CUSTOMER SUPPORT NOTE

# Nonlinear Implicit Dynamic Example for Impact Analysis

| Note Number: | **CSN/LUSAS/1032** |
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This support note is issued as a guideline only.

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# 1. Introduction

Impact analysis may be required to monitor cases when two bodies come together with some relative velocity. After incidence takes place, the two bodies will interact in a small contact area at the interface between them. The pressure in the contact area may results in permanent local deformation and consequent indentation.

At each instant during impact a resultant force due to contact pressure acts in opposite directions (action/reaction) on both bodies, thus resisting interpenetration. This force increases while the speed of the colliding bodies decreases, until the latter turns to zero. Then, the stored energy during compression may drive the two bodies apart until they completely separate.

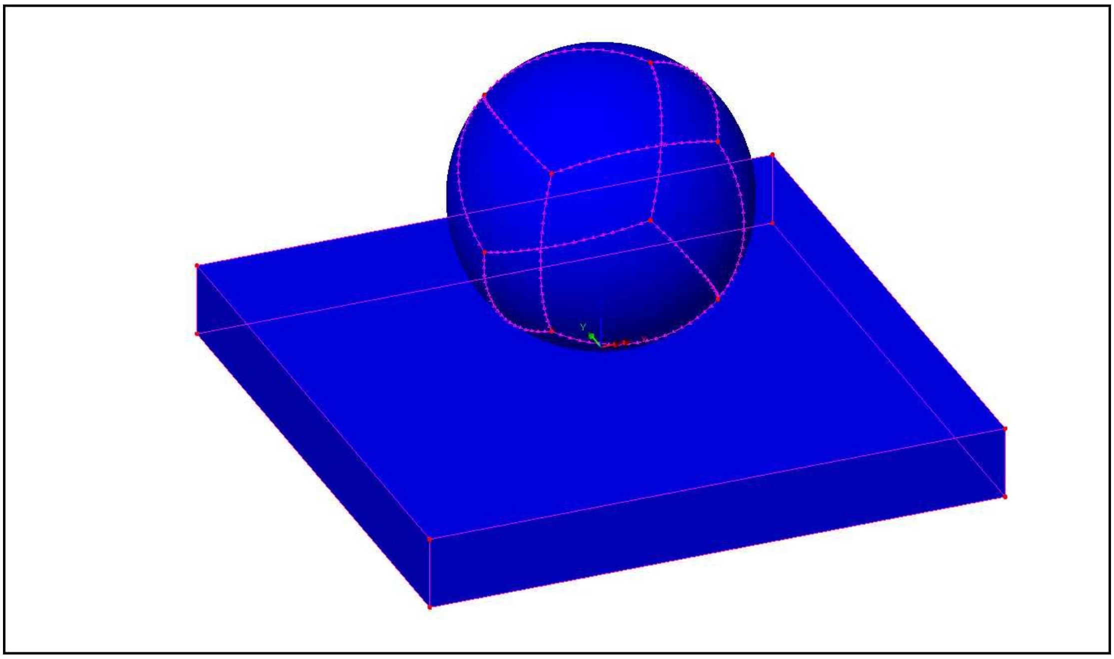
The initial velocity and hardness of the surfaces in contact affects directly the local deformations arising during impact; low speed collisions lead to small deformation in the contact area and hard bodies require small deformations to generate high contact pressures.

# 2. Description

## 2.1 Geometry - Volume Features

As an example, here a sphere of radius 0.025m is modelled in a small distance e.g. 0.01m from a cuboid of0.40m x 0.40m x 0.05m.

Units used are N,m,kg,s,C



## 2.2 Mesh attributes

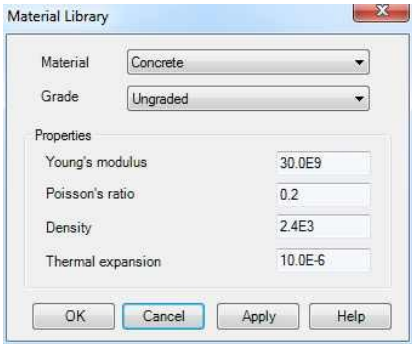
The vertical lines of the cuboid have a null mesh attribute with one division, while the rest of the model has six divisions in this simple test.

Stress hexahedral elements with a linear interpolation order (HX8M) are used throughout.

