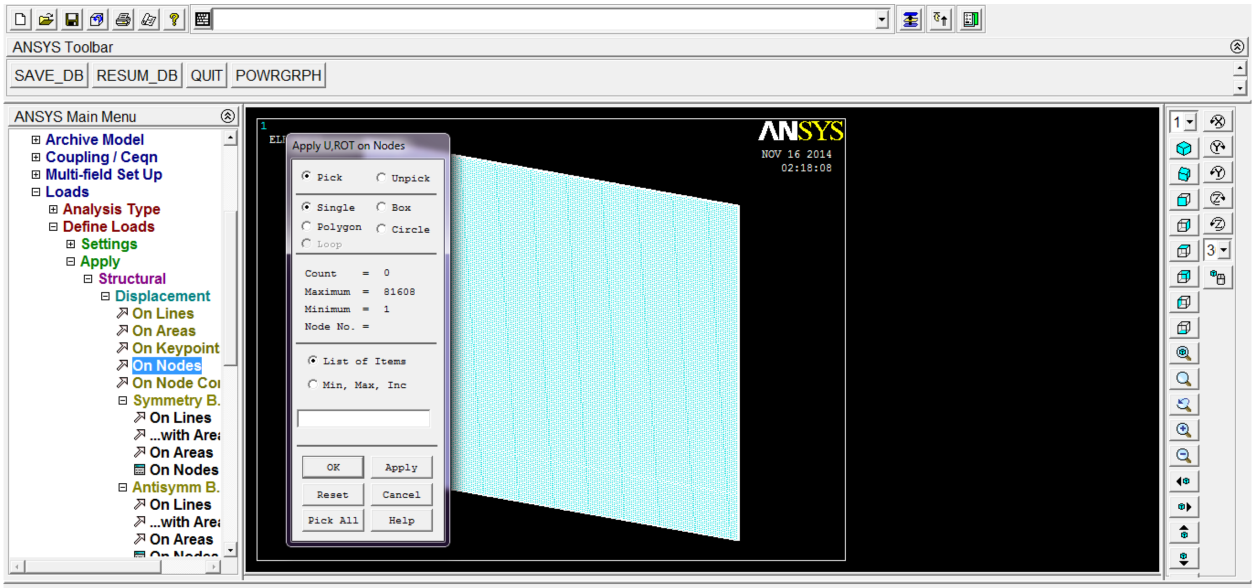
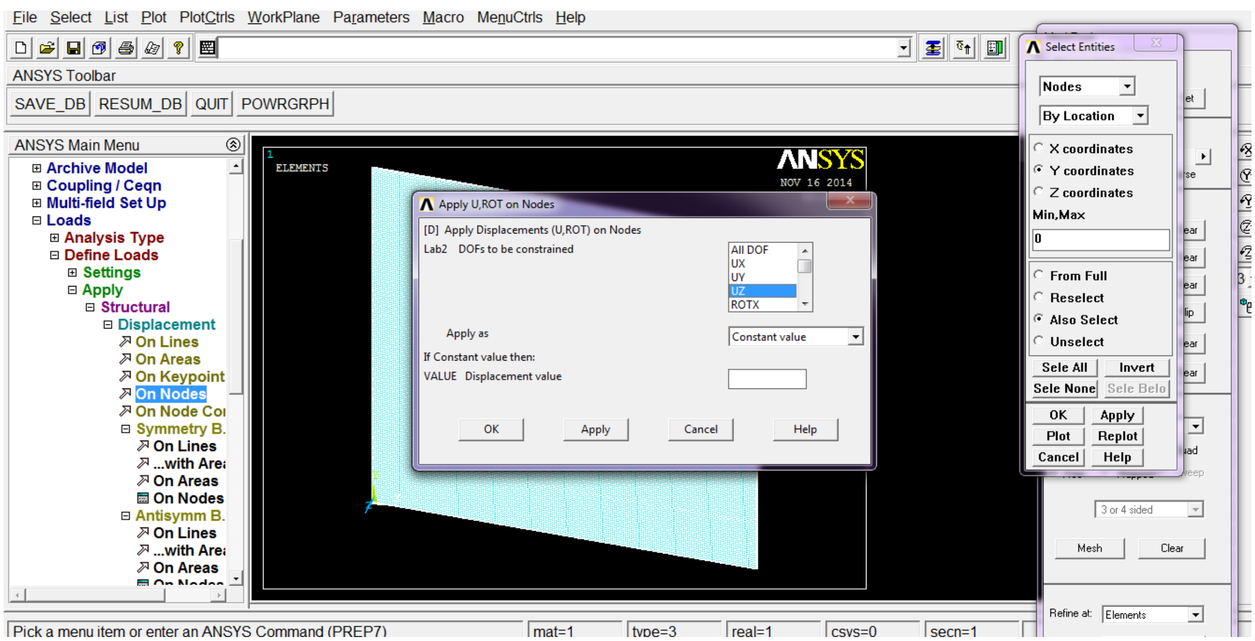
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
ELEMENTS
ANSYS
NOV 16 2014
02:18:08
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=3
real=1
csys=0
secn=1



ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Analysis Type
Define Loads
Settings
Apply
Structural
Displacement
On Lines
On Areas
On Keypoint
On Nodes
Symmetry B.
On Lines
...with Area
On Areas
On Nodes
Antisymm B.
On Lines
...with Area
On Areas
Apply U,ROT on Nodes
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 0
Maximum = 81608
Minimum = 1
Node No. =
List of Items
Min, Max, Inc
OK
Apply
Reset
Cancel
Pick All
Help
ANSYS
NOV 16 2014
02:18:08

File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Archive Model
Coupling / Ceqn
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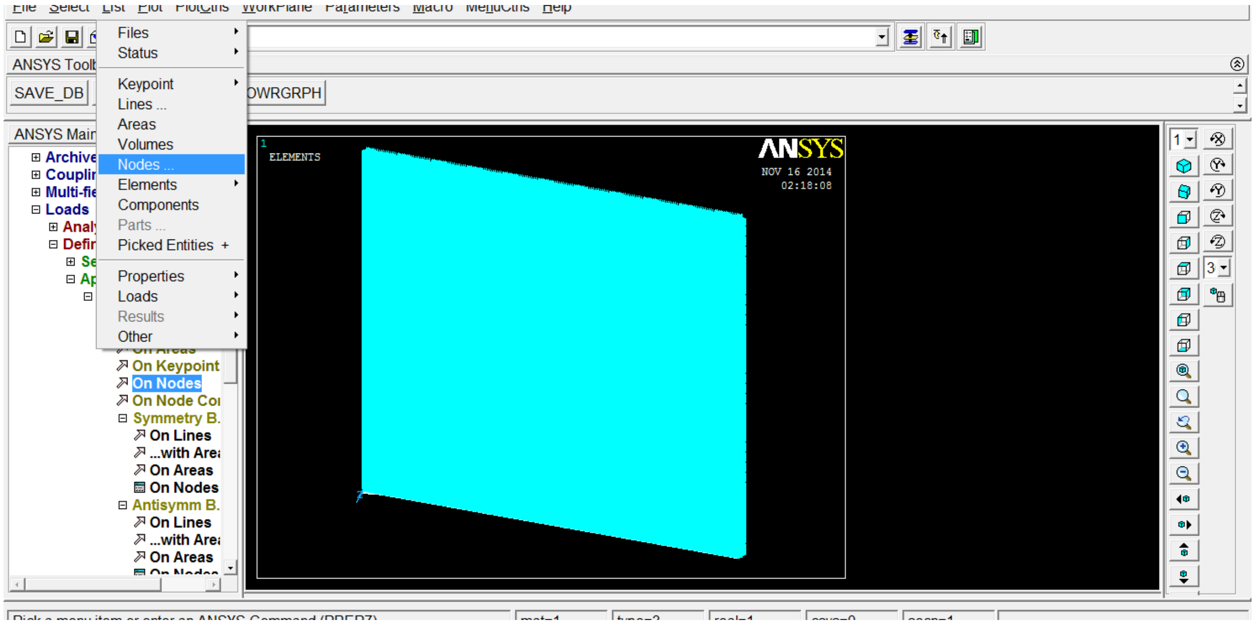
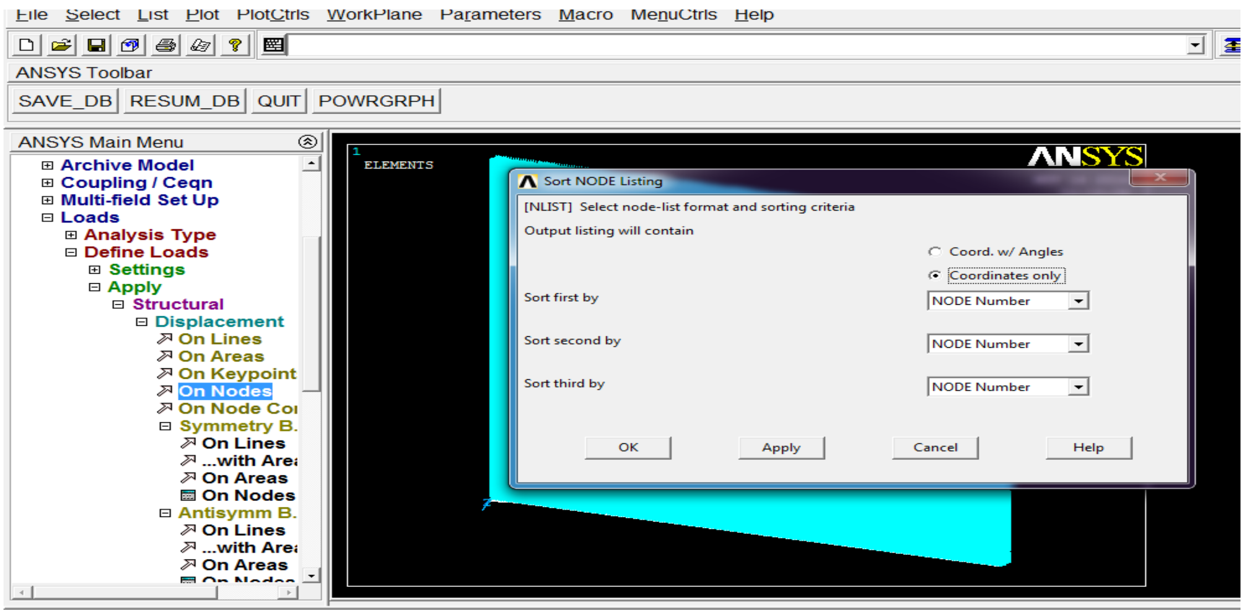
Loads
Analysis Type
Define Loads
Settings
Apply
Structural
Displacement
On Lines
On Areas
On Keypoint
On Nodes
Symmetry B.
On Lines
...with Area
On Areas
On Nodes
Antisymm B.
On Lines
...with Area
On Areas
ELEMENTS
ANSYS
NOV 16 2014
Apply U,ROT on Nodes
[D] Apply Displacements (U,ROT) on Nodes
Lab2 DOFs to be constrained
All DOF
UX
UY
UZ
ROTX
Apply as
Constant value
If Constant value then:
VALUE Displacement value
OK
Apply
Cancel
Help
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=3
real=1
csys=0
secn=1


Files
Status
Keypoint
Lines ...
Areas
Volumes
Nodes ...
Elements
Components
Parts ...
Picked Entities +
Properties
Loads
Results
Other
ANSYS Toolbar
SAVE_DB
POWRGRPH
ANSYS Main Menu
Archive
Loads
On Keypoint
On Nodes
On Node Co
Symmetry B.
On Lines
...with Area
On Areas
On Nodes
Antisymm B.
On Lines
...with Area
On Areas
ELEMENTS
ANSYS
NOV 16 2014
02:18:08


File
Select
List
Plot
PlotCtrls
WorkPlane
Parameters
Macro
MenuCtrls
Help
ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
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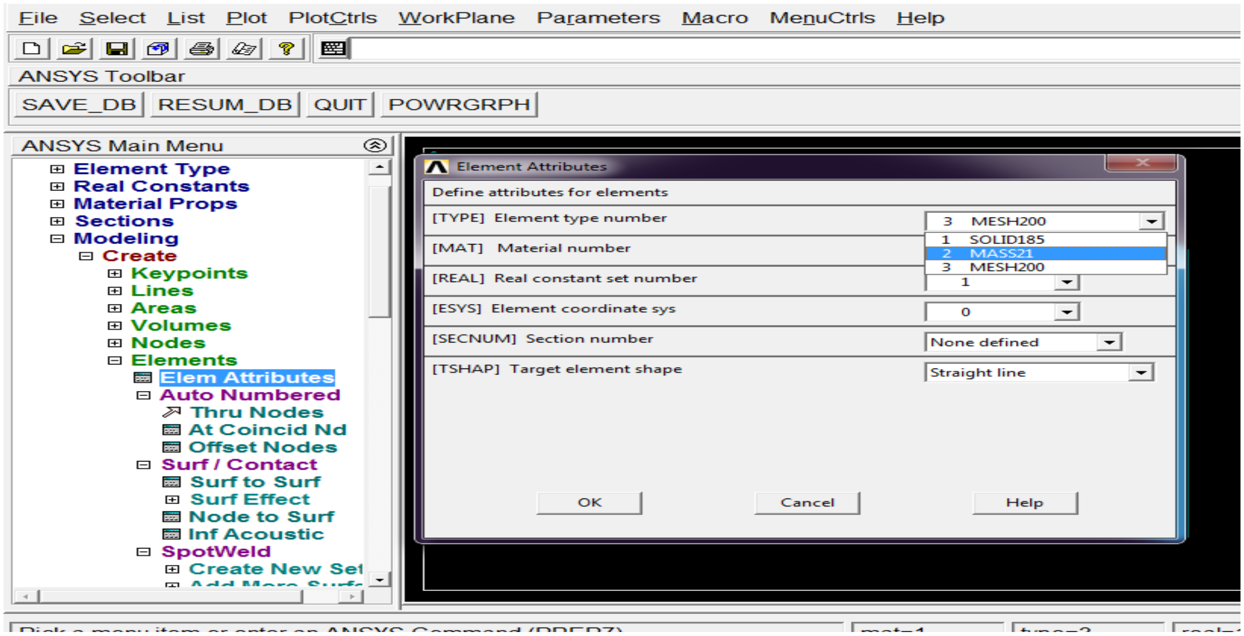
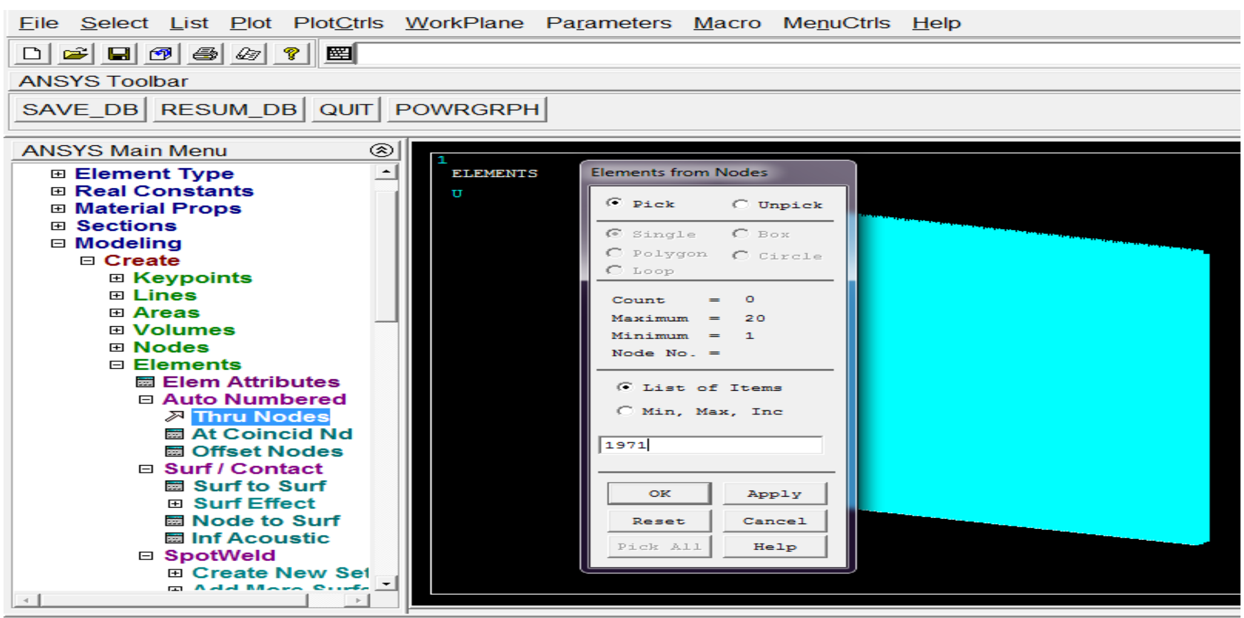
Loads
Analysis Type
Define Loads
Settings
Apply
Structural
Displacement
On Lines
On Areas
On Keypoint
On Nodes
On Node Co
Symmetry B.
On Lines
...with Area
On Areas
On Nodes
Antisymm B.
On Lines
...with Area
On Areas
ELEMENTS
ANSYS
Sort NODE Listing
[NLIST] Select node-list format and sorting criteria
Output listing will contain
Coord. w/ Angles
Coordinates only
Sort first by
NODE Number
Sort second by
NODE Number
Sort third by
NODE Number
OK
Apply
Cancel
Help


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Keypoints
Lines
Areas
Volumes
Nodes
Elements
Elem Attributes
Auto Numbered
Thru Nodes
At Coincid Nd
Offset Nodes
Surf / Contact
Surf to Surf
Surf Effect
Node to Surf
Inf Acoustic
SpotWeld
Create New Set
Element Attributes
Define attributes for elements
[TYPE] Element type number
3 MESH200
1 SOLID185
2 MASS21
3 MESH200
[MAT] Material number
[REAL] Real constant set number
1
[ESYS] Element coordinate sys
0
[SECNUM] Section number
None defined
[TSHAP] Target element shape
Straight line
OK
Cancel
Help