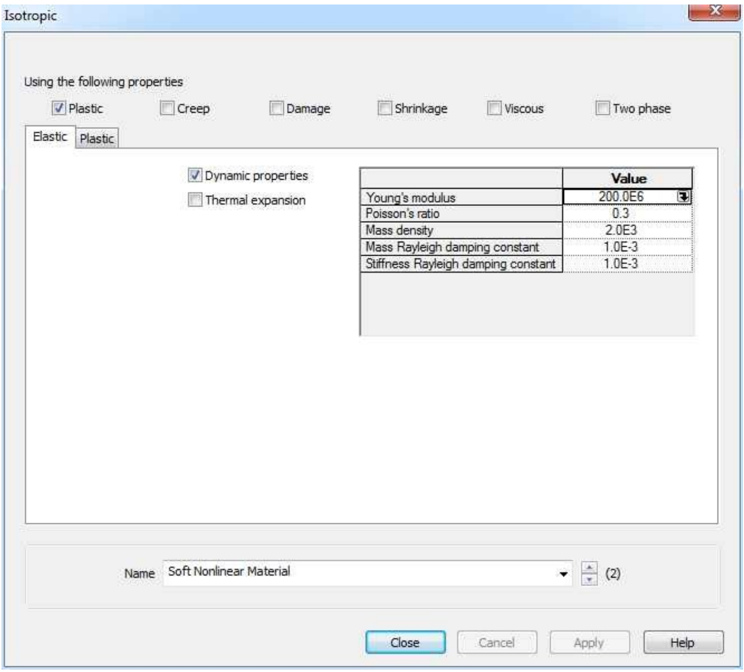
## 2.3 Material attributes

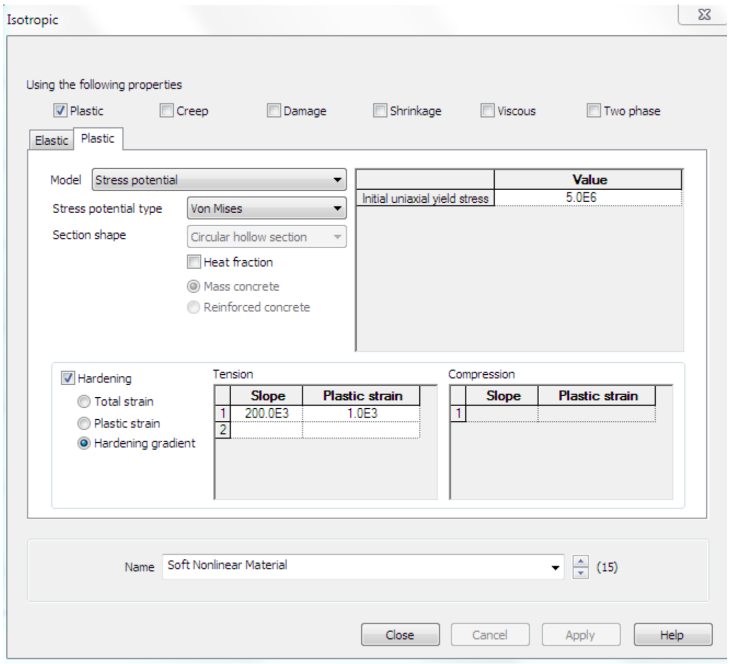
A linear ungraded concrete material is on the cuboid to represent a hard material