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Element Type
Real Constants
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Keypoints
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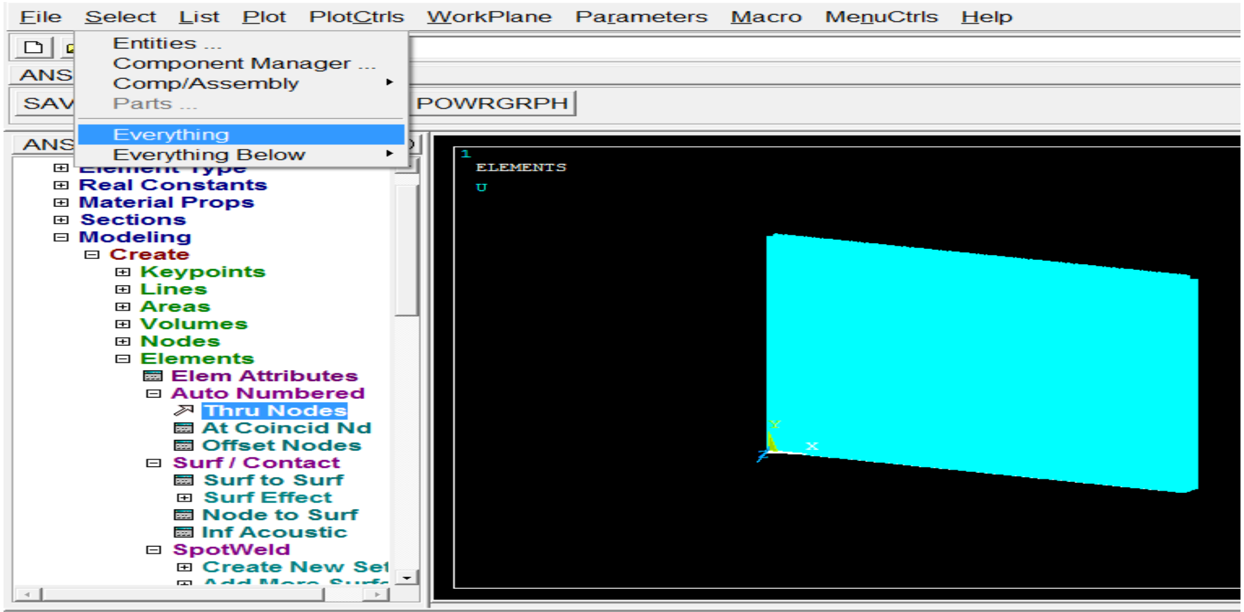
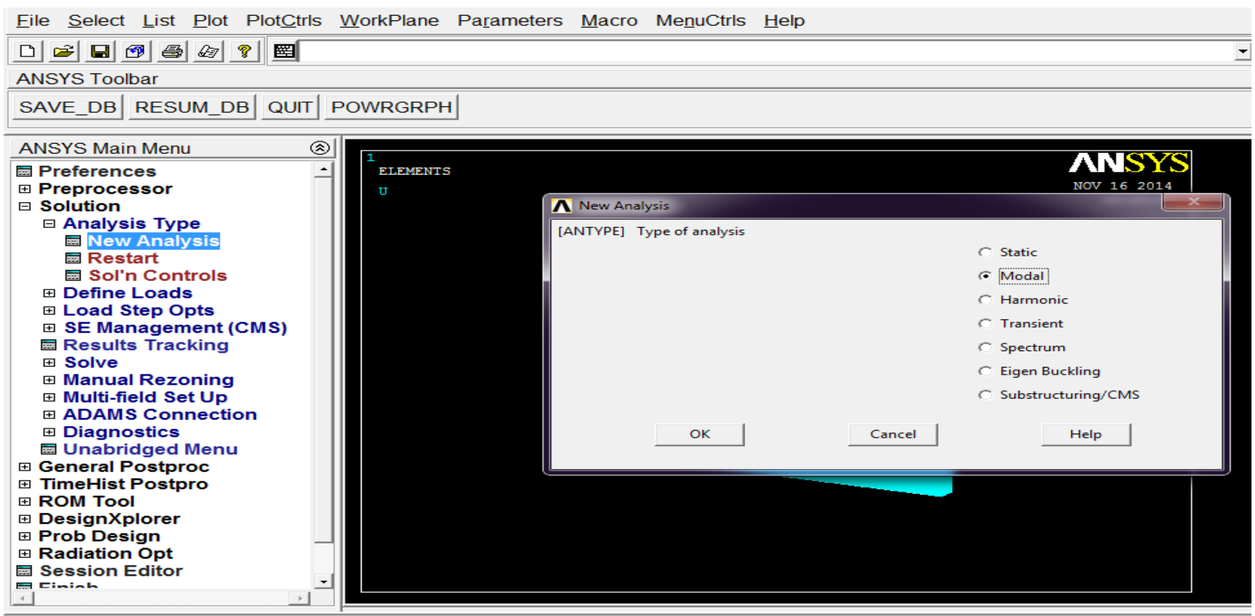
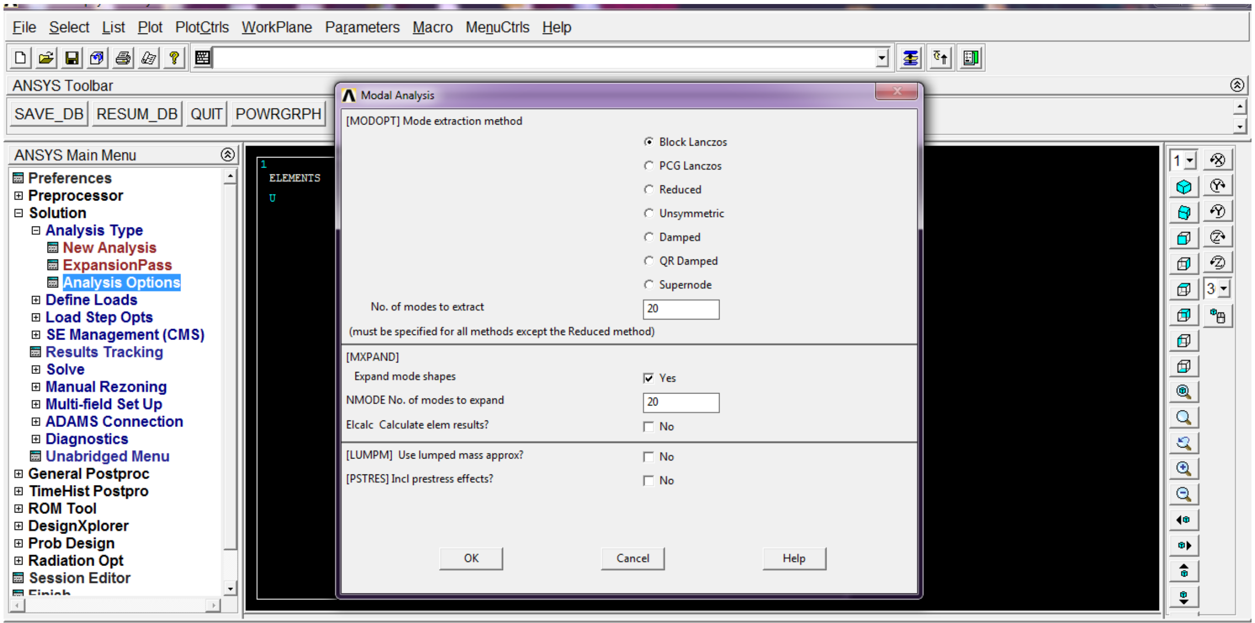
Areas
Volumes
Nodes
Elements
Elem Attributes
Auto Numbered
Thru Nodes
At Coincid Nd
Offset Nodes
Surf / Contact
Surf to Surf
Surf Effect
Node to Surf
Inf Acoustic
SpotWeld
Create New Set
ELEMENTS
U
Elements from Nodes
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 0
Maximum = 20
Minimum = 1
Node No. =
List of Items
Min, Max, Inc
1971
OK
Apply
Reset
Cancel
Pick All
Help


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
Entities ...
Component Manager ...
Comp/Assembly
Parts ...
Everything
Everything Below
POWRGRPH
Real Constants
Material Props
Sections
Modeling
Create
Keypoints
Lines
Areas
Volumes
Nodes
Elements
Elem Attributes
Auto Numbered
Thru Nodes
At Coincid Nd
Offset Nodes
Surf / Contact
Surf to Surf
Surf Effect
Node to Surf
Inf Acoustic
SpotWeld
Create New Set
ELEMENTS


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
New Analysis
Restart
Sol'n Controls
Define Loads
Load Step Opts
SE Management (CMS)
Results Tracking
Solve
Manual Rezoning
Multi-field Set Up
ADAMS Connection
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
ELEMENTS
ANSYS
NOV 16 2014
New Analysis
[ANTYPE] Type of analysis
Static
Modal
Harmonic
Transient
Spectrum
Eigen Buckling
Substructuring/CMS
OK
Cancel
Help


File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
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Solution
Analysis Type
New Analysis
ExpansionPass
Analysis Options
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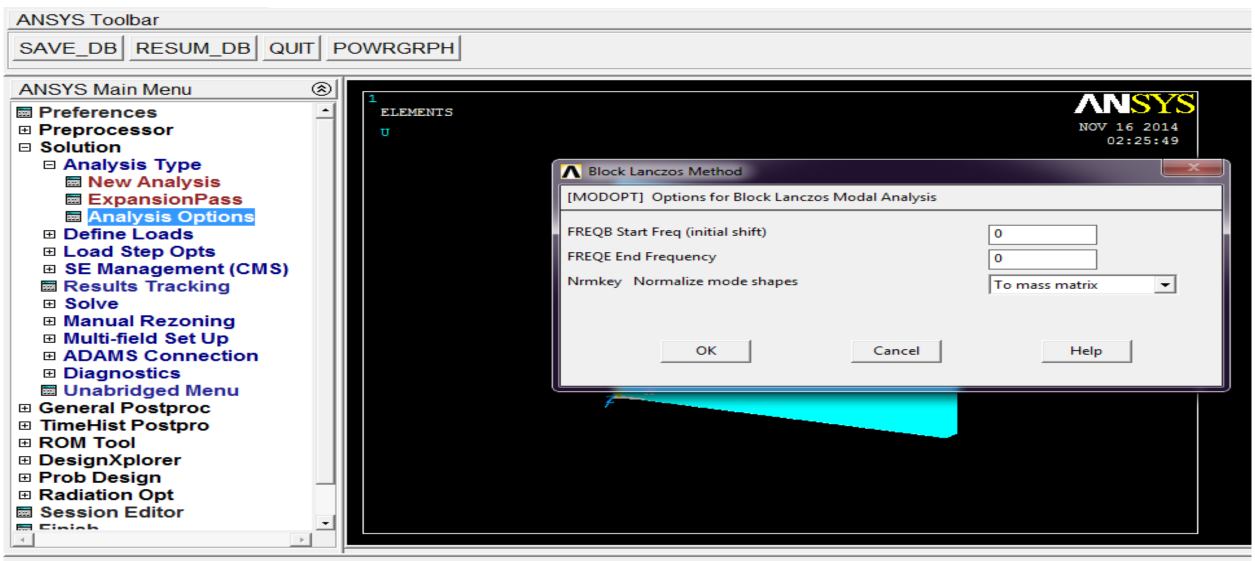
Manual Rezoning
Multi-field Set Up
ADAMS Connection
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
ELEMENTS
Modal Analysis
[MODOPT] Mode extraction method
Block Lanczos
PCG Lanczos
Reduced
Unsymmetric
Damped
QR Damped
Supernode
No. of modes to extract
20
(must be specified for all methods except the Reduced method)
[MXPAND]
Expand mode shapes
Yes
NMODE No. of modes to expand
20
Elcalc Calculate elem results?
No
[LUMPM] Use lumped mass approx?
No
[PSTRES] Incl prestress effects?
No
OK
Cancel
Help


ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
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Analysis Type
New Analysis
ExpansionPass
Analysis Options
Define Loads
Load Step Opts
SE Management (CMS)
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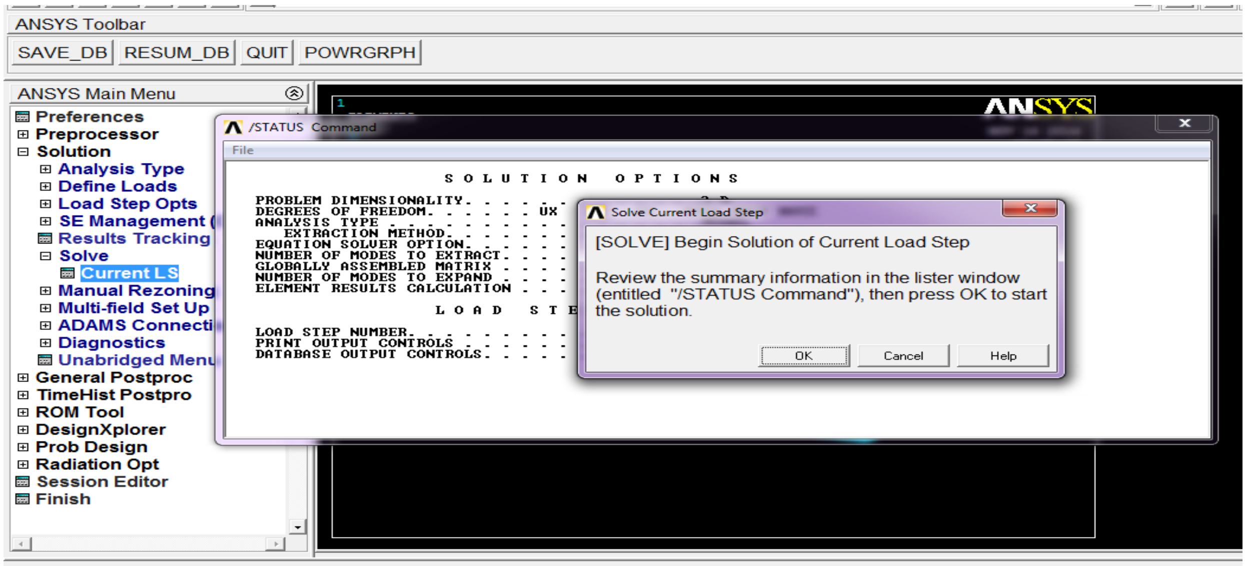
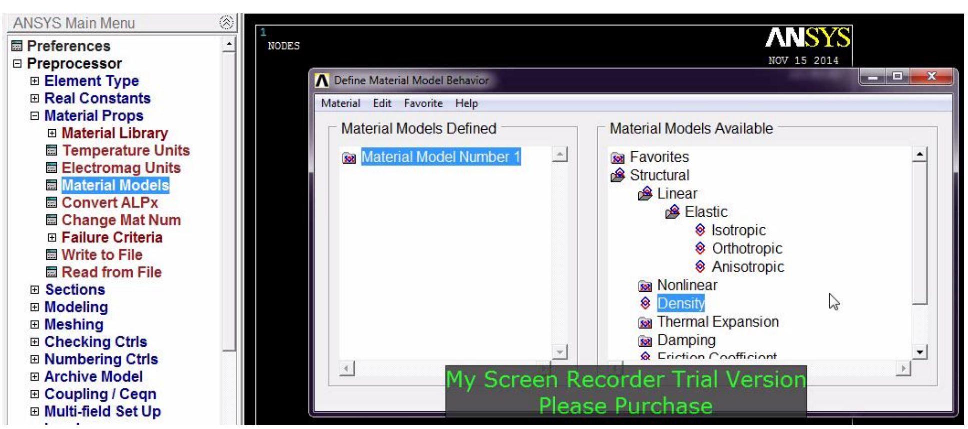
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
ELEMENTS
ANSYS
NOV 16 2014
02:25:49
Block Lanczos Method
[MODOPT] Options for Block Lanczos Modal Analysis
FREQB Start Freq (initial shift)
0
FREQE End Frequency
0
Nrmkey Normalize mode shapes
To mass matrix
OK
Cancel
Help


ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
Define Loads
Load Step Opts
SE Management
Results Tracking
Solve
Current LS
Manual Rezoning
Multi-field Set Up
Diagnostics
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
/STATUS Command
S O L U T I O N   O P T I O N S
Solve Current Load Step
[SOLVE] Begin Solution of Current Load Step
Review the summary information in the lister window (entitled "/STATUS Command"), then press OK to start the solution.
OK
Cancel
Help

## For coutout


ANSYS Main Menu
Preferences
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Element Type
Real Constants
Material Props
Material Library
Temperature Units
Electromag Units
Material Models
Convert ALPx
Change Mat Num
Failure Criteria
Write to File
Read from File
Sections
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Meshing
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
ANSYS
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Define Material Model Behavior
Material Edit Favorite Help
Material Models Defined
Material Model Number 1
Material Models Available
Favorites
Structural
Linear
Elastic
Isotropic
Orthotropic
Anisotropic
Nonlinear
Density
Thermal Expansion
Damping
My Screen Recorder Trial Version
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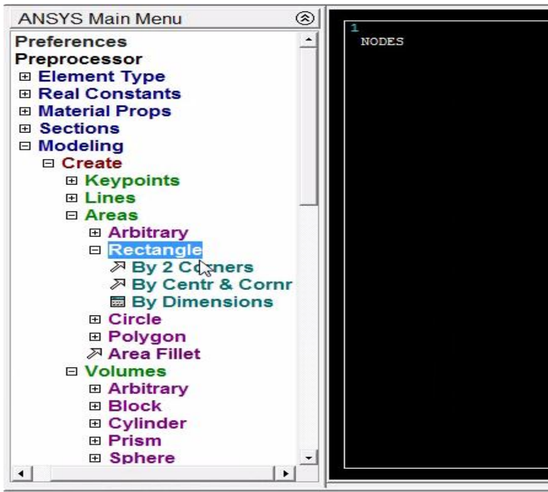
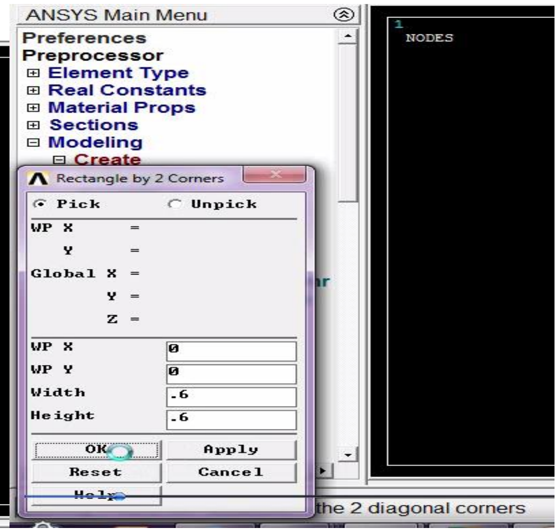
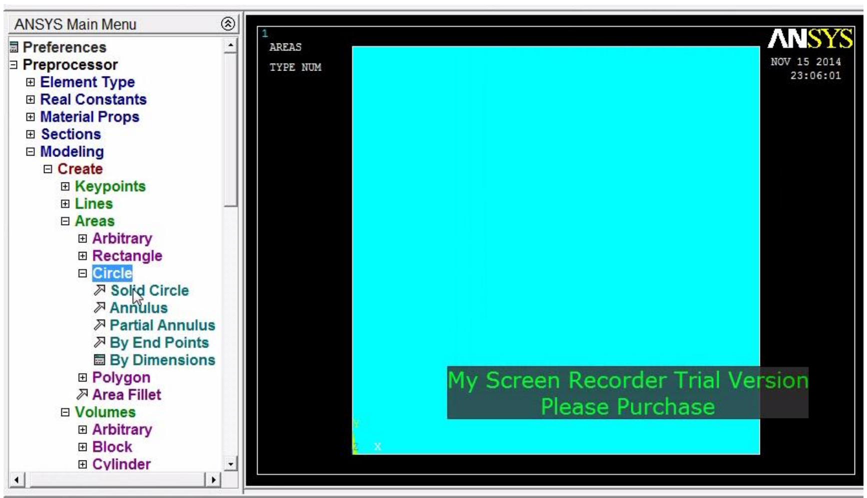

ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Keypoints
Lines
Areas
Arbitrary
Rectangle
By 2 Corners
By Centr & Cornr
By Dimensions
Circle
Polygon
Area Fillet
Volumes
Arbitrary
Block
Cylinder
Prism
Sphere
NODES


ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Rectangle by 2 Corners
Pick
Unpick
WP X =
Y =
Global X =
Y =
Z =
WP X 0
WP Y 0
Width .6
Height .6
OK
Apply
Reset
Cancel
Help
NODES
the 2 diagonal corners


ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Keypoints
Lines
Areas
Arbitrary
Rectangle
Circle
Solid Circle
Annulus
Partial Annulus
By End Points
By Dimensions
Polygon
Area Fillet
Volumes
Arbitrary
Block
Cylinder
AREAS
TYPE NUM
ANSYS
NOV 15 2014
23:06:01
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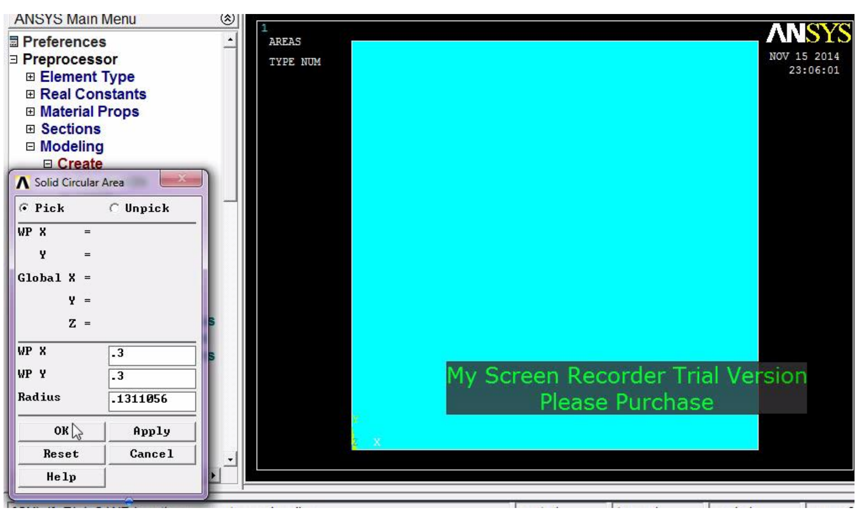
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Solid Circular Area
Pick
Unpick
WP X =
Y =
Global X =
Y =
Z =
WP X .3
WP Y .3
Radius .1311056
OK
Apply
Reset
Cancel
Help
AREAS
TYPE NUM
ANSYS
NOV 15 2014
23:06:01
My Screen Recorder Trial Version
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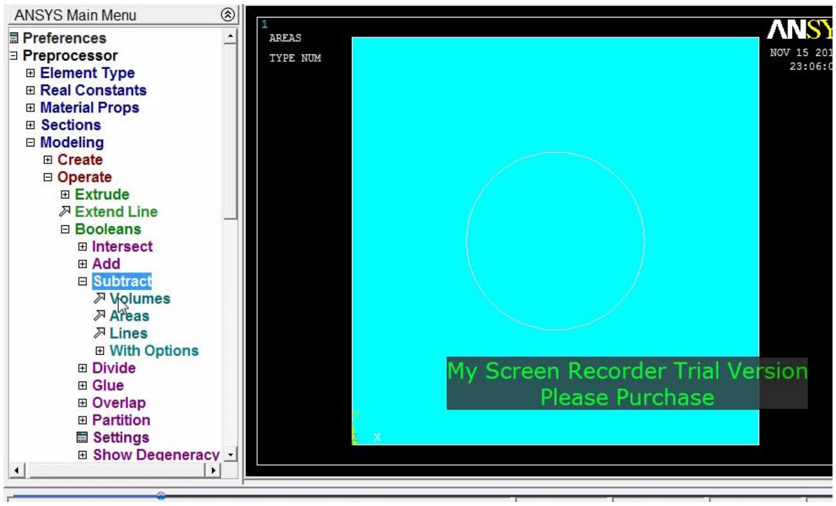
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Operate
Extrude
Extend Line
Booleans
Intersect
Add
Subtract
Volumes
Areas
Lines
With Options
Divide
Glue
Overlap
Partition
Settings
Show Degeneracy
AREAS
TYPE NUM
My Screen Recorder Trial Version
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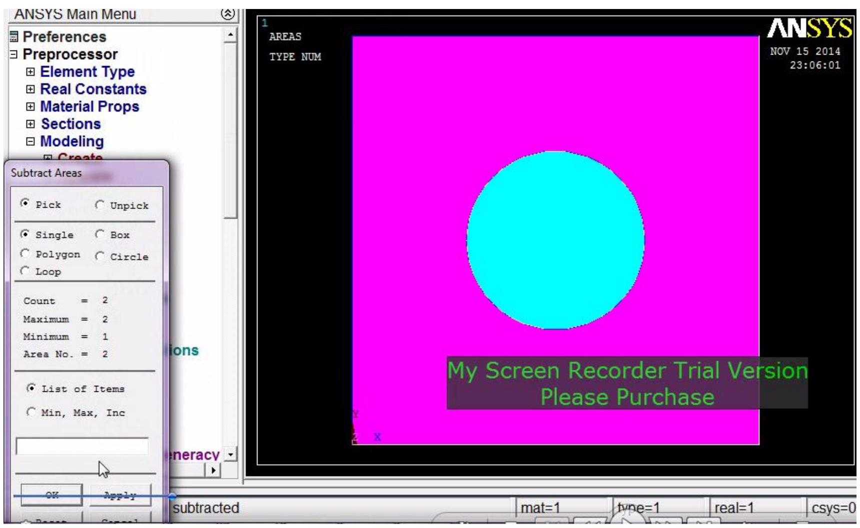
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Subtract Areas
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 2
Maximum = 2
Minimum = 1
Area No. = 2
List of Items
Min, Max, Inc
OK
Apply
AREAS
TYPE NUM
ANSYS
NOV 15 2014
23:06:01
My Screen Recorder Trial Version
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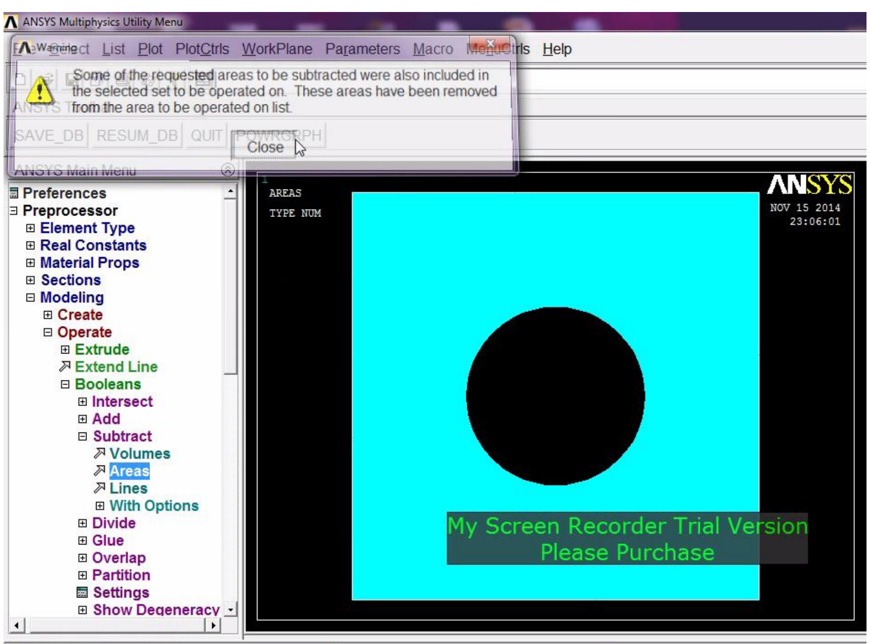
subtracted
mat=1
type=1
real=1
csys=0


ANSYS Multiphysics Utility Menu
List
Plot
PlotCtrls
WorkPlane
Parameters
Macro
Help
Warning
Some of the requested areas to be subtracted were also included in the selected set to be operated on. These areas have been removed from the area to be operated on list.
Close
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Operate
Extrude
Extend Line
Booleans
Intersect
Add
Subtract
Volumes
Areas
Lines
With Options
Divide
Glue
Overlap
Partition
Settings
Show Degeneracy
AREAS
TYPE NUM
ANSYS
NOV 15 2014
23:06:01
My Screen Recorder Trial Version
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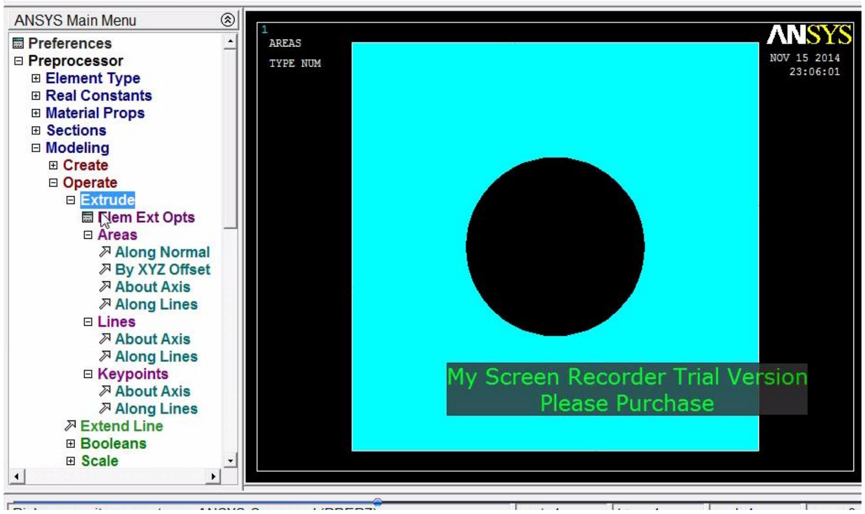
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Operate
Extrude
Elem Ext Opts
Areas
Along Normal
By XYZ Offset
About Axis
Along Lines
Lines
About Axis
Along Lines
Keypoints
About Axis
Along Lines
Extend Line
Booleans
Scale
AREAS
TYPE NUM
ANSYS
NOV 15 2014
23:06:01
My Screen Recorder Trial Version
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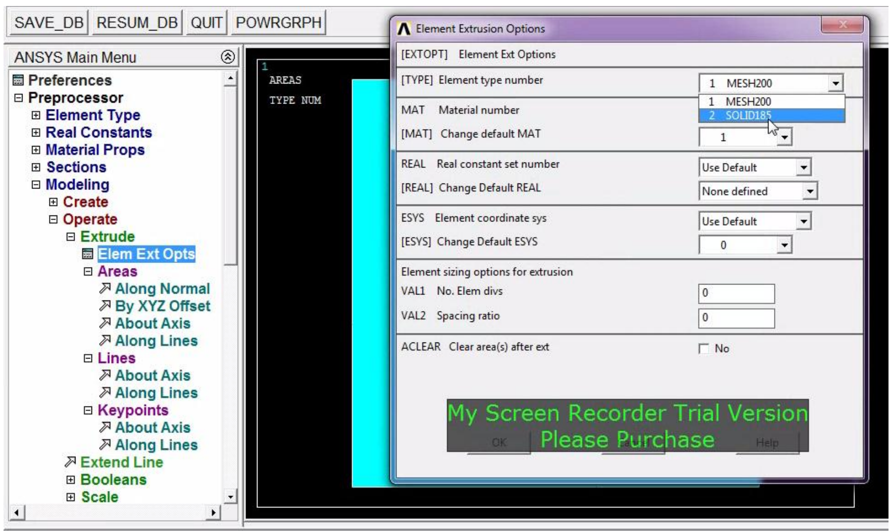
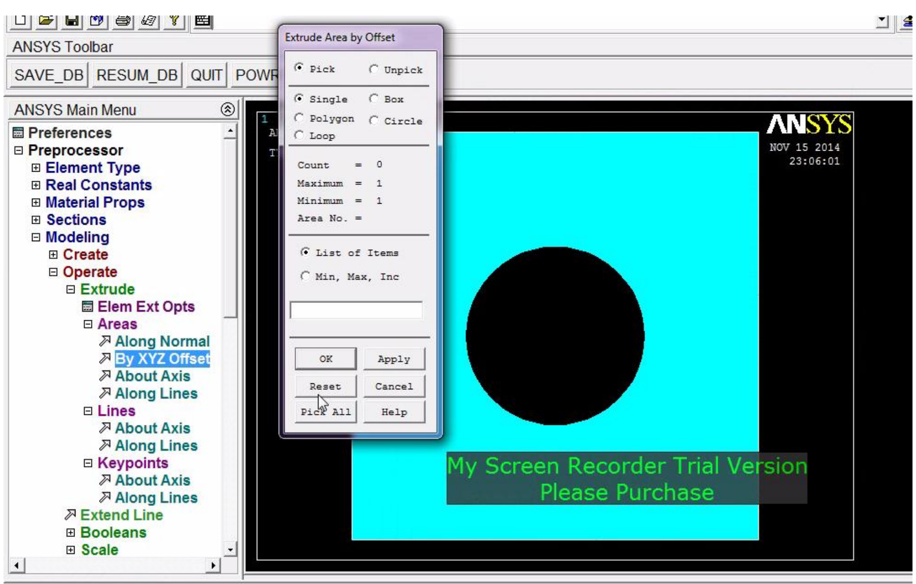

SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Element Extrusion Options
[EXTOPT] Element Ext Options
[TYPE] Element type number
1 MESH200
2 SOLID185
MAT Material number
[MAT] Change default MAT
REAL Real constant set number
Use Default
[REAL] Change Default REAL
None defined
ESYS Element coordinate sys
Use Default
[ESYS] Change Default ESYS
Element sizing options for extrusion
VAL1 No. Elem divs
VAL2 Spacing ratio
ACLEAR Clear area(s) after ext
No
My Screen Recorder Trial Version
Please Purchase


ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
Extrude Area by Offset
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 0
Maximum = 1
Minimum = 1
Area No. =
List of Items
Min, Max, Inc
OK
Apply
Reset
Cancel
Pick All
Help
ANSYS
NOV 15 2014
23:06:01
My Screen Recorder Trial Version
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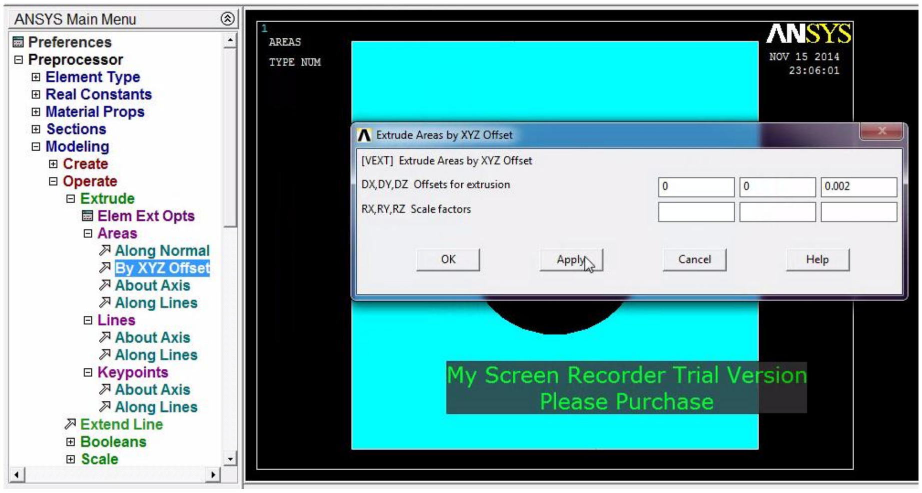
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Create
Operate
Extrude
Elem Ext Opts
Areas
Along Normal
By XYZ Offset
About Axis
Along Lines
Lines
About Axis
Along Lines
Keypoints
About Axis
Along Lines
Extend Line
Booleans
Scale
AREAS
TYPE NUM
ANSYS
NOV 15 2014
23:06:01
Extrude Areas by XYZ Offset
[VEXT] Extrude Areas by XYZ Offset
DX,DY,DZ Offsets for extrusion
0
0
0.002
RX,RY,RZ Scale factors
OK
Apply
Cancel
Help
My Screen Recorder Trial Version
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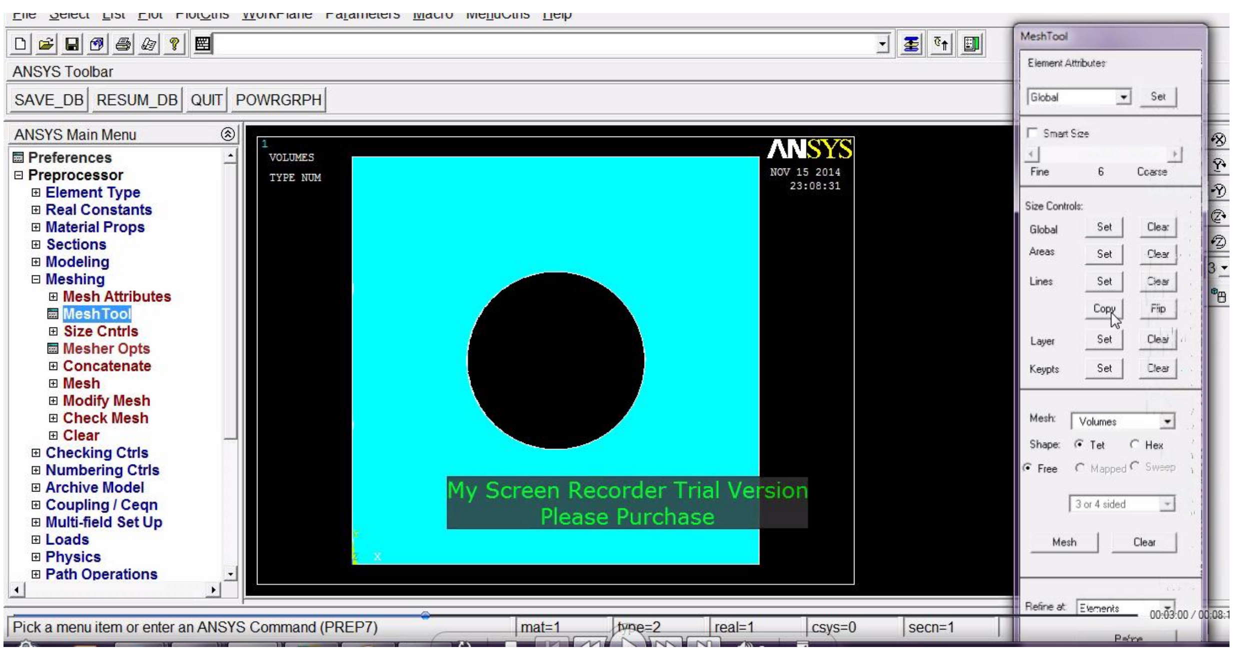
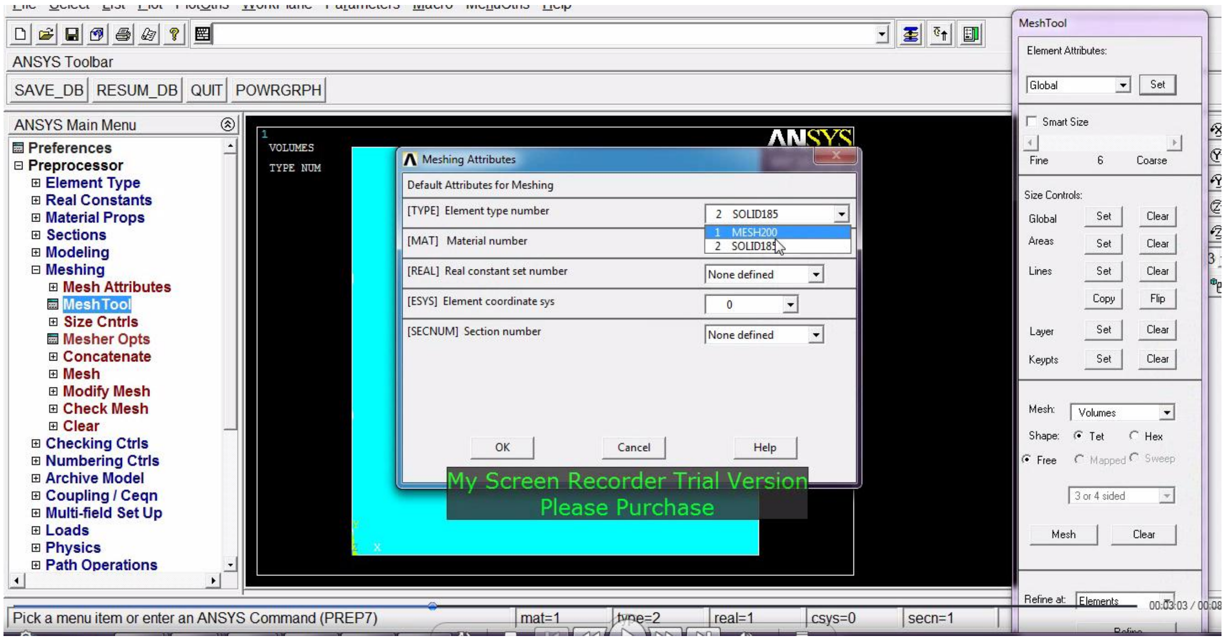
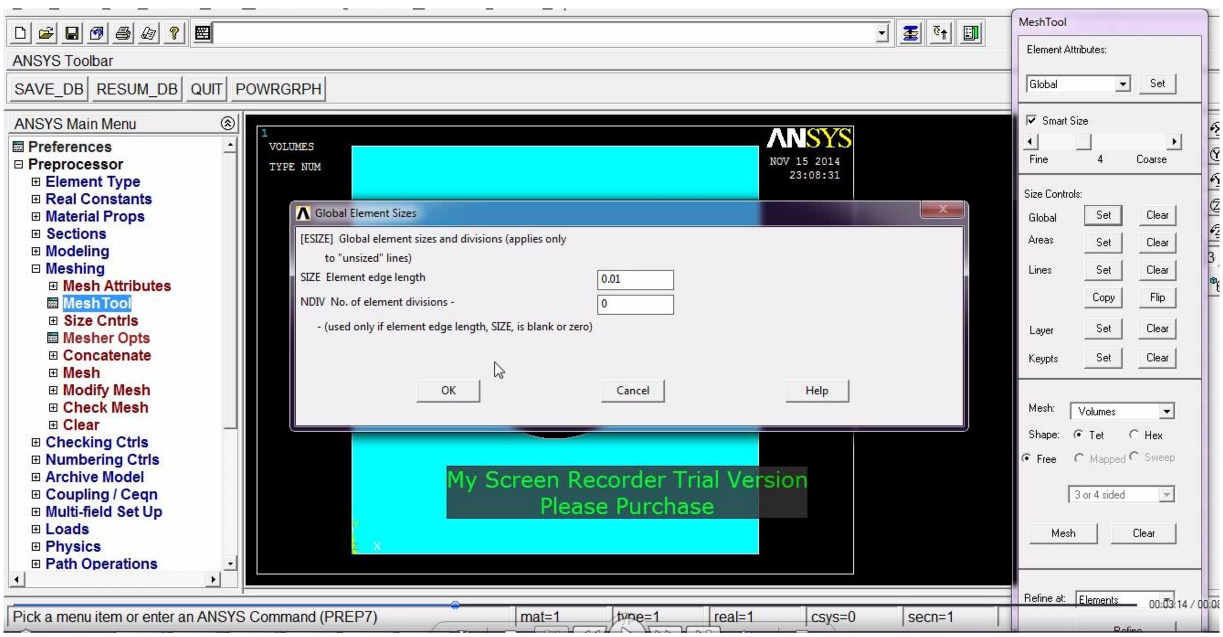
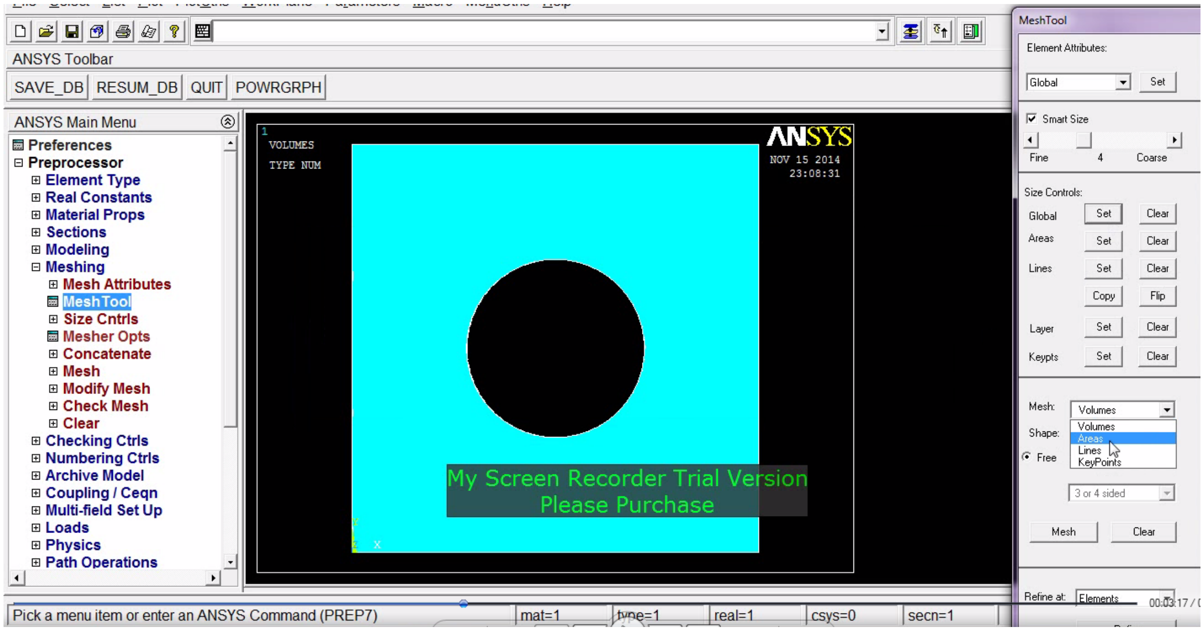

ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
VOLUMES
TYPE NUM
ANSYS
NOV 15 2014
23:08:31
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
6
Coarse
Size Controls:
Global
Areas
Lines
Copy
Flip
Layer
Keypts
Clear
Mesh:
Volumes
Shape:
Tet
Hex
Free
Mapped
Sweep
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Refine
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=2
real=1
csys=0
secn=1