*Attributes > Material > Material Library*



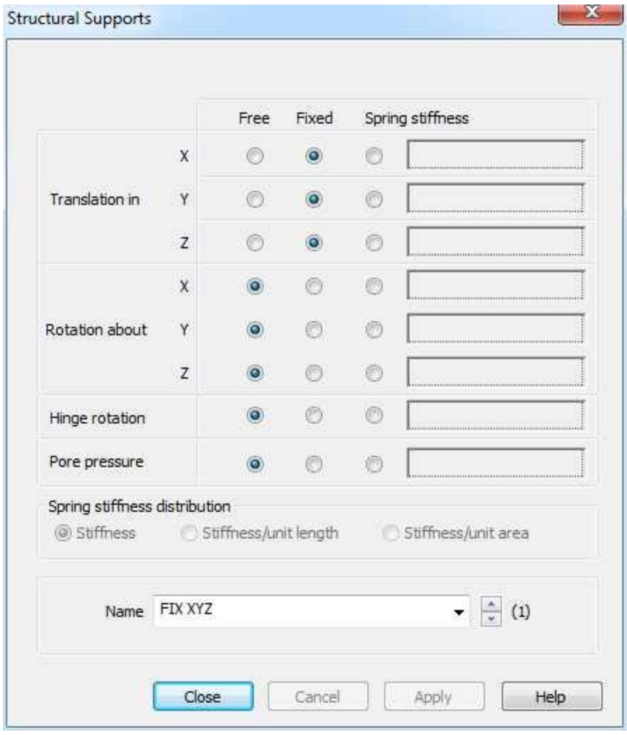

The ball is represented with a soft plastic material with Rayleigh damping. Providing a small hardening slope (about E/1000) is recommended, as it can help overcome numerical difficulties in nonlinear models.



## 2.4 Support attributes

Support attributes are assigned at the bottom surface of the cuboid.




Select the supported surface of the base volume and drag and drop the support attribute onto the model.

## 2.5 Loading attributes

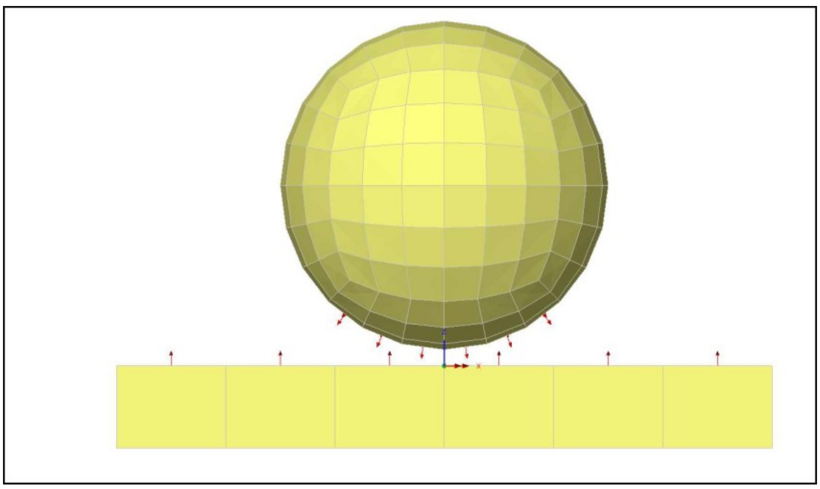
An initial velocity of -15m/sec is assigned onto the ball along the vertical axis.

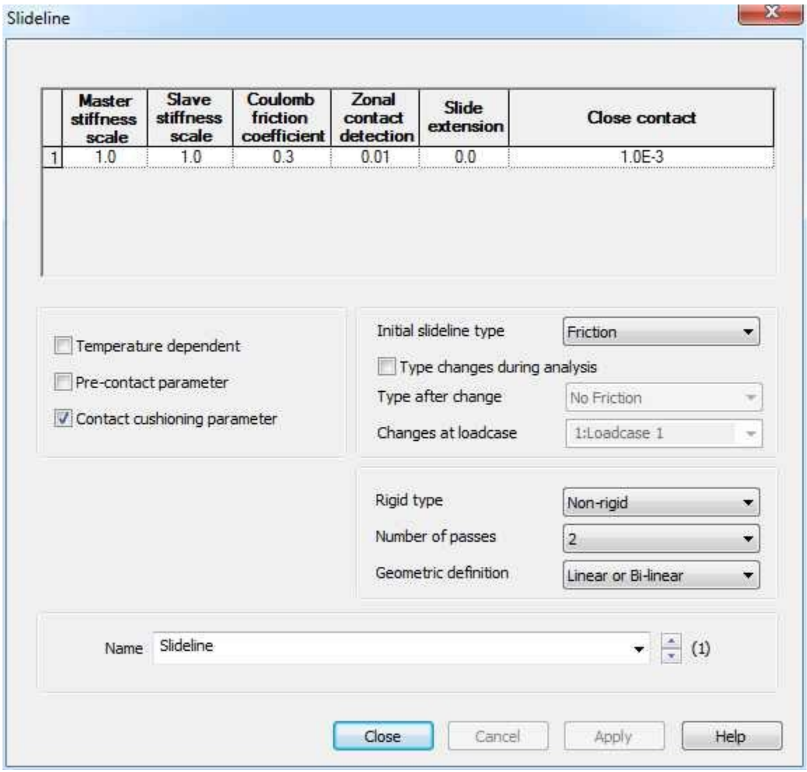
*Attributes* > *Loading* > *Velocity*

## 2.6 Slideline attributes

A friction type slideline is used between the upper surface of the cuboid (master) and the lower surface of the ball (slave).