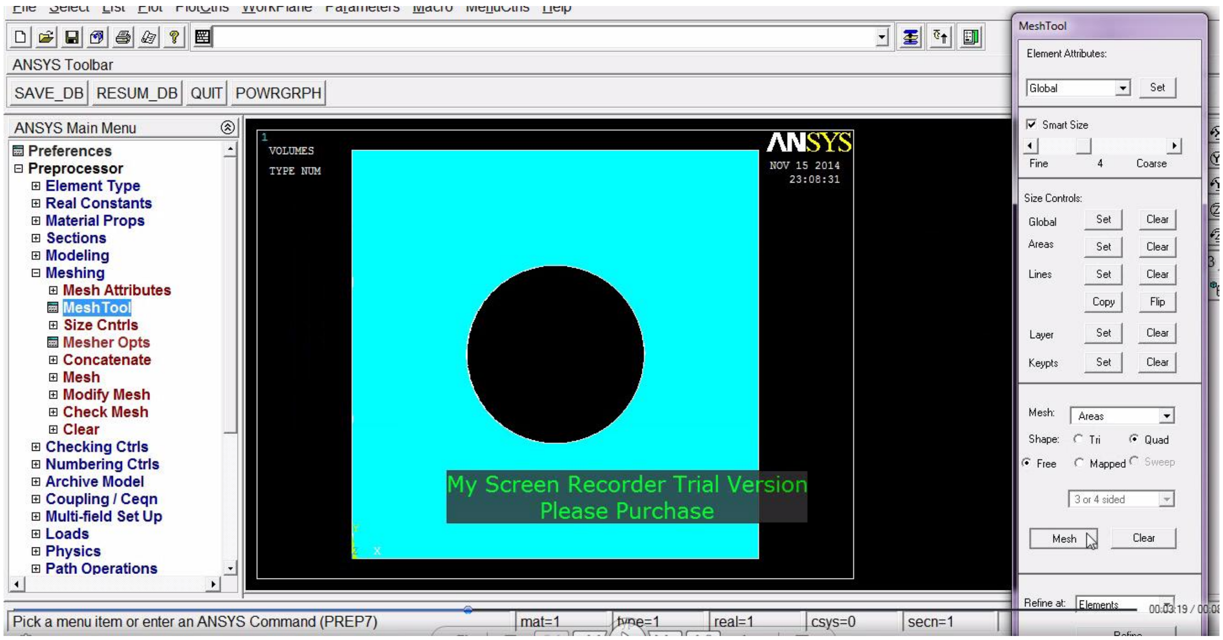


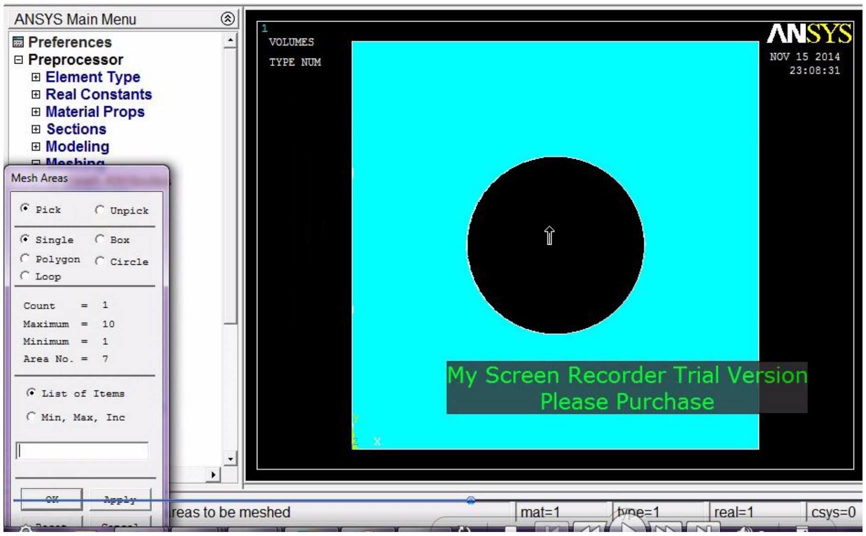
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
VOLUMES
TYPE NUM
Meshing Attributes
Default Attributes for Meshing
[TYPE] Element type number
2 SOLID185
1 MESH200
2 SOLID185
[MAT] Material number
[REAL] Real constant set number
None defined
[ESYS] Element coordinate sys
0
[SECNUM] Section number
None defined
OK
Cancel
Help
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine 6 Coarse
Size Controls:
Global
Areas
Lines
Copy
Flip
Layer
Keypts
Mesh: Volumes
Shape: Tet Hex
Free Mapped Sweep
3 or 4 sided
Mesh
Clear
Refine at: Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=2
real=1
csys=0
secn=1

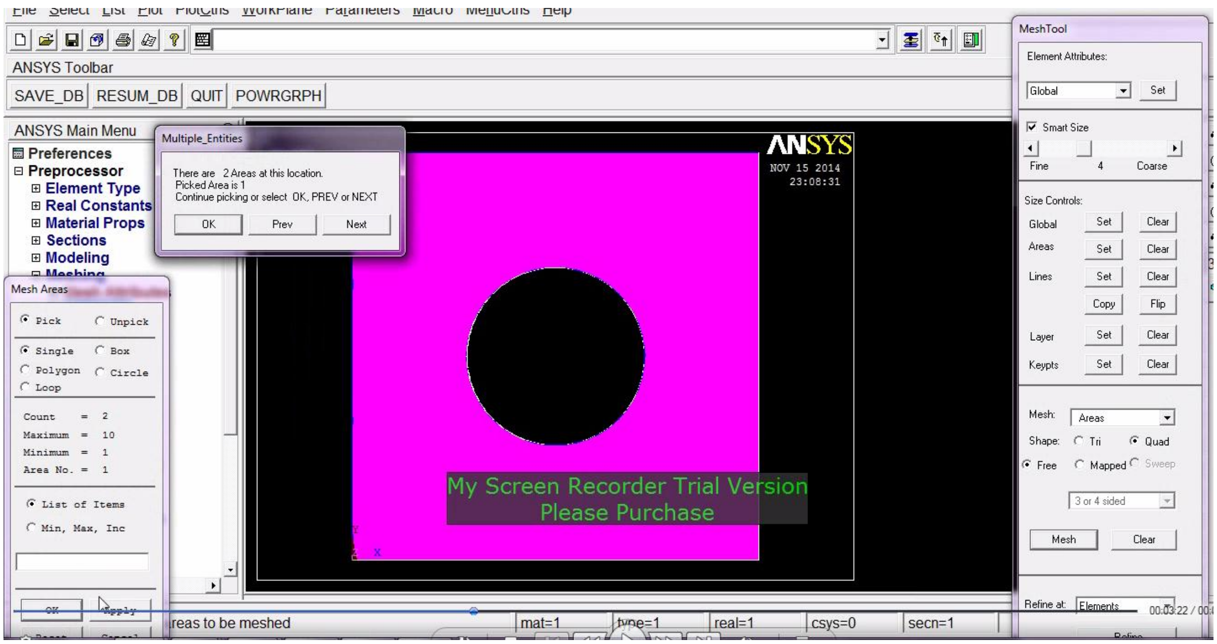



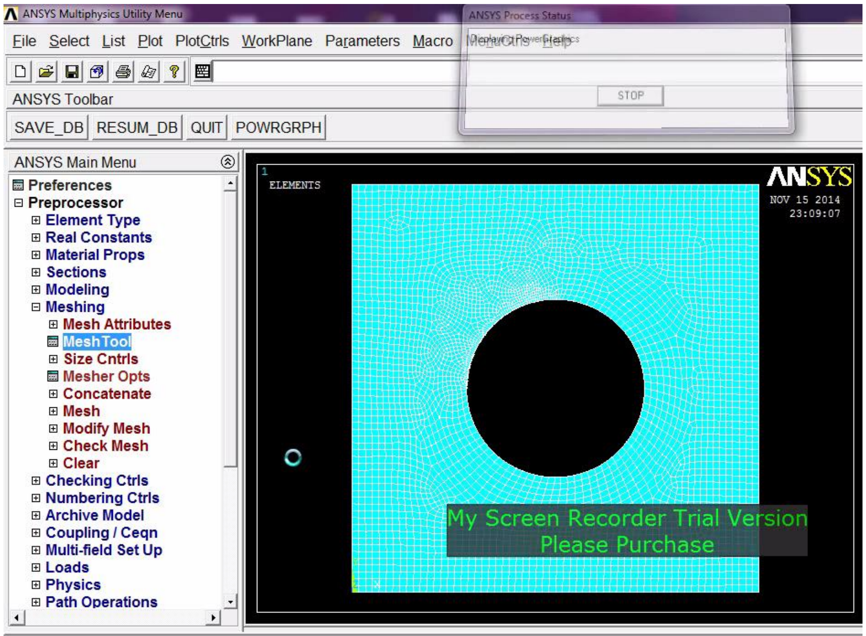
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Meshing
Mesh Attributes
MeshTool
Size Cntrls
VOLUMES
TYPE NUM
NOV 15 2014
23:08:31
Global Element Sizes
[ESIZE] Global element sizes and divisions (applies only
to "unsized" lines)
SIZE Element edge length
0.01
NDIV No. of element divisions -
0
- (used only if element edge length, SIZE, is blank or zero)
OK
Cancel
Help
My Screen Recorder Trial Version
Please Purchase
MeshTool
Smart Size
Fine 4 Coarse
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1


ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
VOLUMES
TYPE NUM
ANSYS
NOV 15 2014
23:08:31
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
4
Coarse
Size Controls:
Global
Areas
Lines
Copy
Flip
Layer
Keypts
Set
Clear
Mesh:
Volumes
Shape:
Free
Volumes
Areas
Lines
KeyPoints
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1


ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
VOLUMES
TYPE NUM
ANSYS
NOV 15 2014
23:08:31
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
4
Coarse
Size Controls:
Global
Areas
Lines
Copy
Flip
Layer
Keypts
Set
Clear
Mesh:
Areas
Shape:
Tri
Quad
Free
Mapped
Sweep
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1


ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Mesh Areas
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 1
Maximum = 10
Minimum = 1
Area No. = 7
List of Items
Min, Max, Inc
OK
Apply
VOLUMES
TYPE NUM
ANSYS
NOV 15 2014
23:08:31
My Screen Recorder Trial Version
Please Purchase
reas to be meshed
mat=1
real=1
csys=0


ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Multiple_Entities
There are 2 Areas at this location.
Picked Area is 1
Continue picking or select OK, PREV or NEXT
OK
Prev
Next
Mesh Areas
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 2
Maximum = 10
Minimum = 1
Area No. = 1
List of Items
Min, Max, Inc
ANSYS
NOV 15 2014
23:08:31
My Screen Recorder Trial Version
Please Purchase
reas to be meshed
mat=1
real=1
csys=0
secn=1
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
4
Coarse
Size Controls:
Global
Areas
Lines
Layer
Keypts
Set
Clear
Copy
Flip
Mesh:
Areas
Shape:
Tri
Quad
Free
Mapped
Sweep
3 or 4 sided
Mesh
Clear
Refine at:
Elements


ANSYS Multiphysics Utility Menu
ANSYS Process Status
File Select List Plot PlotCtrls WorkPlane Parameters Macro
STOP
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:09:07
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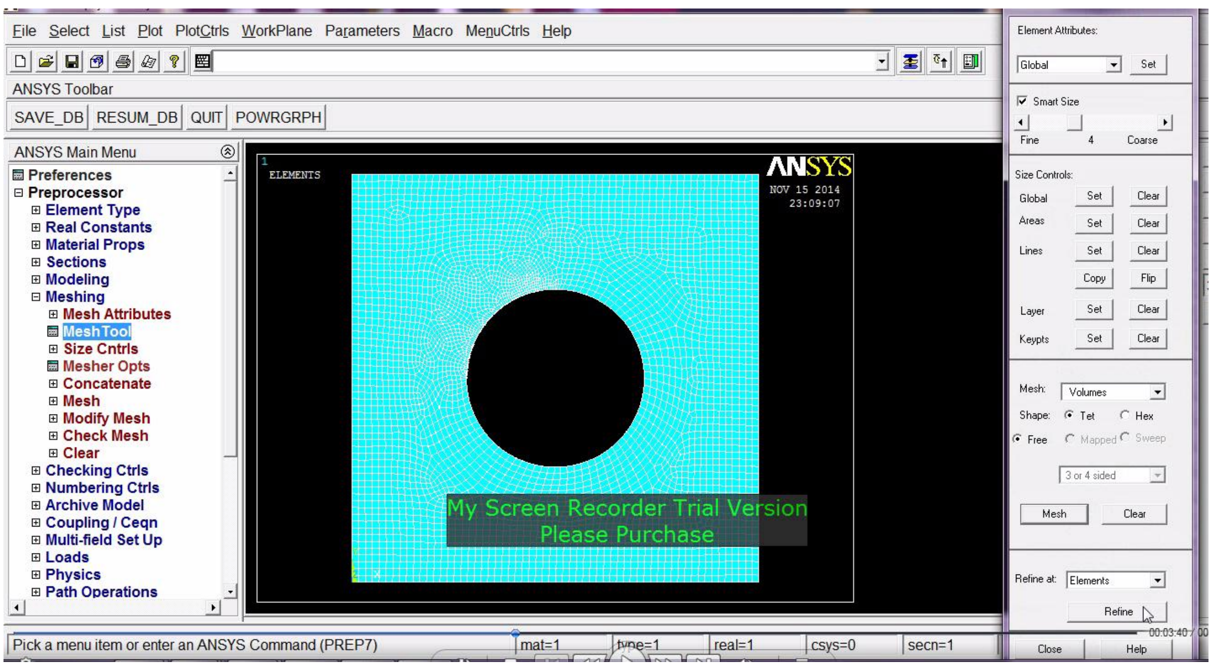
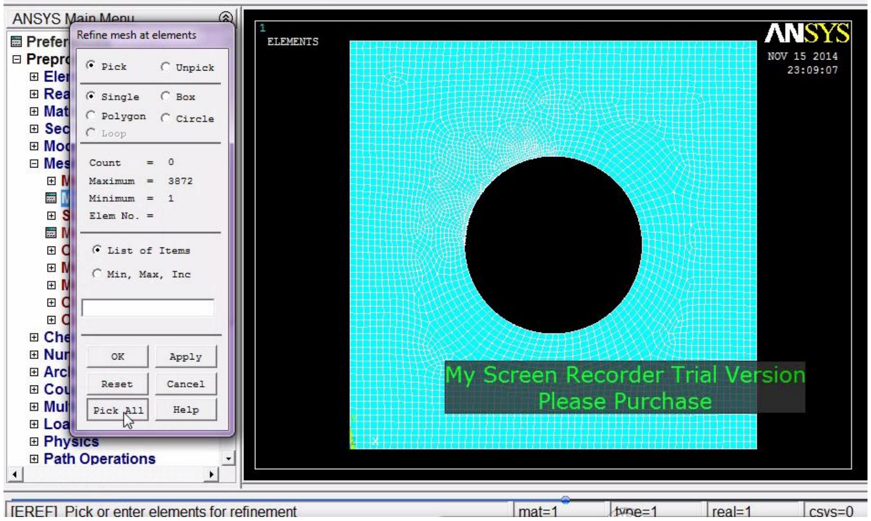
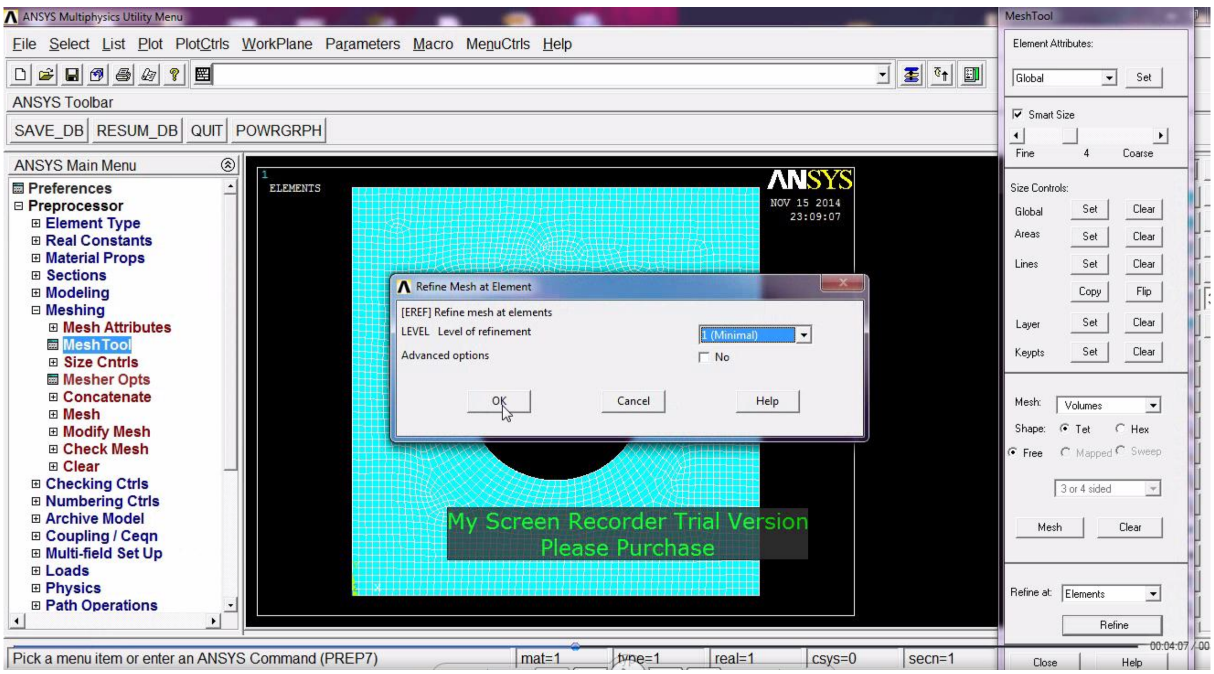
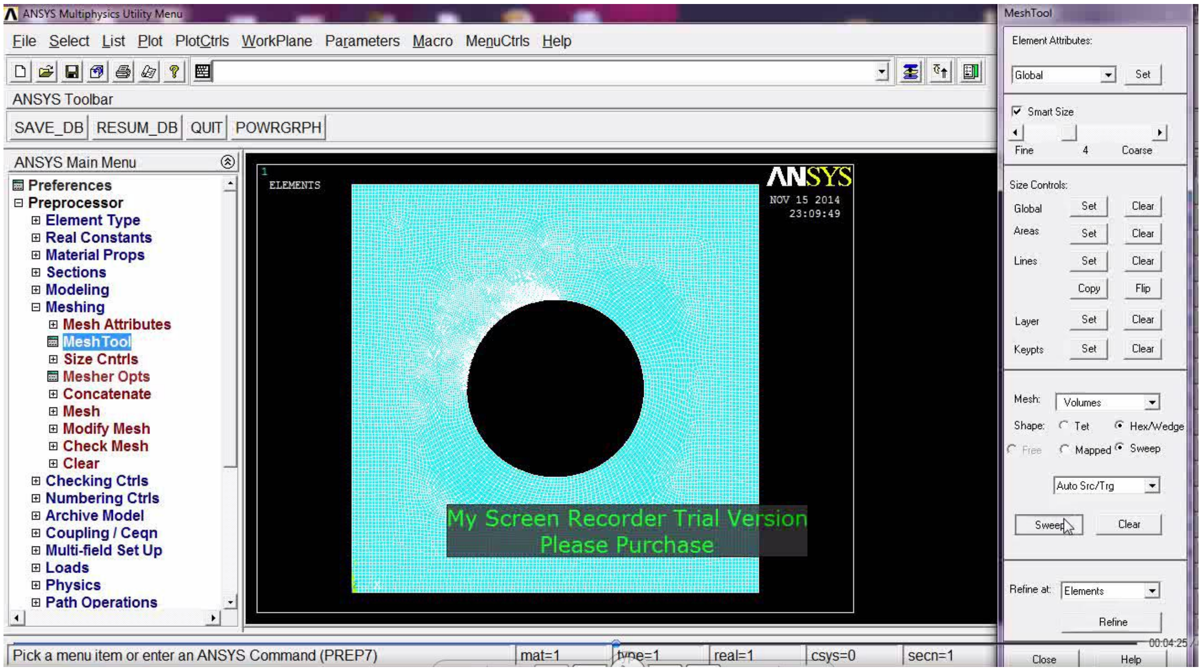

File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:09:07
My Screen Recorder Trial Version
Please Purchase
Element Attributes:
Global Set
Smart Size
Fine 4 Coarse
Size Controls:
Global Set Clear
Areas Set Clear
Lines Set Clear
Copy Flip
Layer Set Clear
Keypts Set Clear
Mesh: Volumes
Shape: Tet Hex
Free Mapped Sweep
3 or 4 sided
Mesh Clear
Refine at: Elements
Refine
Close Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1 type=1 real=1 csys=0 secn=1



ANSYS Main Menu
Refine mesh at elements
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 0
Maximum = 3872
Minimum = 1
Elem No. =
List of Items
Min, Max, Inc
OK
Apply
Reset
Cancel
Pick All
Help
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:09:07
My Screen Recorder Trial Version
Please Purchase
[EREF] Pick or enter elements for refinement
mat=1
type=1
real=1
csys=0

ANSYS Multiphysics Utility Menu
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:09:07
Refine Mesh at Element
[EREF] Refine mesh at elements
LEVEL Level of refinement
1 (Minimal)
Advanced options
No
OK
Cancel
Help
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine
4
Coarse
Size Controls:
Global
Areas
Lines
Layer
Keypts
Set
Clear
Copy
Flip
Mesh:
Volumes
Shape:
Tet
Hex
Free
Mapped
Sweep
3 or 4 sided
Mesh
Clear
Refine at:
Elements
Refine
Close
Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1



ANSYS Multiphysics Utility Menu
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
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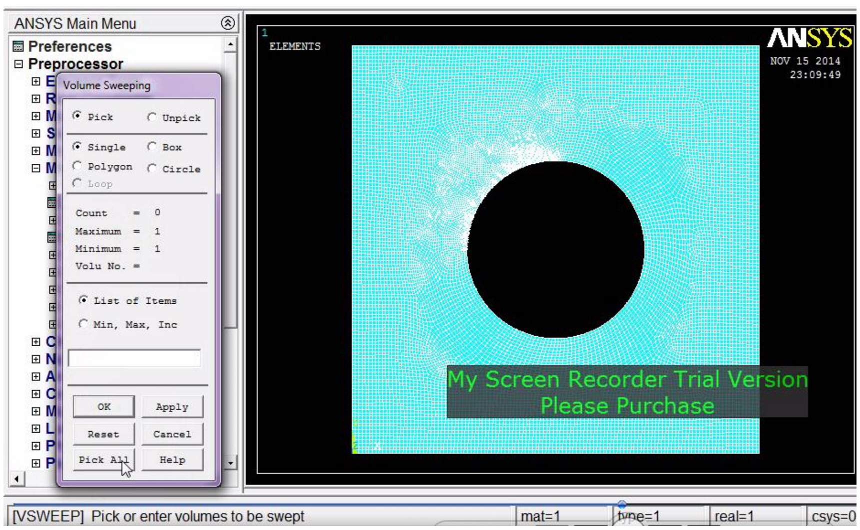
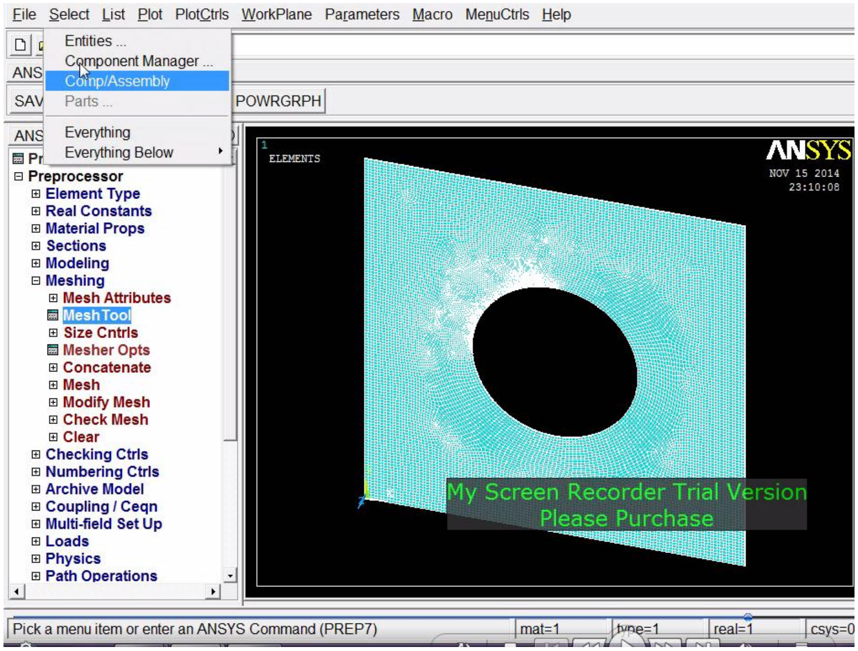
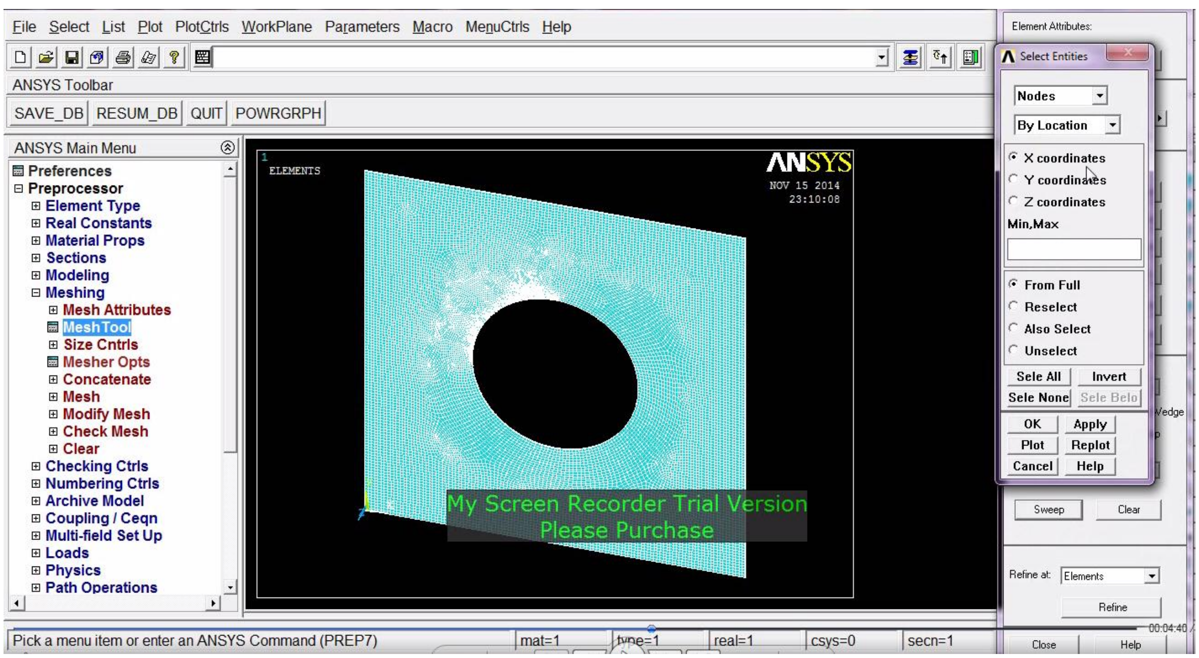
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:09:49
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global Set
Smart Size
Fine 4 Coarse
Size Controls:
Global Set Clear
Areas Set Clear
Lines Set Clear
Copy Flip
Layer Set Clear
Keypts Set Clear
Mesh: Volumes
Shape: Tet Hex/Wedge
Free Mapped Sweep
Auto Src/Trg
Sweep Clear
Refine at: Elements
Refine
Close Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1 type=1 real=1 csys=0 secn=1

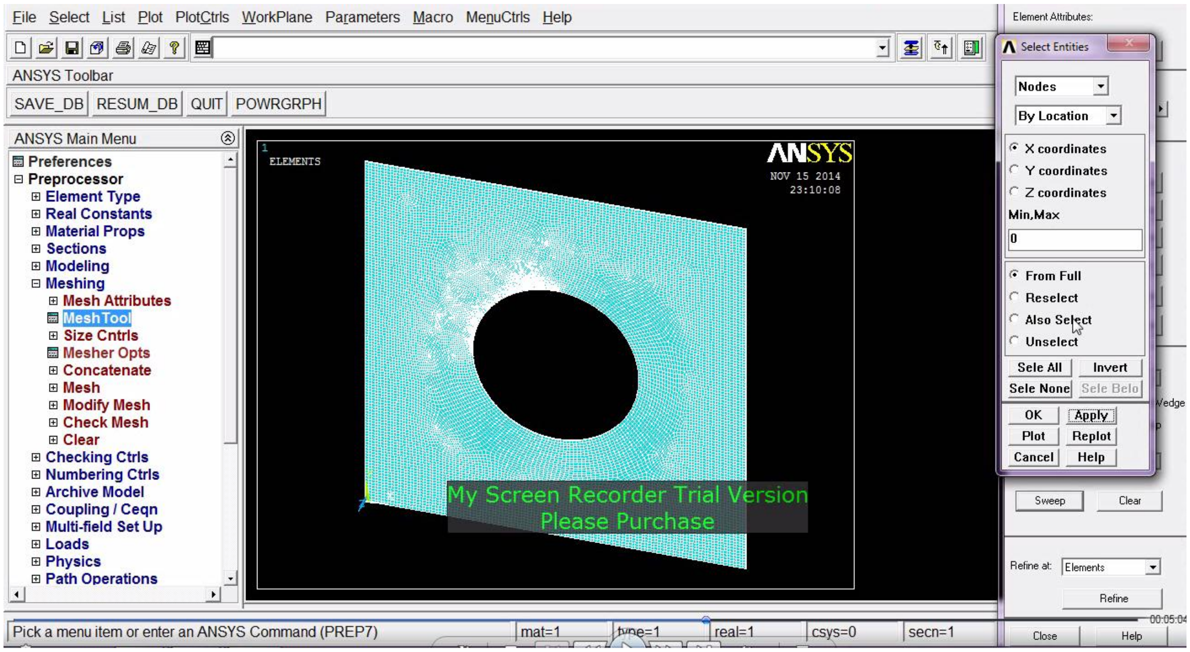
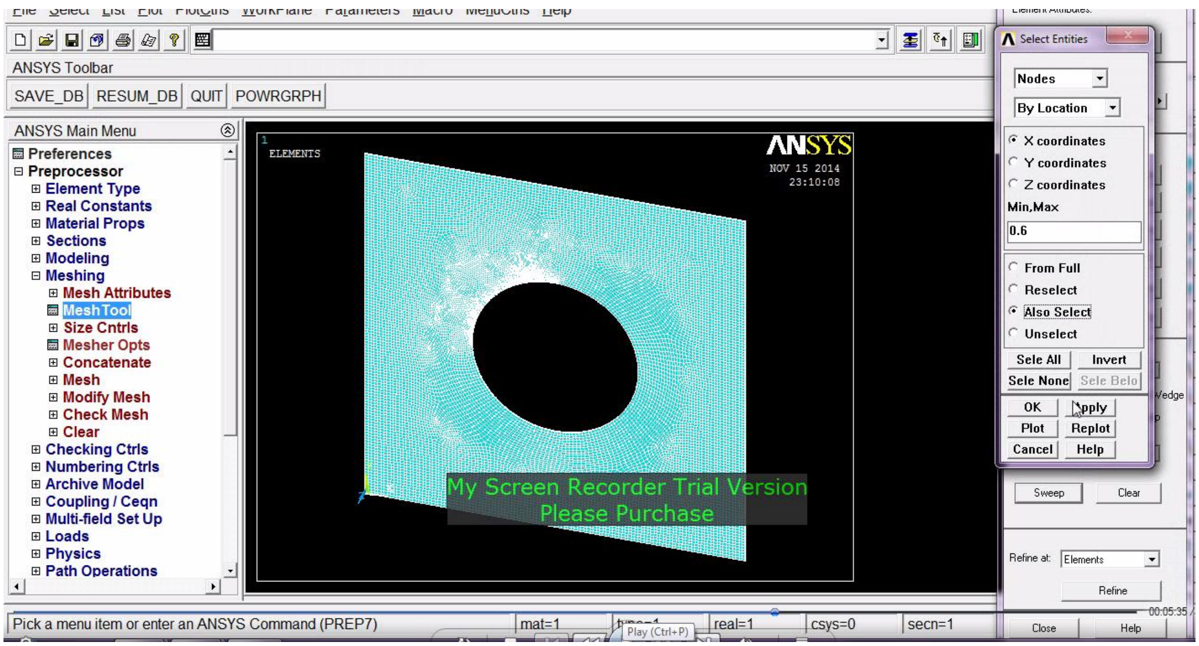
ANSYS Main Menu
Preferences
Preprocessor
Volume Sweeping
Pick Unpick
Single Box
Polygon Circle
Loop
Count = 0
Maximum = 1
Minimum = 1
Volu No. =
List of Items
Min, Max, Inc
OK Apply
Reset Cancel
Pick All Help
ELEMENTS
ANSYS
NOV 15 2014
23:09:49
My Screen Recorder Trial Version
Please Purchase
[VSWEEP] Pick or enter volumes to be swept
mat=1 type=1 real=1 csys=0

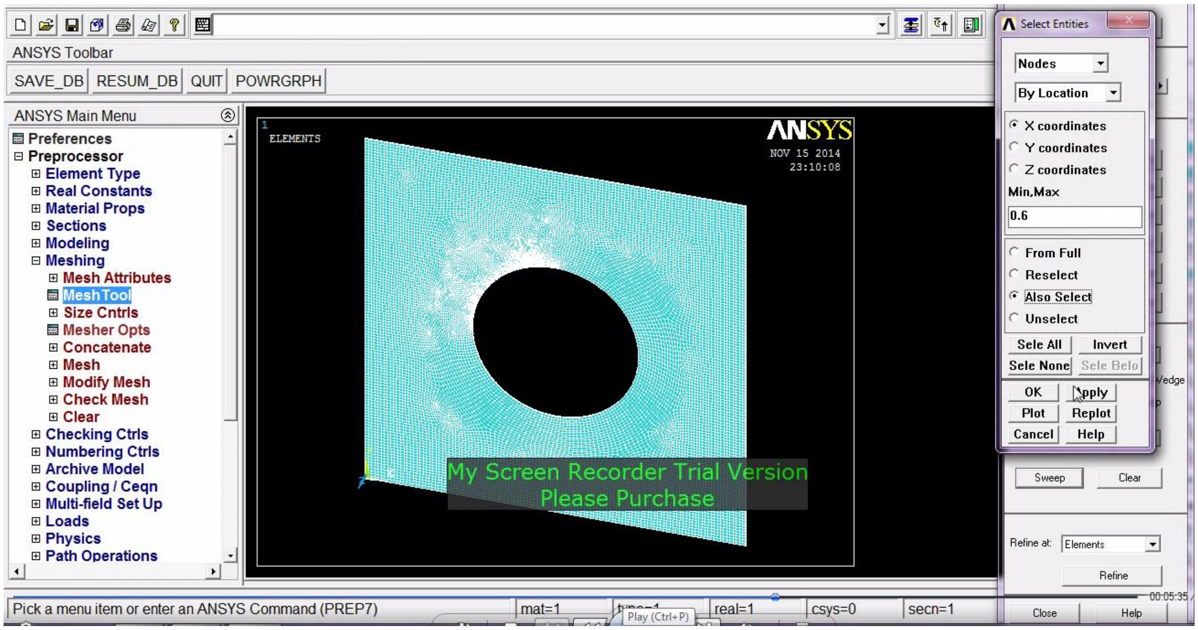


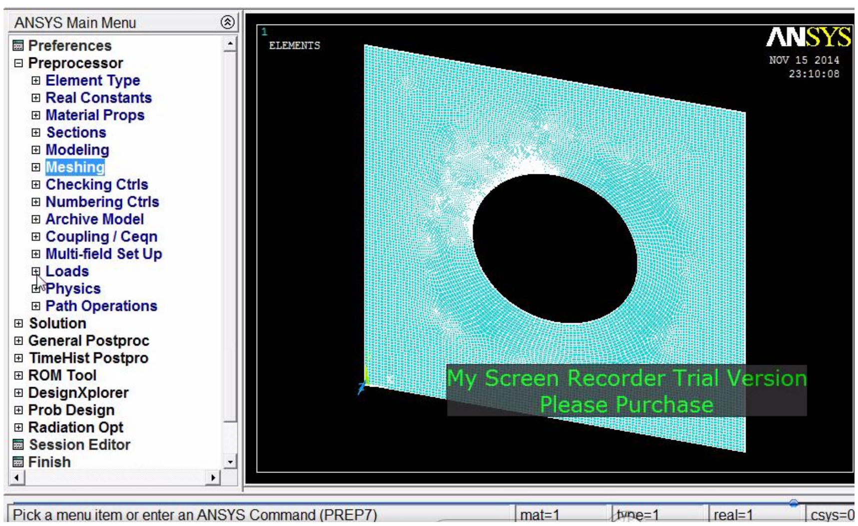
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
Entities ...
Component Manager ...
Comp/Assembly
Parts ...
Everything
Everything Below
POWRGRPH
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0

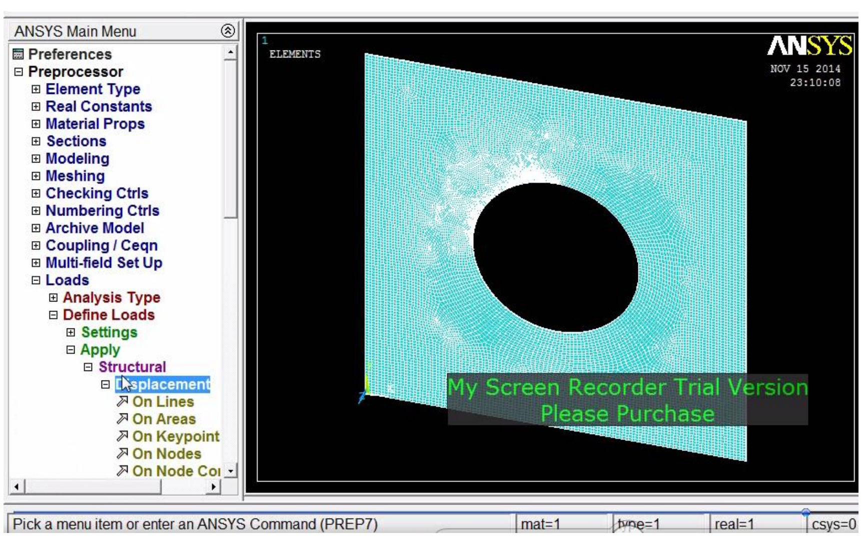



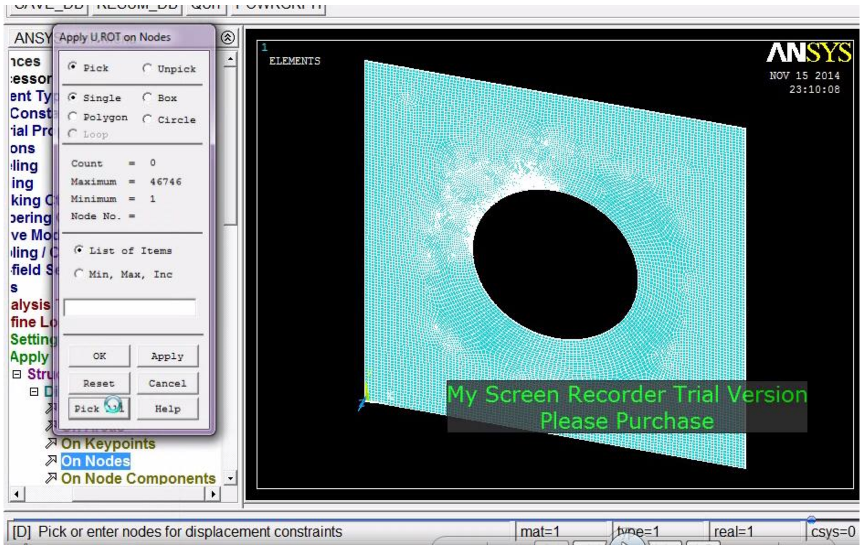
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Element Attributes:
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
Sweep
Clear
Refine at:
Elements
Refine
Close
Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1

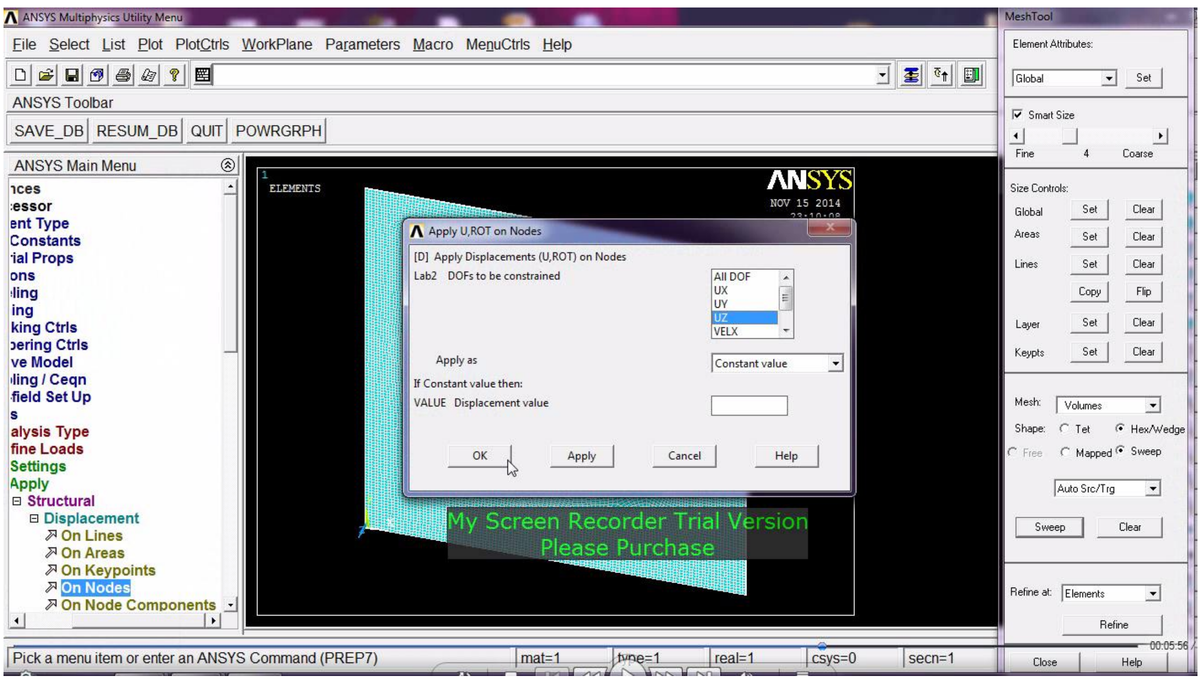

File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
Sweep
Clear
Refine at:
Elements
Refine
Close
Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1

ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0.6
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
Sweep
Clear
Refine at:
Elements
Refine
Close
Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
real=1
csys=0
secn=1
Play (Ctrl+P)

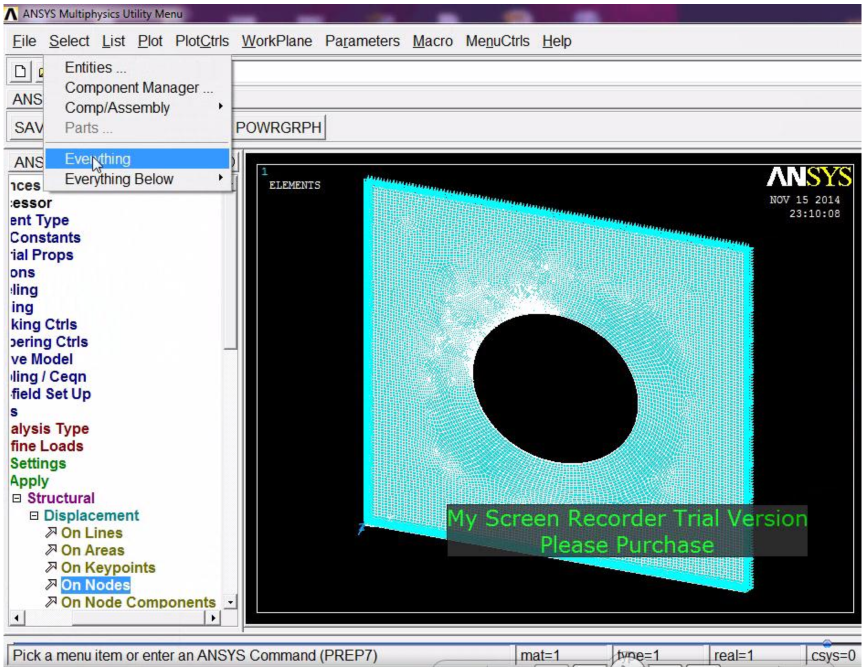

ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Mesh Attributes
MeshTool
Size Cntrls
Mesher Opts
Concatenate
Mesh
Modify Mesh
Check Mesh
Clear
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Select Entities
Nodes
By Location
X coordinates
Y coordinates
Z coordinates
Min,Max
0.6
From Full
Reselect
Also Select
Unselect
Sele All
Invert
Sele None
Sele Belo
OK
Apply
Plot
Replot
Cancel
Help
Sweep
Clear
Refine at:
Elements
Refine
Close
Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
real=1
csys=0
secn=1