*Attributes* > *Slideline*





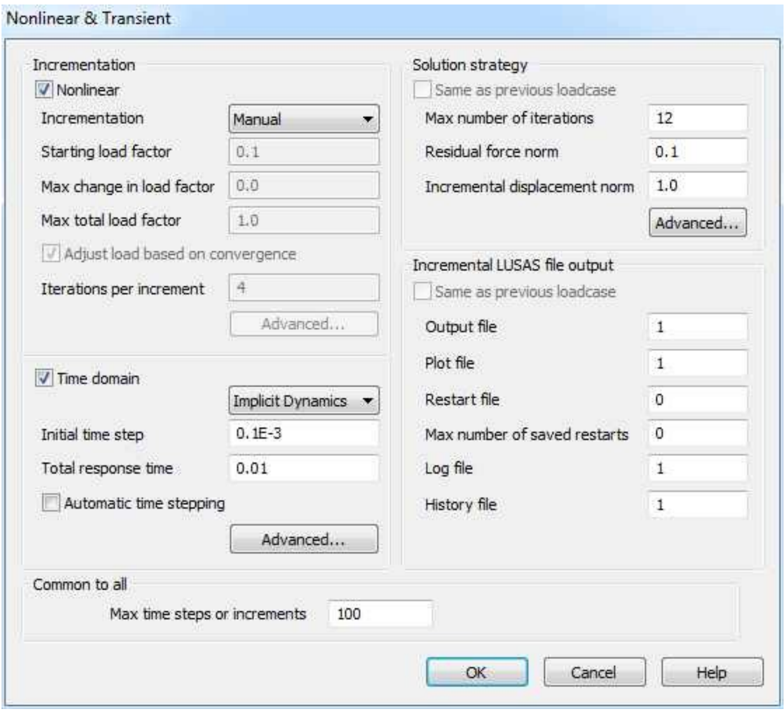

A friction coefficient of 0.3 between the two colliding bodies was defined.

Contact cushioning can be used when convergence difficulties related to in-contact/out-of-contact chatter are experienced. Contact cushioning can help improve nonlinear convergence when chatter is encountered and the set of active contact nodes is continually changing, as in this case when the two bodies collide.

## 2.7 Nonlinear controls

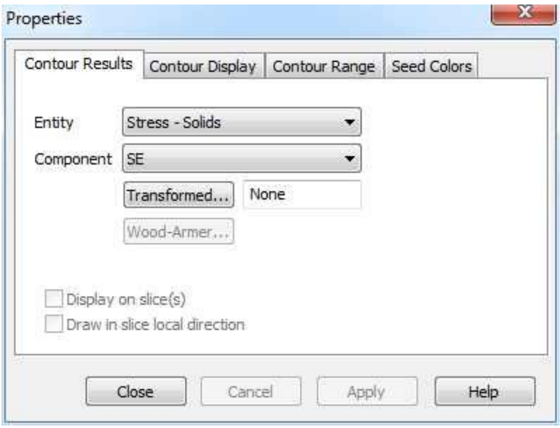
Impact analyses are commonly performed using explicit elements, however here we use implicit elements with very small time steps to monitor the impact. Implicit elements have the extra advantage that equilibrium is guaranteed at the end of each time step and increment and thus the solution process is accurate.  For explicit analysis however, since equilibrium is not accounted for, the solution may increasingly drift away from the true nonlinear load-deformation curve as the solution progresses.

The analysis setting is nonlinear implicit dynamics with initial time step of 0.1E-3sec and total duration is 0.01sec. 100 time steps are monitored and defined in the settings.