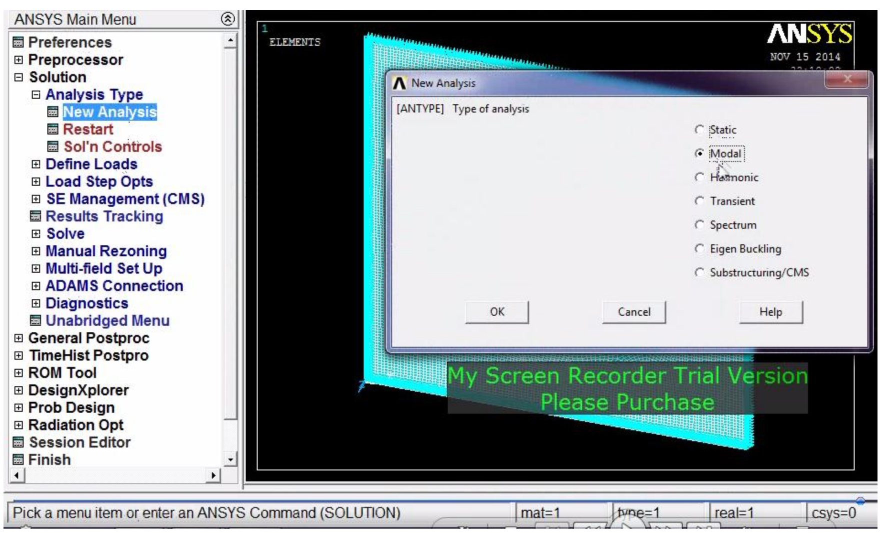

ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Physics
Path Operations
Solution
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0

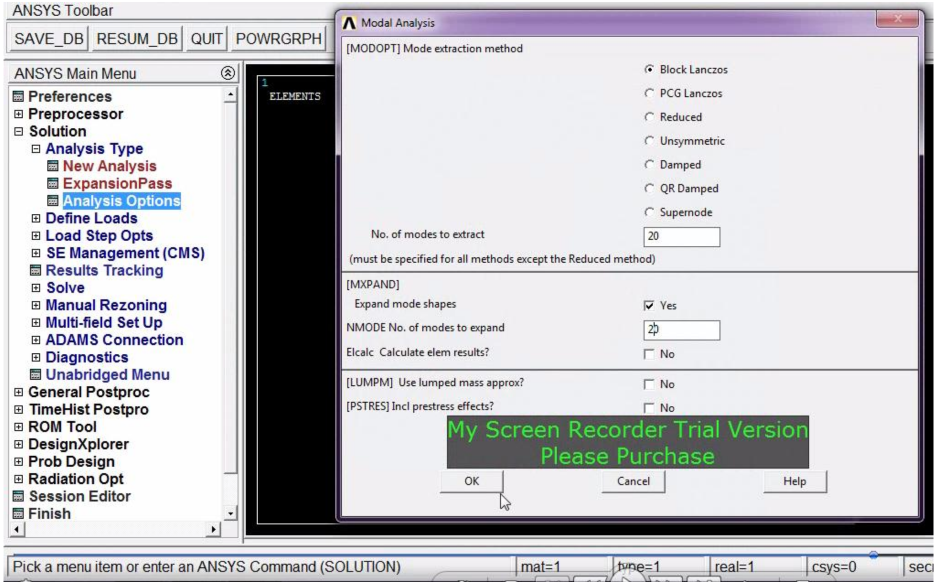

ANSYS Main Menu
Preferences
Preprocessor
Element Type
Real Constants
Material Props
Sections
Modeling
Meshing
Checking Ctrls
Numbering Ctrls
Archive Model
Coupling / Ceqn
Multi-field Set Up
Loads
Analysis Type
Define Loads
Settings
Apply
Structural
Displacement
On Lines
On Areas
On Keypoint
On Nodes
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0

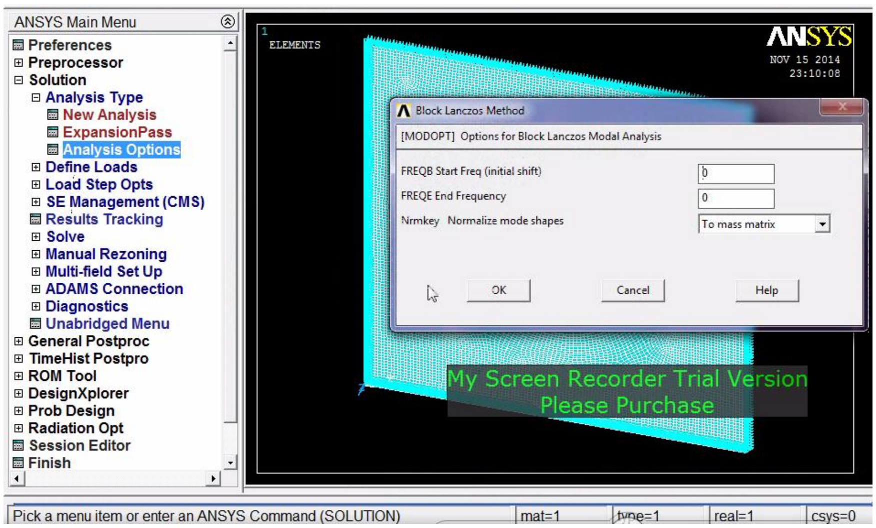

Apply U,ROT on Nodes
Pick
Unpick
Single
Box
Polygon
Circle
Loop
Count = 0
Maximum = 46746
Minimum = 1
Node No. =
List of Items
Min, Max, Inc
OK
Apply
Reset
Cancel
Pick All
Help
On Keypoints
On Nodes
On Node Components
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
[D] Pick or enter nodes for displacement constraints
mat=1
type=1
real=1
csys=0

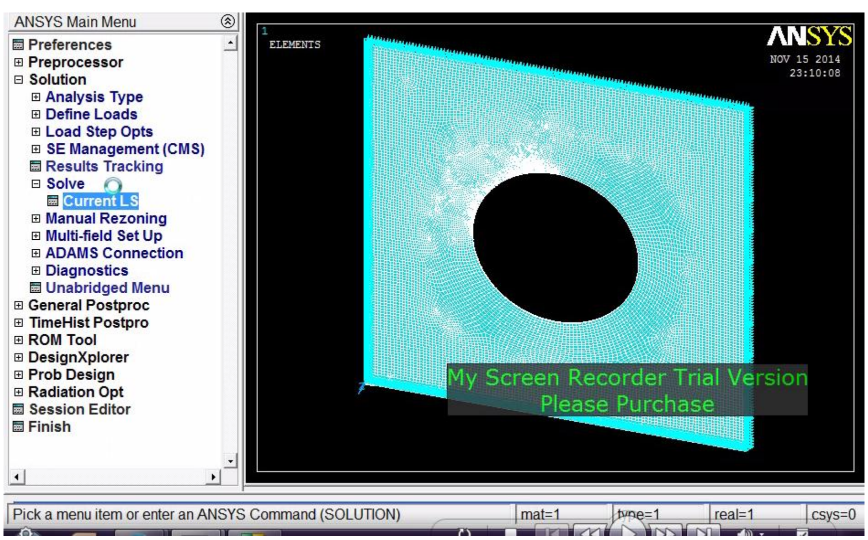

ANSYS Multiphysics Utility Menu
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
ANSYS Toolbar
SAVE_DB RESUM_DB QUIT POWRGRPH
ANSYS Main Menu
Structural
Displacement
On Lines
On Areas
On Keypoints
On Nodes
On Node Components
Apply U,ROT on Nodes
[D] Apply Displacements (U,ROT) on Nodes
Lab2 DOFs to be constrained
All DOF
UX
UY
UZ
VELX
Apply as
Constant value
If Constant value then:
VALUE Displacement value
OK
Apply
Cancel
Help
ELEMENTS
ANSYS
NOV 15 2014
My Screen Recorder Trial Version
Please Purchase
MeshTool
Element Attributes:
Global
Set
Smart Size
Fine 4 Coarse
Size Controls:
Global
Areas
Lines
Copy
Flip
Layer
Keypts
Clear
Mesh: Volumes
Shape: Tet Hex/Wedge
Free Mapped Sweep
Auto Src/Trg
Sweep
Refine at: Elements
Refine
Close
Help
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0
secn=1

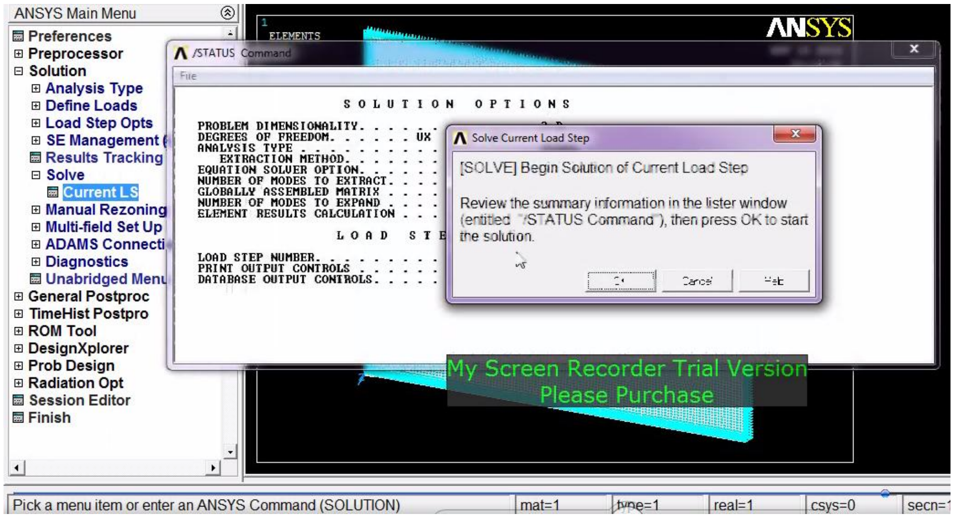

ANSYS Multiphysics Utility Menu
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
Entities ...
Component Manager ...
Comp/Assembly
Parts ...
Everything
Everything Below
POWRGRPH
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
Structural
Displacement
On Lines
On Areas
On Keypoints
On Nodes
On Node Components
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (PREP7)
mat=1
type=1
real=1
csys=0

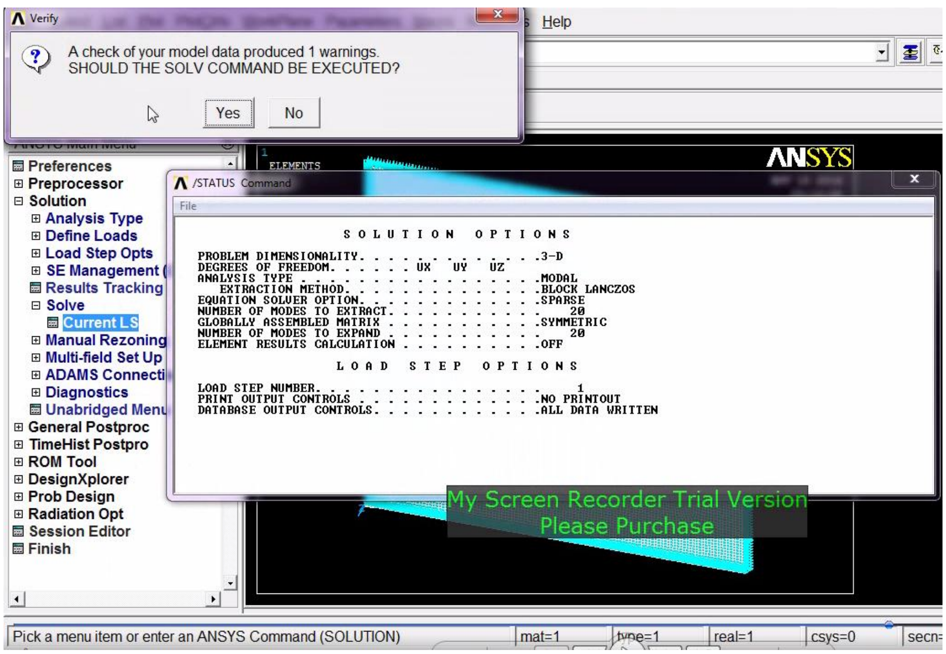

ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
New Analysis
Restart
Sol'n Controls
Define Loads
Load Step Opts
SE Management (CMS)
Results Tracking
Solve
Manual Rezoning
Multi-field Set Up
ADAMS Connection
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
ELEMENTS
ANSYS
NOV 15 2014
New Analysis
[ANTYPE] Type of analysis
Static
Modal
Harmonic
Transient
Spectrum
Eigen Buckling
Substructuring/CMS
OK
Cancel
Help
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
type=1
real=1
csys=0

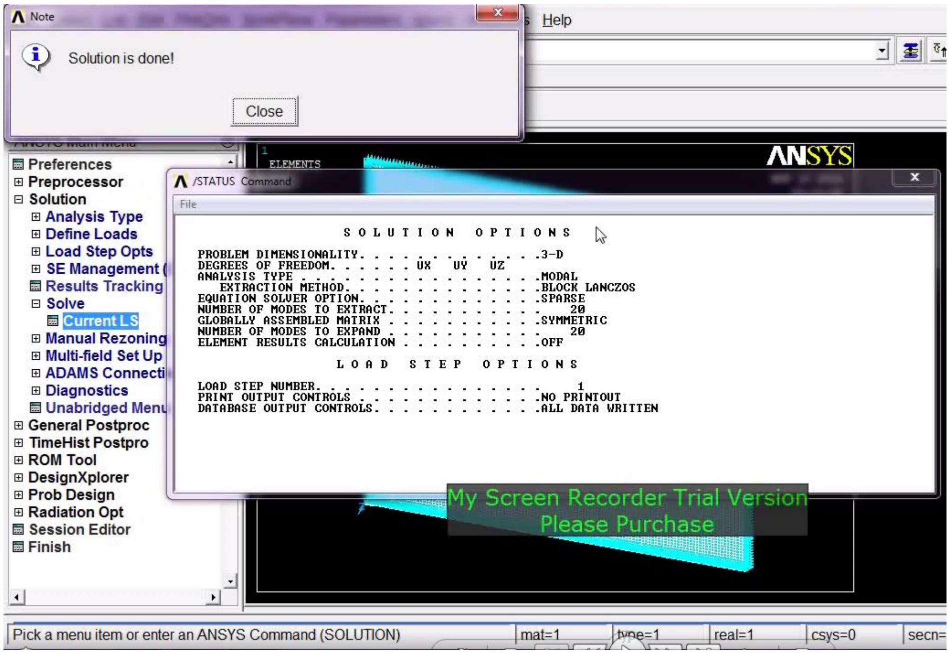

ANSYS Toolbar
SAVE_DB
RESUM_DB
QUIT
POWRGRPH
ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
New Analysis
ExpansionPass
Analysis Options
Define Loads
Load Step Opts
SE Management (CMS)
Results Tracking
Solve
Manual Rezoning
Multi-field Set Up
ADAMS Connection
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
ELEMENTS
Modal Analysis
[MODOPT] Mode extraction method
Block Lanczos
PCG Lanczos
Reduced
Unsymmetric
Damped
QR Damped
Supernode
No. of modes to extract
20
(must be specified for all methods except the Reduced method)
[MXPAND]
Expand mode shapes
Yes
NMODE No. of modes to expand
20
Elcalc Calculate elem results?
No
[LUMPM] Use lumped mass approx?
No
[PSTRES] Incl prestress effects?
No
My Screen Recorder Trial Version
Please Purchase
OK
Cancel
Help
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
type=1
real=1
csys=0

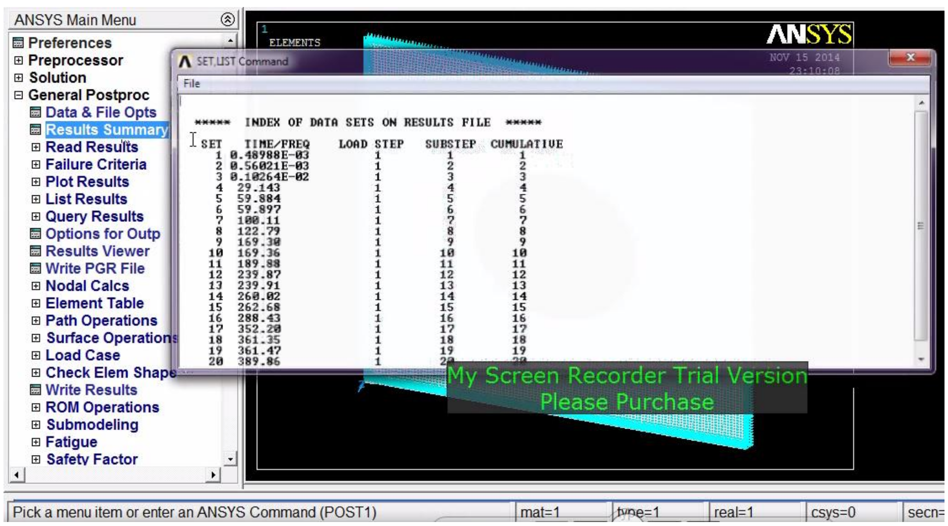

ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
New Analysis
ExpansionPass
Analysis Options
Define Loads
Load Step Opts
SE Management (CMS)
Results Tracking
Solve
Manual Rezoning
Multi-field Set Up
ADAMS Connection
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
Block Lanczos Method
[MODOPT] Options for Block Lanczos Modal Analysis
FREQB Start Freq (initial shift)
0
FREQE End Frequency
0
Nrmkey Normalize mode shapes
To mass matrix
OK
Cancel
Help
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
type=1
real=1
csys=0


ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
Define Loads
Load Step Opts
SE Management (CMS)
Results Tracking
Solve
Current LS
Manual Rezoning
Multi-field Set Up
ADAMS Connection
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
type=1
real=1
csys=0


ANSYS Main Menu
Preferences
Preprocessor
Solution
Analysis Type
Define Loads
Load Step Opts
SE Management
Results Tracking
Solve
Current LS
Manual Rezoning
Multi-field Set Up
ADAMS Connecti
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
/STATUS Command
SOLUTION OPTIONS
Solve Current Load Step
[SOLVE] Begin Solution of Current Load Step
Review the summary information in the lister window (entitled "/STATUS Command"), then press OK to start the solution.
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
real=1
csys=0


Verify
A check of your model data produced 1 warnings.
SHOULD THE SOLV COMMAND BE EXECUTED?
Yes
No
Help
/STATUS Command
SOLUTION OPTIONS
PROBLEM DIMENSIONALITY. . . . . . . . . . . . .3-D
DEGREES OF FREEDOM. . . . . . UX UY UZ
ANALYSIS TYPE . . . . . . . . . . . . . . . . .MODAL
EXTRACTION METHOD. . . . . . . . . . . . . .BLOCK LANCZOS
EQUATION SOLVER OPTION. . . . . . . . . . . . .SPARSE
NUMBER OF MODES TO EXTRACT. . . . . . . . . . . 20
GLOBALLY ASSEMBLED MATRIX . . . . . . . . . . .SYMMETRIC
NUMBER OF MODES TO EXPAND . . . . . . . . . . . 20
ELEMENT RESULTS CALCULATION . . . . . . . . . .OFF
LOAD STEP OPTIONS
LOAD STEP NUMBER. . . . . . . . . . . . . . . . 1
PRINT OUTPUT CONTROLS . . . . . . . . . . . . .NO PRINTOUT
DATABASE OUTPUT CONTROLS. . . . . . . . . . . .ALL DATA WRITTEN
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
real=1
csys=0


Note
Solution is done!
Close
Help
Preferences
Preprocessor
Solution
Analysis Type
Define Loads
Load Step Opts
SE Management (
Results Tracking
Solve
Current LS
Manual Rezoning
Multi-field Set Up
ADAMS Connecti
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
ROM Tool
DesignXplorer
Prob Design
Radiation Opt
Session Editor
Finish
ELEMENTS
ANSYS
/STATUS Command
File
S O L U T I O N   O P T I O N S
PROBLEM DIMENSIONALITY. . . . . . . . . . . . . .3-D
DEGREES OF FREEDOM. . . . . . UX UY UZ
ANALYSIS TYPE . . . . . . . . . . . . . . . . .MODAL
EXTRACTION METHOD. . . . . . . . . . . . . . .BLOCK LANCZOS
EQUATION SOLVER OPTION. . . . . . . . . . . . .SPARSE
NUMBER OF MODES TO EXTRACT. . . . . . . . . . . 20
GLOBALLY ASSEMBLED MATRIX . . . . . . . . . . .SYMMETRIC
NUMBER OF MODES TO EXPAND . . . . . . . . . . . 20
ELEMENT RESULTS CALCULATION . . . . . . . . . .OFF
L O A D   S T E P   O P T I O N S
LOAD STEP NUMBER. . . . . . . . . . . . . . . . 1
PRINT OUTPUT CONTROLS . . . . . . . . . . . . .NO PRINTOUT
DATABASE OUTPUT CONTROLS. . . . . . . . . . . .ALL DATA WRITTEN
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (SOLUTION)
mat=1
type=1
real=1
csys=0
secn=