## 2.8 Creating contours animation

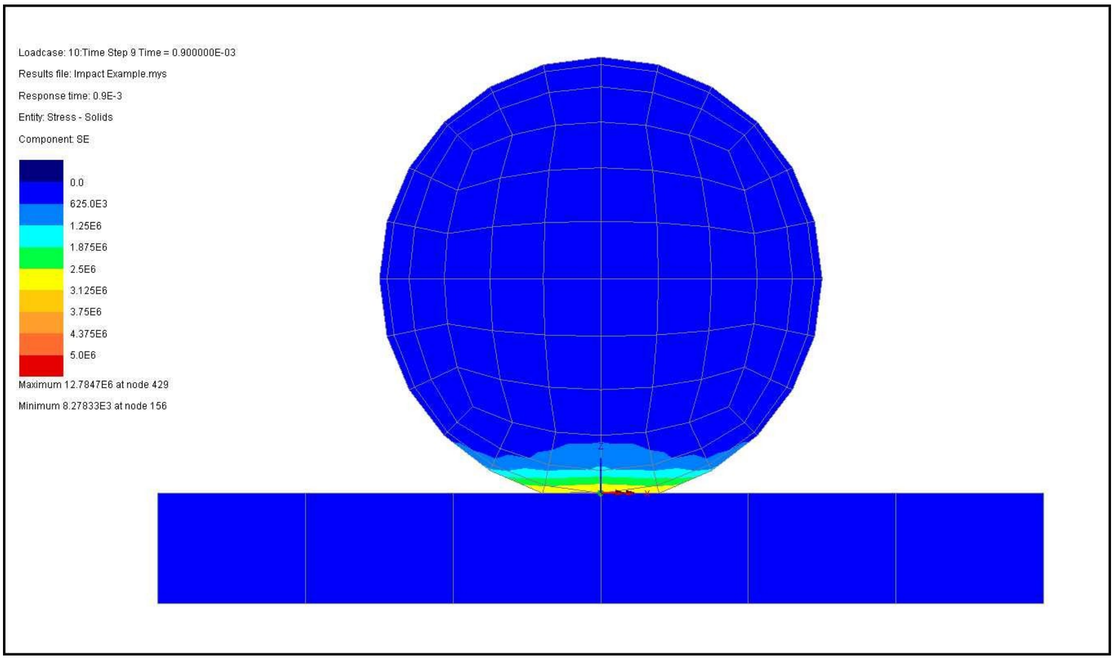
After the analysis runs, Mesh and Geometry layers are turned off, while Deformed mesh and Contours layers are turned on. Deformed mesh must have a scale factor of 1 specified to avoid misleading display of deformations.

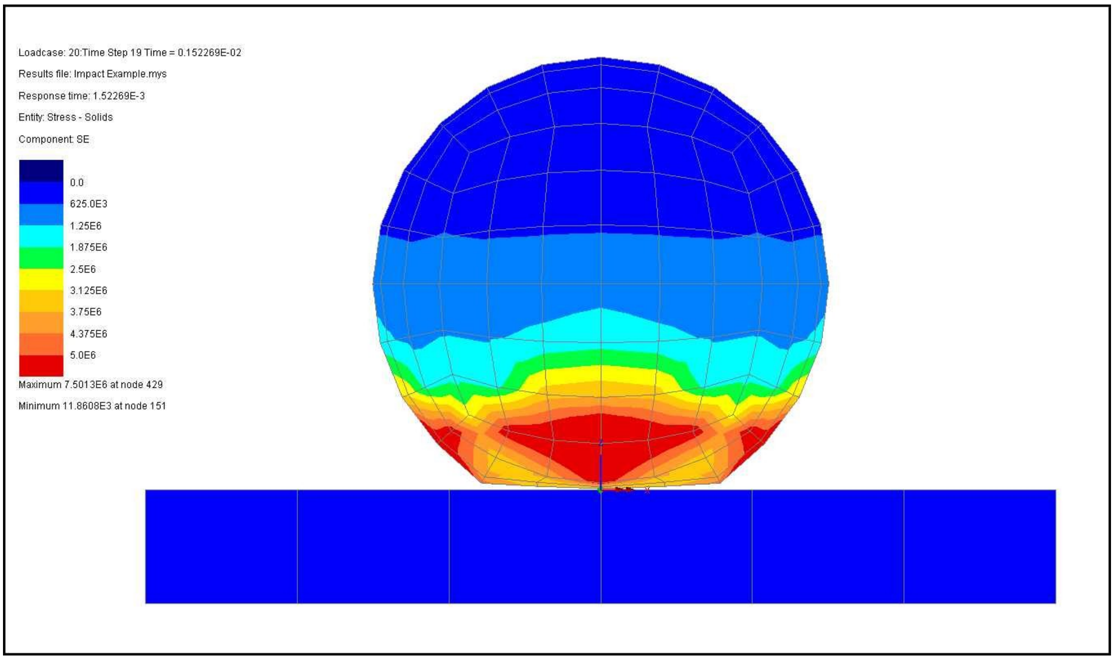


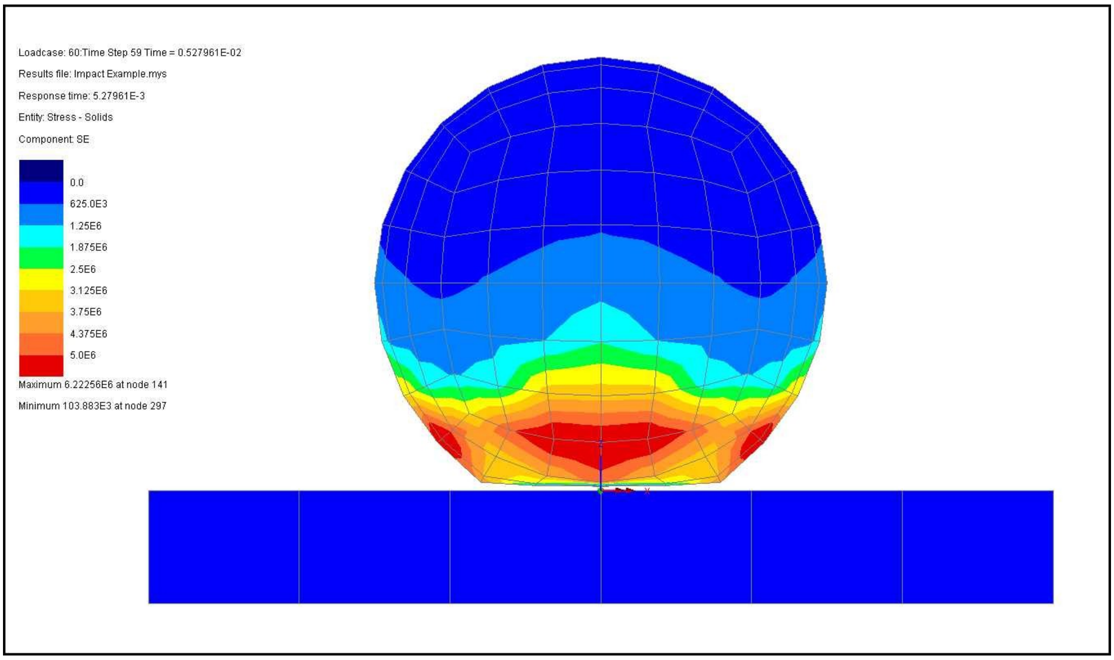

Create an animation of the changing contours for all time steps of the analysis.