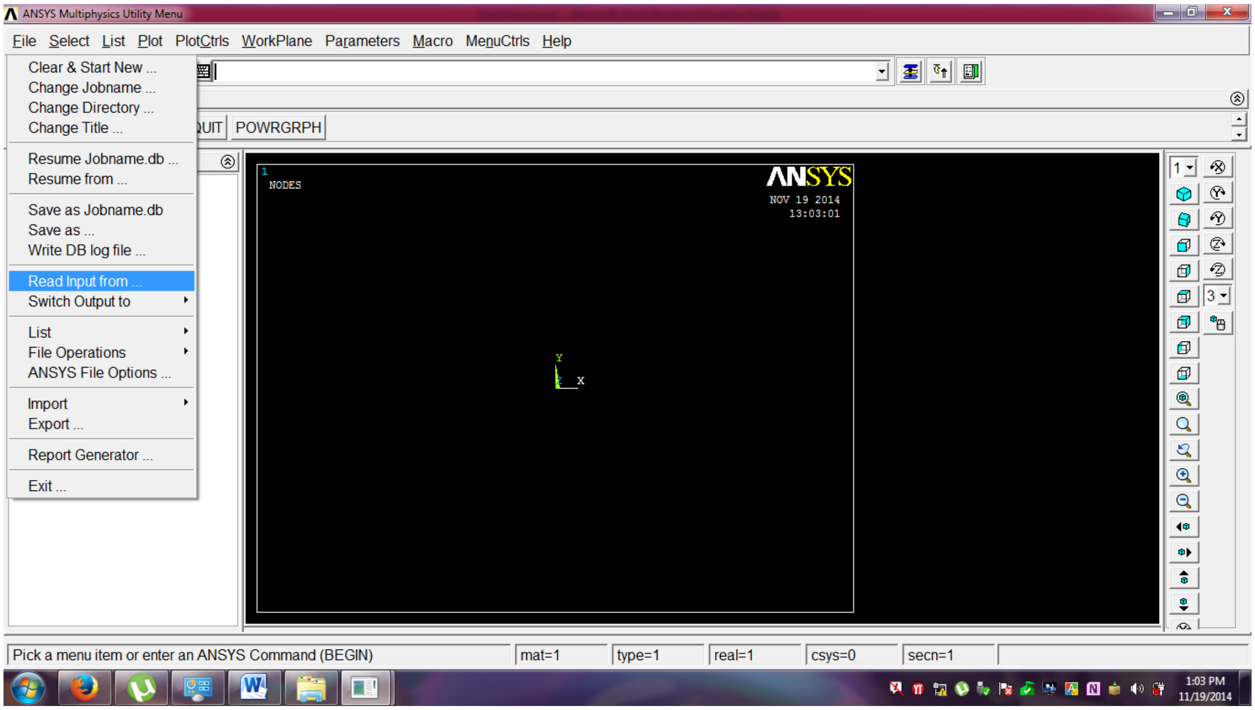

ANSYS Main Menu
Preferences
Preprocessor
Solution
General Postproc
Data & File Opts
Results Summary
Read Results
Failure Criteria
Plot Results
List Results
Query Results
Options for Outp
Results Viewer
Write PGR File
Nodal Calcs
Element Table
Path Operations
Surface Operations
Load Case
Check Elem Shape
Write Results
ROM Operations
Submodeling
Fatigue
Safety Factor
ELEMENTS
ANSYS
NOV 15 2014
23:10:08
SET,LIST Command
File
***** INDEX OF DATA SETS ON RESULTS FILE *****
SET TIME/FREQ LOAD STEP SUBSTEP CUMULATIVE
1 0.48988E-03 1 1 1
2 0.56021E-03 1 2 2
3 0.10264E-02 1 3 3
4 29.143 1 4 4
5 59.884 1 5 5
6 59.897 1 6 6
7 100.11 1 7 7
8 122.79 1 8 8
9 169.30 1 9 9
10 169.36 1 10 10
11 189.88 1 11 11
12 239.87 1 12 12
13 239.91 1 13 13
14 260.02 1 14 14
15 262.68 1 15 15
16 288.43 1 16 16
17 352.20 1 17 17
18 361.35 1 18 18
19 361.47 1 19 19
20 389.86 1
My Screen Recorder Trial Version
Please Purchase
Pick a menu item or enter an ANSYS Command (POST1)
mat=1
type=1
real=1
csys=0
secn=

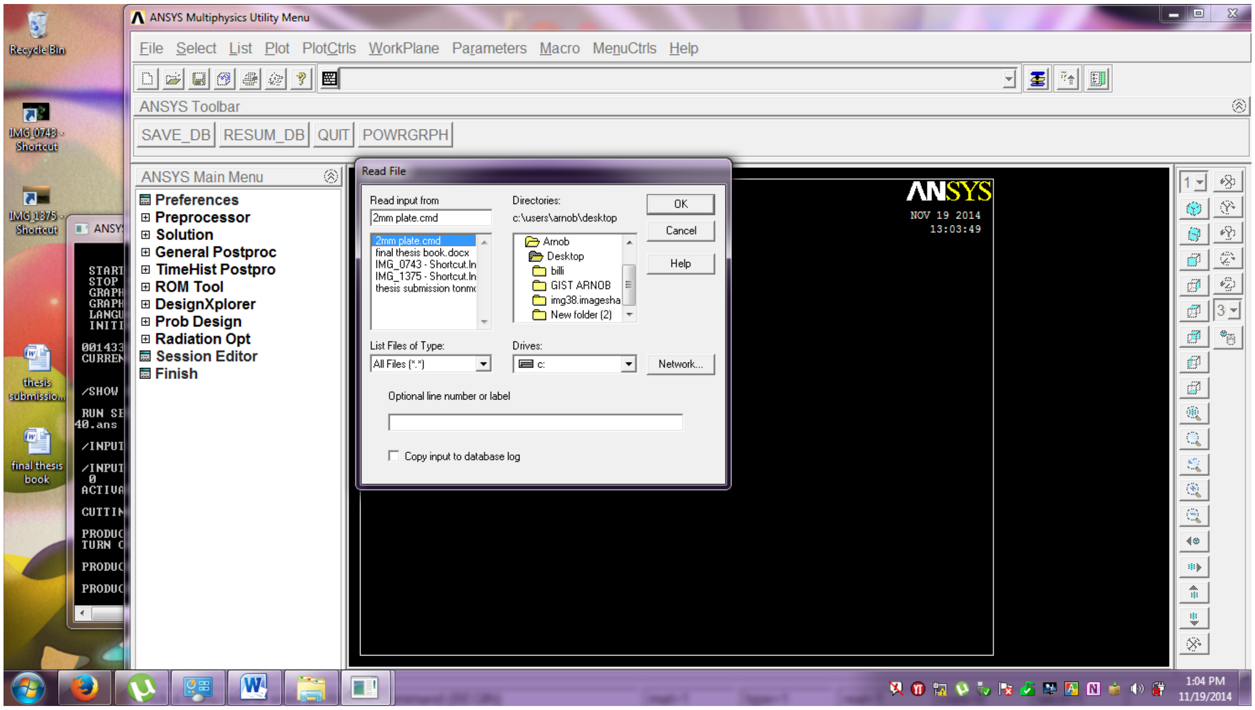
# CODING FOR   ANSYS INPUT:

We can input coding in liew of drawing the geometry.

For 2mm bare simply supported square plate the codings are given below:

Write the codings in notepad and save it in cmd format (eg:NAME.cmd).





CODING:

```
For/prep7
keyw,PR_SET,1
keyw,PR_STRUC,1
rho=7850
nu=0.3
modulas=210e09
et,1,solid185,,3
et,2,mesh200,6
mp,dens,1,rho
mp,ex,1,modulas
mp,prxy,1,nu
length=0.6
width=0.6
thickness=0.002
rectng,0,0.6,0,0.6
/vup,all,z
type,1
mat,1
extopt,esize,10
vext,all,,,,,0.002
type,2
esize,0.01
amesh,1
mshape,0,3d
mshkey,2
TYPE,    1
MAT,        1
REAL,
ESYS,        0
SECNUM,
!*
SMRT,6
```

```
SMRT,5
SMRT,4
ESIZE,0.01,0,
MSHAPE,0,2D
MSHKEY,0
!*
CM,_Y,AREA
ASEL, , , ,        1
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDELE,_Y
CMDELE,_Y1
CMDELE,_Y2
!*
CM,_Y,VOLU
VSEL, , , ,        1
CM,_Y1,VOLU
CHKMSH,'VOLU'
CMSEL,S,_Y
!*
VSWEEP,_Y1
!*
CMDELE,_Y
CMDELE,_Y1
CMDELE,_Y2
NSEL,S,LOC,X,0
NSEL,A,LOC,X,0.6
NSEL,A,LOC,Y,0.6
NSEL,A,LOC,Y,0
FLST,2,480,1,ORDE,4
FITEM,2,1
FITEM,2,-240
FITEM,2,7203
FITEM,2,-7442
D,P51X, , , , , ,UZ, , , , ,
ALLSEL,ALL
FINISH
```

# CHAPTER 4

## RESULTS AND DISCUSSION

### FOR CUTOUT

A simply supported square plate made of mild steel was considered with dimensions of 60cm ×60cm×0.2cm. The geometry of the bare plate structure under this analysis is shown in Figure 1 indicating different positions of the plate. The thickness of the plate is constant in the *z* direction. The material of the plate was chosen to have the mechanical properties defined by Young's modulus 210 GPa, density 7850 Kg/m$^3$ and Poisson's ratio 0.3. A Finite Element Method by ANSYS APDL has been carried out to investigate the natural frequency of bare plate and plate with different sizes and orientations of circular cutouts.

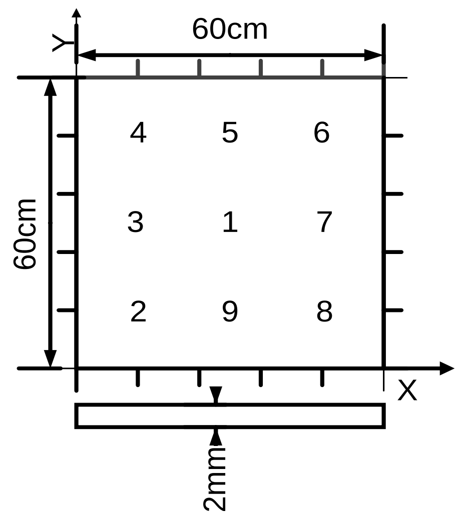



**Figure 3: A simply supported square plate with uniform thickness**

### For Case 1:

A circular cutout is considered at the middle of the plate and the percentage of mass reduction is changed by changing the size of the cutout (cutout circle radius). The natural frequency is compared with the bare plate of different sizes of cutout. (Figure 2).

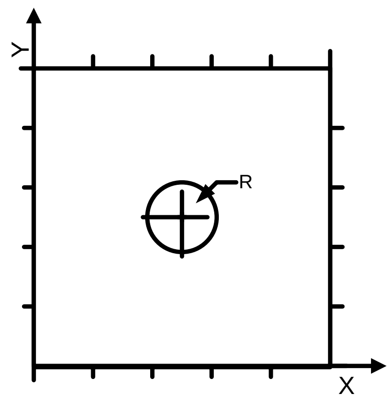



**Figure 4: Circular Cutout of Various Radius (position 1)**

## Results:

The natural frequency of the plate with single cutout for different percentage of mass reduction is compared with the natural frequency of the bare plate for 11 modes is shown in Table 1 and Figure 7. In this case, mass reduction of the plate by single cutout is considered from 0 to 15% of the bare plate mass, where 0% indicates the bare plate. If the reduction of mass is increased as shown in Figure 7, the natural frequency of the plate deviates from the natural frequency of the bare plate shows visible amount of deviation after 5% of the total mass reduction. For 10% mass reduction, the frequency deviation from the bare plate ranges 1-13.6% where the maximum deviation occurs at 6$^{th}$ mode. Again for 15% mass reduction, the frequency deviation from the bare plate ranges 3-38.9% where the maximum deviation occurs also at 6$^{th}$mode.

**Table 1: Natural frequency change due to size of a single cutout at the middle (case1).**

| Mode No | Bare Plate | 3% mass reduction | % of deviation from bare plate | 6% mass reduction | % of deviation from bare plate | **10%** mass reduction | %of deviation from bare plate | **15%** mass reduction | % of deviation from bare plate |
|---|---|---|---|---|---|---|---|---|---|
| 1$^{st}$ | 27.306 | 27.127 | -0.655 | 26.787 | -1.900 | 26.963 | -1.2561 | 29.153 | 6.764 |
| 2$^{nd}$ | 68.288 | 68.291 | 0.0043 | 67.609 | -0.994 | 64.596 | -5.4065 | 59.975 | **-12.173** |
| 3$^{rd}$ | 68.288 | 68.298 | 0.0146 | 67.619 | -0.979 | 64.612 | -5.3830 | 59.958 | **-12.198** |
| 4$^{th}$ | 109.25 | 108.85 | -0.366 | 107.45 | -1.647 | 104.84 | -4.036 | 100.15 | **-8.329** |
| 5$^{th}$ | 136.64 | 135.94 | -0.512 | 133.81 | -2.068 | 129.75 | -5.042 | 122.89 | **-10.062** |
| 6$^{th}$ | 136.64 | 135.65 | -0.724 | 138.75 | 1.547 | 155.23 | **13.605** | 189.83 | **38.927** |
| 7$^{th}$ | 177.59 | 177.62 | 0.0168 | 175.90 | -0.947 | 171.82 | -3.249 | 169.40 | -4.608 |
| 8$^{th}$ | 177.59 | 177.64 | 0.0281 | 175.94 | -0.926 | 171.89 | -3.209 | 169.35 | -4.636 |
| 9$^{th}$ | 232.42 | 232.03 | -0.167 | 226.32 | -2.623 | 220.87 | -4.969 | 239.96 | 3.244 |
| 10$^{th}$ | 232.42 | 231.98 | -0.189 | 226.42 | -2.580 | 220.89 | -4.960 | 240.02 | 3.269 |
| 11$^{th}$ | 245.9 | 245.69 | -0.085 | 250.07 | 1.697 | 263.2 | **7.035** | 260.26 | 5.839 |

## For Case 2:

The single circular cutout of constant radius is placed into several positions on the plate as shown in Figure 3.

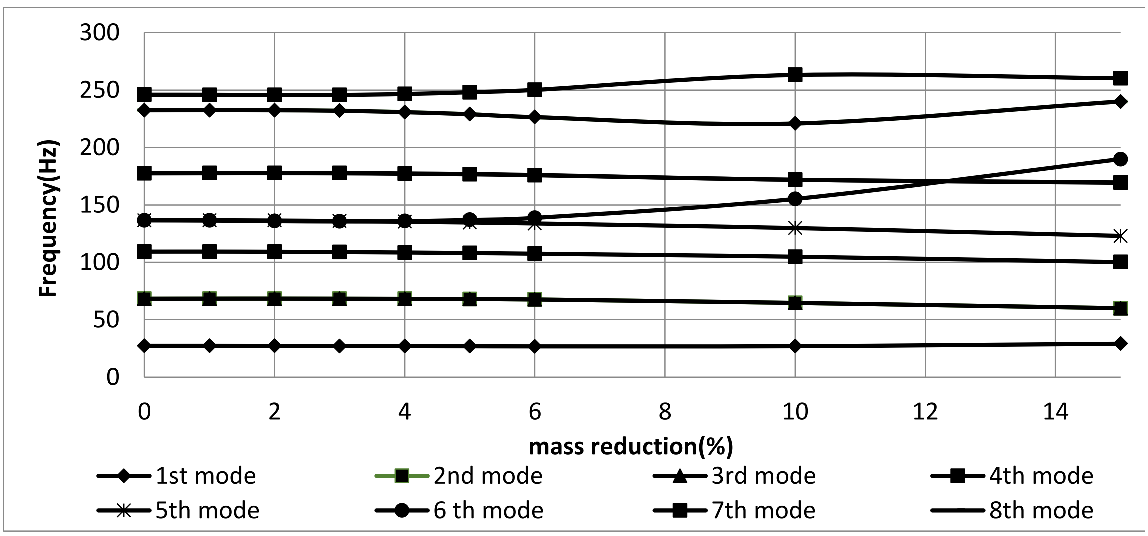
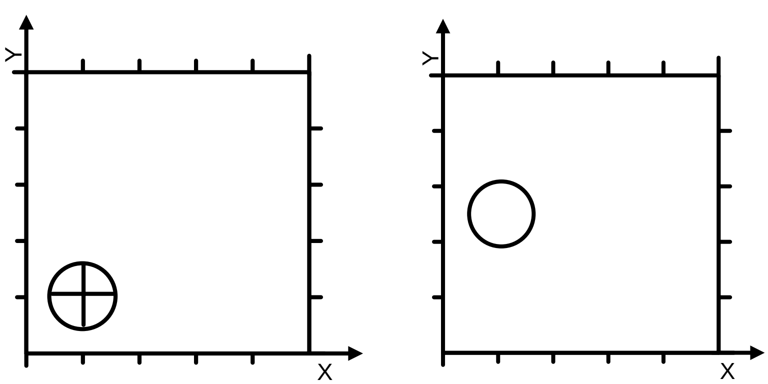



Figure 5 : Natural frequency vs. Mass reduction for plate with single cutout (case1)




**position 2 (center at 0.15m, 0.15m)** **position 3 (center at 0.15m, 0.3m)**

**Figure 6: Circular Cutout at Various Positions**

## Results:

Cutout at position 1 is now changes to position 2 and position 3 (Figure 3) to observe the change of natural frequency compared to bare plate and case1. Mass reduction is considered in this case only for 10% & 15 %.

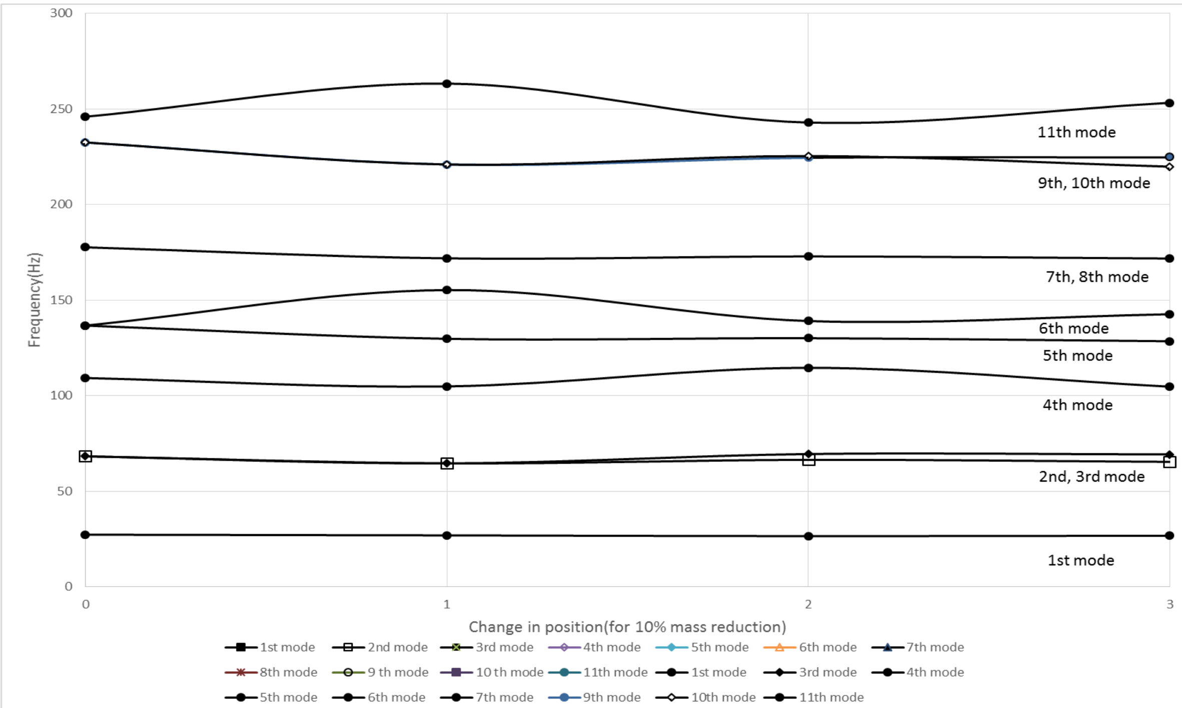



**Figure 7:** Natural Frequency vs. Position of Cutout (for 10% mass reduction)

**Table 1: Natural Frequency of 10% Mass Reduction Due to Change in Position**

For cutout with 10% reduction of the total mass, the deviation is between 1-13.6% when it is situated at position 1 (Table 3). The % of deviation shows between1-5.68 for position 2 which is much less than position 1(case 1). The maximum deviation which was at 6$^{th}$ mode in position 1 is now shifted to 8$^{th}$ mode. The % of deviation shows between1-8.1% for position 3 which is much less than position1 (case 1). The maximum deviation which was at 6$^{th}$ mode in position 1 is now

| Mode No. | Natural Frequency(bare plate) | Natural Frequency for cutout at Position 1 | % of deviation from bare plate | Natural Frequency for cutout at Position 2 | % of deviation from bare plate | Natural Frequency for cutout at Position 3 | % of deviation from bare plate |
|---|---|---|---|---|---|---|---|
| 1st | 27.306 | 26.963 | -1.2561 | 26.545 | -2.7869 | 26.792 | -1.8827 |
| 2nd | 68.288 | 64.596 | -5.4065 | 66.464 | -2.6710 | 65.386 | -4.2496 |
| 3rd | 68.288 | 64.612 | -5.3830 | 69.485 | 1.7528 | 69.271 | 1.4394 |
| 4th | 109.25 | 104.84 | -4.0366 | 114.56 | 4.8604 | 104.7 | -4.1647 |
| 5th | 136.64 | 129.75 | -5.0424 | 130.05 | -4.8228 | 128.46 | -5.9865 |
| 6th | 136.64 | 155.23 | **13.6050** | 139.03 | 1.7491 | 142.59 | 4.3545 |
| 7th | 177.59 | 171.82 | -3.2490 | 172.82 | -2.6859 | 171.73 | -3.2997 |
| 8th | 177.59 | 171.89 | -3.2096 | 187.68 | **5.6816** | 192.01 | **8.1198** |
| 9th | 232.42 | 220.87 | -4.9694 | 224.42 | -3.4420 | 224.58 | -3.3732 |
| 10th | 232.42 | 220.89 | -4.9608 | 225.31 | -3.0591 | 219.75 | -5.4513 |
| 11th | 245.9 | 263.2 | **7.0353** | 242.82 | -1.2525 | 253.16 | 2.9524 |

shifted to 8th mode. The data shows for that the maximum deviation increases than position 2.