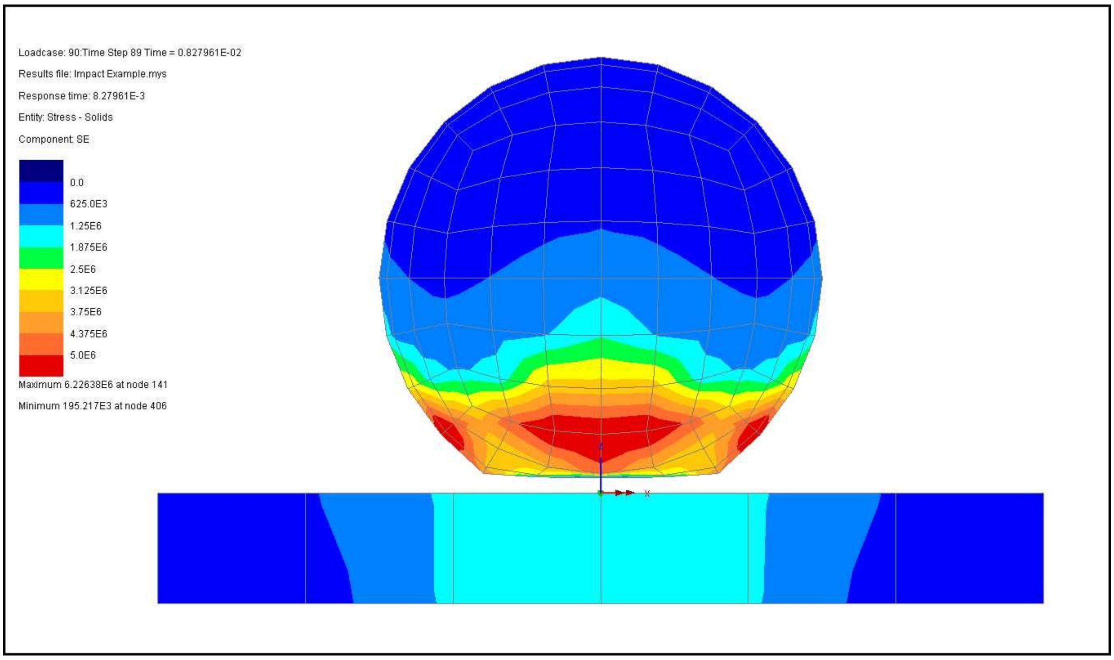
*Utilities > Animation Wizard*

Following the deformed mesh and contours at different time steps are shown. As the ball is much softer than the cuboid it deforms until it bounces back as shown in the following screenshots.


Loadcase: 10:Time Step 9 Time = 0.900000E-03
Results file: Impact Example.mys
Response time: 0.9E-3
Entity: Stress - Solids
Component: SE
0.0
625.0E3
1.25E6
1.875E6
2.5E6
3.125E6
3.75E6
4.375E6
5.0E6
Maximum 12.7847E6 at node 429
Minimum 8.27833E3 at node 156


Loadcase: 20:Time Step 19 Time = 0.152269E-02
Results file: Impact Example.mys
Response time: 1.52269E-3
Entity: Stress - Solids
Component: SE
0.0
625.0E3
1.25E6
1.875E6
2.5E6
3.125E6
3.75E6
4.375E6
5.0E6
Maximum 7.5013E6 at node 429
Minimum 11.8608E3 at node 151




An animation of the repose is provided along with a working model in the downloaded zip file.

## 2.9 Creating velocity vs time graph

Another way to monitor the response of the model over time is to create a velocity vs time graph of a contact node of the two surfaces.

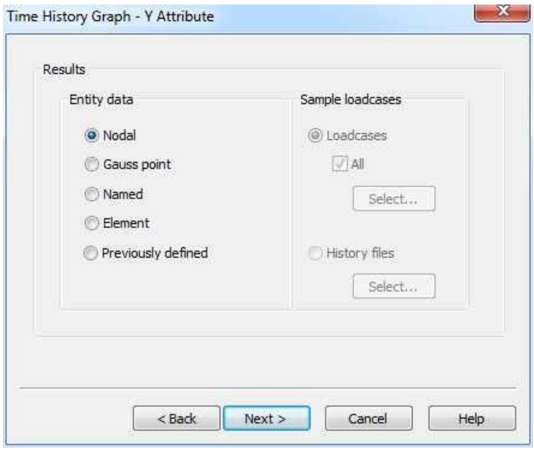
Select a node on the ball ( say node 81) and follow the steps below:

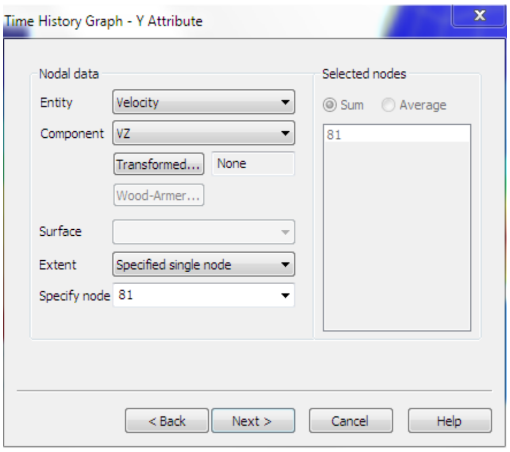
*Utilities > Graph Wizard*

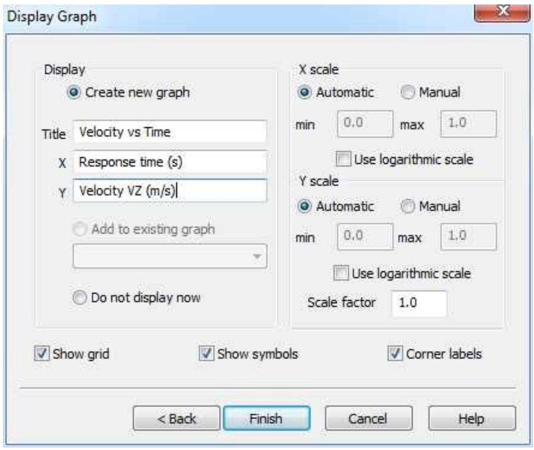

Graph Wizard
Type of graph dataset to generate
Time history
Fourier expansion
Modal expansion
Load curve
Variation
Specified datasets
Thermal surfaces
Slidelines (assigned to lines)
< Back
Next >
Cancel
Help