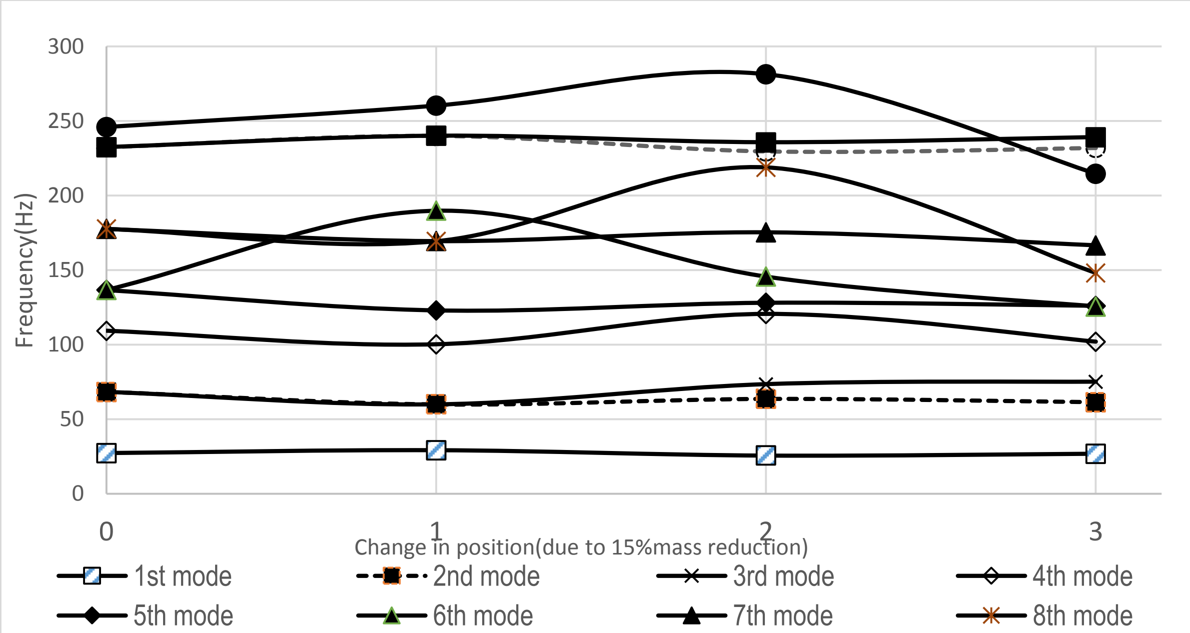



**Figure 8:** Natural Frequency VS Change of Position of Cutout (for 15% mass reduction)

**Table 2: Natural Frequency of 15% Mass Reduction Due to Change in Position**

| Mode No | Natural Frequency (bare plate) | Natural Frequency for cutout at Position 1 | % of deviation | Natural Frequency for cutout at Position 2 | % of deviation | Natural Frequency for cutout at Position 3 | % of deviation |
|---|---|---|---|---|---|---|---|
| 1st | 27.306 | 29.153 | 6.7640 | 25.656 | -6.042 | 26.86 | -1.633 |
| 2nd | 68.288 | 59.975 | -12.173 | 63.616 | -6.841 | 61.459 | -10.000 |
| 3rd | 68.288 | 59.958 | -12.198 | 73.452 | 7.562 | 75.085 | 9.953 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4th | 109.25 | 100.15 | -8.329 | 120.53 | 10.325 | 101.92 | -6.709 |
| 5th | 136.64 | 122.89 | -10.062 | 128.06 | -6.2792 | 126 | -7.786 |
| 6th | 136.64 | 189.83 | **38.927** | 145.62 | 6.572 | 125.61 | -8.072 |
| 7th | 177.59 | 169.406 | -4.608 | 175.35 | -1.261 | 166.6 | -6.188 |
| 8th | 177.59 | 169.356 | -4.636 | 218.89 | **23.255** | 148.15 | **-16.577** |
| 9th | 232.42 | 239.96 | 3.244 | 229.62 | -1.204 | 231.91 | -0.219 |
| 10th | 232.42 | 240.02 | 3.2699 | 235.67 | 1.398 | 239.11 | 2.878 |
| 11th | 245.9 | 260.26 | 5.839 | 281.3 | 14.396 | 214.63 | -12.716 |

For cutout with 15% reduction, the deviation is between 3.24-38.92% when it is situated at position 1 (Table 4). The % of deviation shows between1.2-23.25 for position 2 which is much less than position 1(case 1). The maximum deviation which was at 6$^{th}$ mode in position 1 is now shifted to 8$^{th}$ mode.

The % of deviation shows between1-8.1 for position 3 which is much less than position 1(case 1). The maximum deviation which was at 6$^{th}$ mode in position 1 is now shifted to 8$^{th}$ mode. The data shows for that the maximum deviation increases than position 2.

## For Case 3:

Same amount of cutout of case 1 is equally distributed into two cutouts on the plate with a distance ***d***. Then the natural frequency is compared with the bare plate's natural frequency and with the natural frequency of plate with single cutout (Figure 4).

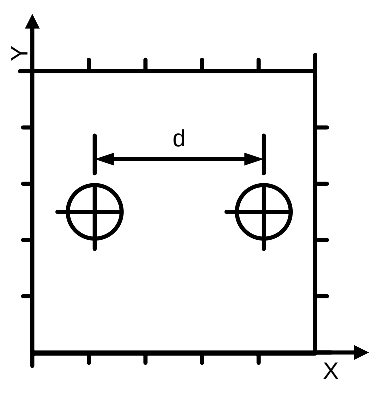



**Figure 4: Circular cutout distributed equally at two positions.**

## Results:

Cutout at position1 (case 1) is now divided into two cutout to observe the change of natural frequency compared to bare plate. Mass reduction are considered in this case only for 10% & 15 %, which show significant deviation of natural frequency from bare plate.

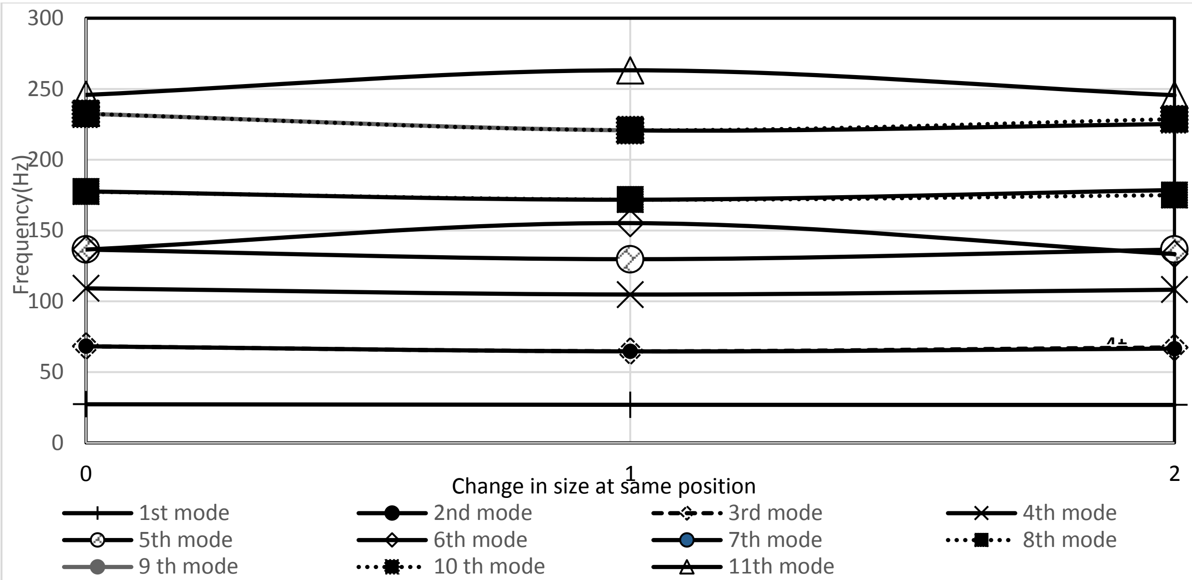



**Figure 9: Natural Frequency VS Distribution of Mass Reduction (for 10% mass reduction)**

For single cutout with 10% reduction, the deviation is between 1.2-13.6% when it is situated at position 1 (Figure 3). The % of deviation shows between0.1-3.04 for 2

| Mode no. | Natural frequency for bare plate | Natural frequency for single cutout (case 1) | % of deviation | Natural frequency for two cutout | % of deviation |
|---|---|---|---|---|---|
| 1st | 27.306 | 26.963 | -1.25613 | 26.866 | -1.61137 |
| 2nd | 68.288 | 64.596 | -5.40651 | 66.611 | -2.45578 |
| 3rd | 68.288 | 64.612 | -5.38308 | 67.467 | -1.20226 |
| 4th | 109.25 | 104.84 | -4.03661 | 108.27 | -0.89703 |
| 5th | 136.64 | 129.75 | -5.04245 | 136.66 | 0.014637 |
| 6th | 136.64 | 155.23 | **13.60509** | 133.47 | -2.31996 |
| 7th | 177.59 | 171.82 | -3.24906 | 178.55 | 0.540571 |
| 8th | 177.59 | 171.89 | -3.20964 | 175.1 | -1.40211 |
| 9th | 232.42 | 220.87 | -4.96945 | 225.34 | **-3.04621** |
| 10th | 232.42 | 220.89 | -4.96085 | 228.63 | -1.63067 |
| 11th | 245.9 | 263.2 | 7.03538 | 245.69 | -0.0854 |

**Table 3: Natural frequency Due to Distribution of cutout (10%)**

Cutout which is much less than single cutout (case 1). The maximum deviation which was at 6th mode at the middle is now shifted to 9th mode for two cutout. In this case the data shows that the deviation is less than the shifting the position of the cutout. For single cutout with 15% reduction, the deviation is between 3.2-38.9% when it is situated at position 1 (Figure 3). The % of deviation shows between 0.13-8.71% for 2 cutout which is much less than single cutout (case 1). The maximum deviation which was at 6th mode at the middle is now shifted to 9th mode for two cutout. In this case the data shows that the deviation is less than the shifting the position of the cutout.

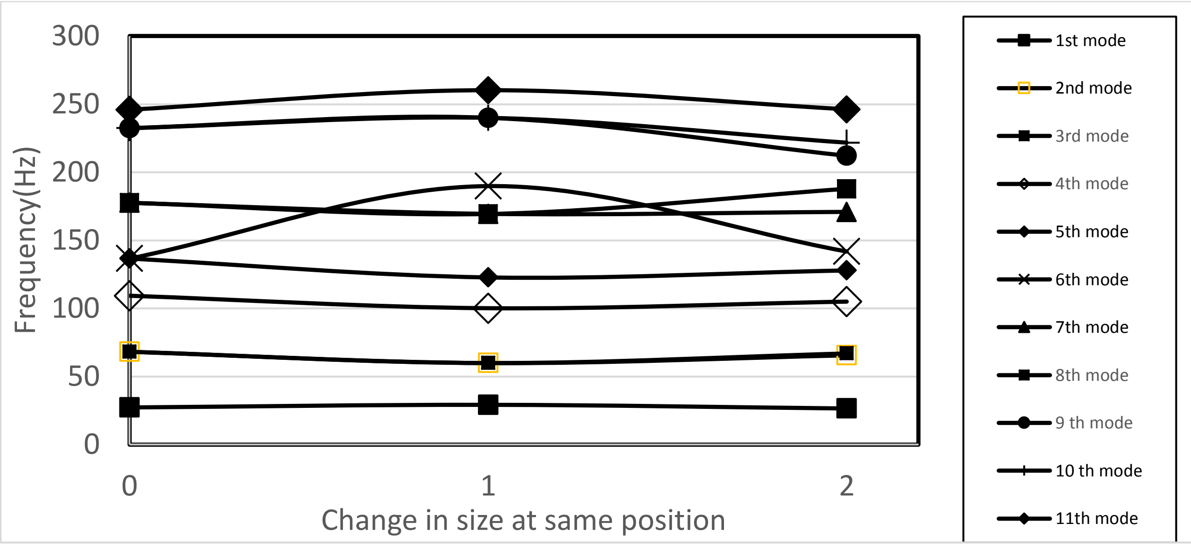


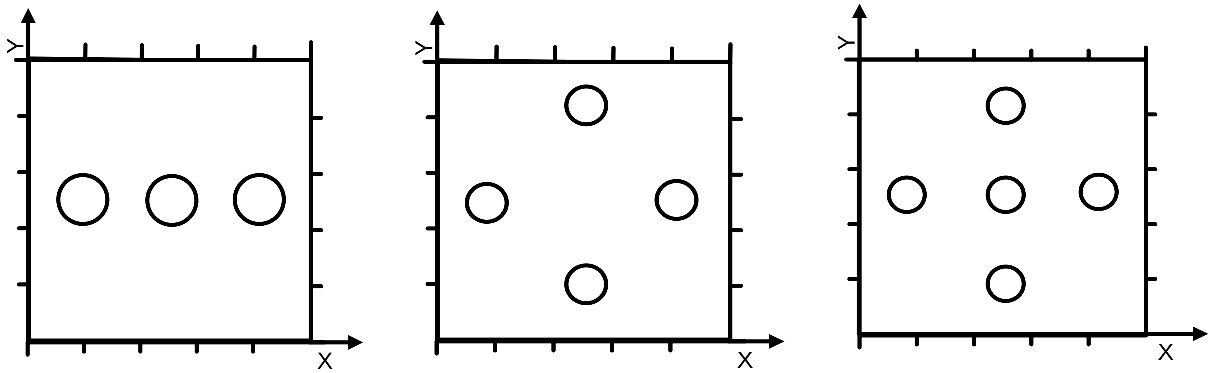

**Figure 10: Natural Frequency VS Distribution of Mass Reduction (15% mass reduction)**

**Table 4: Natural frequency Due to Distribution of cutout (15%)**

| Mode no. | Natural frequency for bare plate | Natural frequency for single cutout | % of deviation from bare plate | Natural frequency for double | % of deviation from bare plate |
|---|---|---|---|---|---|
| 1 | 27.306 | 29.153 | 6.764081 | 26.567 | -2.70636 |
| 2 | 68.288 | 59.975 | -12.1734 | 65.663 | -3.84401 |
| 3 | 68.288 | 59.958 | -12.1983 | 67.052 | -1.80998 |
| 4 | 109.25 | 100.15 | -8.32952 | 104.97 | -3.91762 |
| 5 | 136.64 | 122.89 | -10.0629 | 128 | -6.32319 |
| 6 | 136.64 | 189.83 | **38.92711** | 141.83 | 3.798302 |
| 7 | 177.59 | 169.406 | -4.60837 | 170.87 | -3.784 |
| 8 | 177.59 | 169.356 | -4.63652 | 187.87 | 5.788614 |
| 9 | 232.42 | 239.96 | 3.244127 | 212.17 | **-8.71268** |
| 10 | 232.42 | 240.02 | 3.269942 | 221.74 | -4.59513 |
| 11 | 245.9 | 260.26 | 5.839772 | 246.22 | 0.130134 |

## For Case 4:

The single circular cutout of case 1 is distributed equally into three, four and five different positions of the plate (Figure 5).




**(a)** **(b)** **(c)**

Figure 5: Circular cutout distributed equally at different positions.

Cutout at position (case 1) is now divided into 2,3 and 4 circular cutouts to observe the change of natural frequency compared to bare plate of case1. Mass reduction are considered in this case only for 10%. For single cutout the deviation is between 1.2-13.6% when it is situated at position 1 **(**Table 7). The % of deviation shows between0.1-3.04 for 2 cutout which is much less than single cutout (case 1). The % of deviation shows between0.03-1.2 for 4 cutouts which is much less than 3 cutouts. It shows that the more the no of cut the deviation becomes lower. The maximum deviation which was at 6$^{th}$ mode for single cutout is now shifted to 5$^{th}$ mode for four cutouts.

**Table 5: Natural frequency Due to Distribution of cutout (10%)**

| Mode no | Bare plate | 1 cutout (case 1) | %of deviation from bare | 2 cutout | % of deviation from bare | 3 cutout | % of deviation from bare plate | 4 cutout | % of deviation from | 5 cutout | % of deviation from bare |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.3 | 26.96 | -1.25 | 26.86 | 1.61 | 26.85 | 1.66 | 27.6 | -1.07 | 27.05 | 0.926 |
| 2 | 68.28 | 64.59 | -5.41 | 66.6 | 2.46 | 67.1 | 1.78 | 69.23 | -1.388 | 67.74 | 0.789 |
| 3 | 68.29 | 64.61 | -5.38 | 67.46 | 1.202 | 67.96 | 0.47 | 69.016 | -1.06 | 67.77 | 0.758 |
| 4 | 109.23 | 104.8 | -4.036 | 108.2 | 0.897 | 108.5 | 0.68 | 111.6 | -2.15 | 109.2 | 0.045 |
| 5 | 136.6 | 129.7 | -5.042 | 136.66 | -0.01 | 134.67 | 1.441 | 138.31 | -1.22 | 134.89 | **1.280** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 136.6 | 155.2 | **13.60** | 133.4 | 2.319 | 134.1 | **1.836** | 139.12 | -1.81 | 135.3 | 0.966 |
| 7 | 177.59 | 171.8 | -3.25 | 178.6 | -0.54 | 176.3 | 0.755 | 180.3 | -1.52 | 176.5 | 0.613 |
| 8 | 177.59 | 171.8 | -3.21 | 175.1 | 1.402 | 176.5 | 0.591 | 180.75 | -1.78 | 176.54 | 0.591 |
| 9 | 232.4 | 220.8 | -4.96 | 225.3 | **3.046** | 229.8 | 1.118 | 236.88 | -1.92 | 232.2 | 0.086 |
| 10 | 232.4 | 220.9 | -4.96 | 228.6 | 1.630 | 230.5 | 0.8174 | 238.35 | **-2.55** | 232.33 | 0.038 |
| 11 | 245.9 | 263.2 | 7.035 | 245.69 | 0.085 | 244.9 | 0.378 | 251.03 | -2.08 | 244.57 | 0.54 |

## For Case 5:

The distributed three and five cutouts of case 4 are relocated into different orientation of the plate

## Results:

Previously we saw, for three circular cutout as shown in figure 5(a), the maximum frequency deviation was 1.83% (6$^{th}$ mode). At the time we change the orientation of these cutout as shown in figure 6(a) the maximum frequency deviation reduces to 1.59%. So the frequency become closer to the natural frequency of the bare plate. But the maximum deviation changes its mode. Now it occurs at first mode.

Again when the orientation of five circular cutout is changed as shown in figure 6(b). We can see that the maximum frequency deviation does not change more. It just changes its mode. Previously the maximum deviation occurs at fifth mode now it shifts to fourth mode.

**Table 6: Natural Frequency Due to Orientation of cutout (10%)**

| Mode NO | Bare plate | 3 cutout | % of deviation from bare plate | 5 cutout | % of deviation from bare plate |
|---|---|---|---|---|---|
| 1 | 27.306 | 26.871 | **-1.59306** | 27.095 | -0.77272 |
| 2 | 68.288 | 67.33 | -1.40288 | 67.832 | -0.66776 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 68.288 | 67.993 | -0.43199 | 67.882 | -0.59454 |
| 4 | 109.25 | 107.57 | -1.53776 | 107.85 | **-1.28146** |
| 5 | 136.64 | 134.99 | -1.20755 | 136.13 | -0.37324 |
| 6 | 136.64 | 134.67 | -1.44174 | 135.16 | -1.08314 |
| 7 | 177.59 | 176.16 | -0.80523 | 176.72 | -0.48989 |
| 8 | 177.59 | 176.89 | -0.39417 | 176.76 | -0.46737 |
| 9 | 232.42 | 230.22 | -0.94656 | 232.28 | -0.06024 |
| 10 | 232.42 | 230.78 | -0.70562 | 232.31 | -0.04733 |
| 11 | 245.9 | 244.51 | -0.56527 | 244.69 | -0.49207 |

## Conclusion:

Investigation has been done for single cutout, change of position of single cutout and double (distributed) cutout. The findings can be summarized as bellow:

1) Mass reduction (cutouts) affects the natural frequency of plate mainly after a certain value and significant above the 5%.
2) No single position shows the minimum division of natural frequency from the bare plate for all modes. No of cutout also affects the natural frequency of the plate, although the amount of mass reduction is same for single cut at the middle.
3) Increases in the no of cutout with this specified orientation (Figure 5) decreases the deviation of the natural frequency.
4) Validation has been made for this simulation for single cut and has been found in good agreement.
5) Limitation: Different orientation of circular cutout change the natural frequency of the plate. In this literature we have analyzed only for two different orientation. Other orientations show the significant change of natural frequency.

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