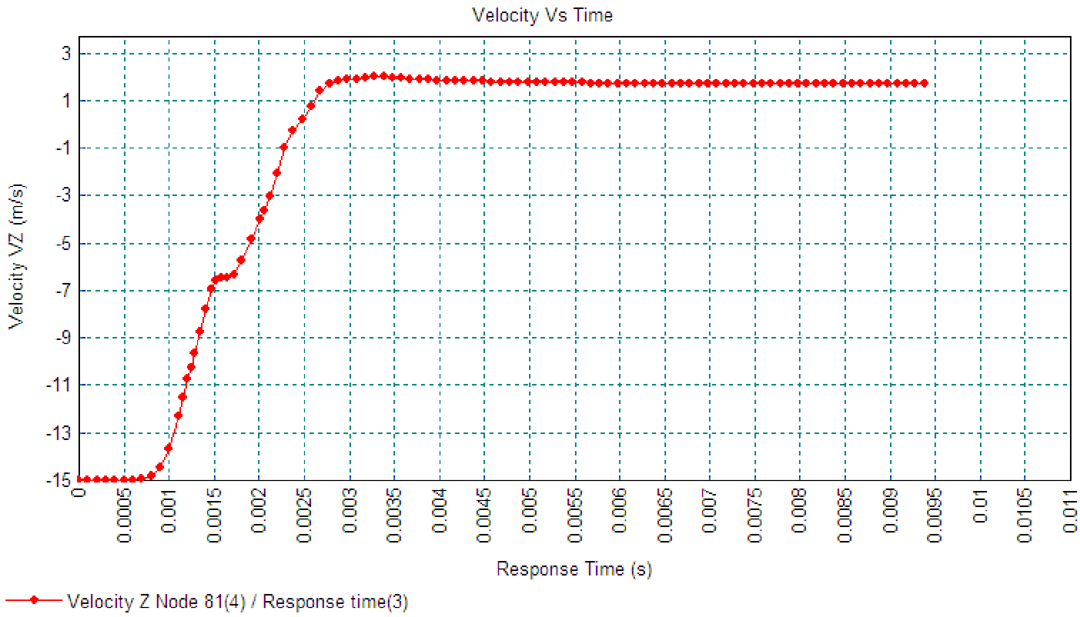

Time History Graph - X Attribute
Results
Entity data
Nodal
Gauss point
Named
Element
Previously defined
Sample loadcases
Loadcases
All
Select...
History files
Select...
< Back
Next >
Cancel
Help


Time History Graph - X Attribute
Named data
Data
Response time
< Back
Next >
Cancel
Help


Time History Graph - Y Attribute
Results
Entity data
Nodal
Gauss point
Named
Element
Previously defined
Sample loadcases
Loadcases
All
Select...
History files
Select...
< Back
Next >
Cancel
Help


Time History Graph - Y Attribute
Nodal data
Entity
Velocity
Component
VZ
Transformed...
None
Wood-Armer...
Surface
Extent
Specified single node
Specify node
81
Selected nodes
Sum
Average
81
< Back
Next >
Cancel
Help


Display Graph
Display
Create new graph
Title
Velocity vs Time
X
Response time (s)
Y
Velocity VZ (m/s)
Add to existing graph
Do not display now
X scale
Automatic
Manual
min
0.0
max
1.0
Use logarithmic scale
Y scale
Automatic
Manual
min
0.0
max
1.0
Use logarithmic scale
Scale factor
1.0
Show grid
Show symbols
Corner labels
< Back
Finish
Cancel
Help




The graph depicts that after 6.0E-4 second the two parts of the model come in contact, hence the value of the vertical velocity increases gradually and the velocity of this node changes direction at 0.0024 second.