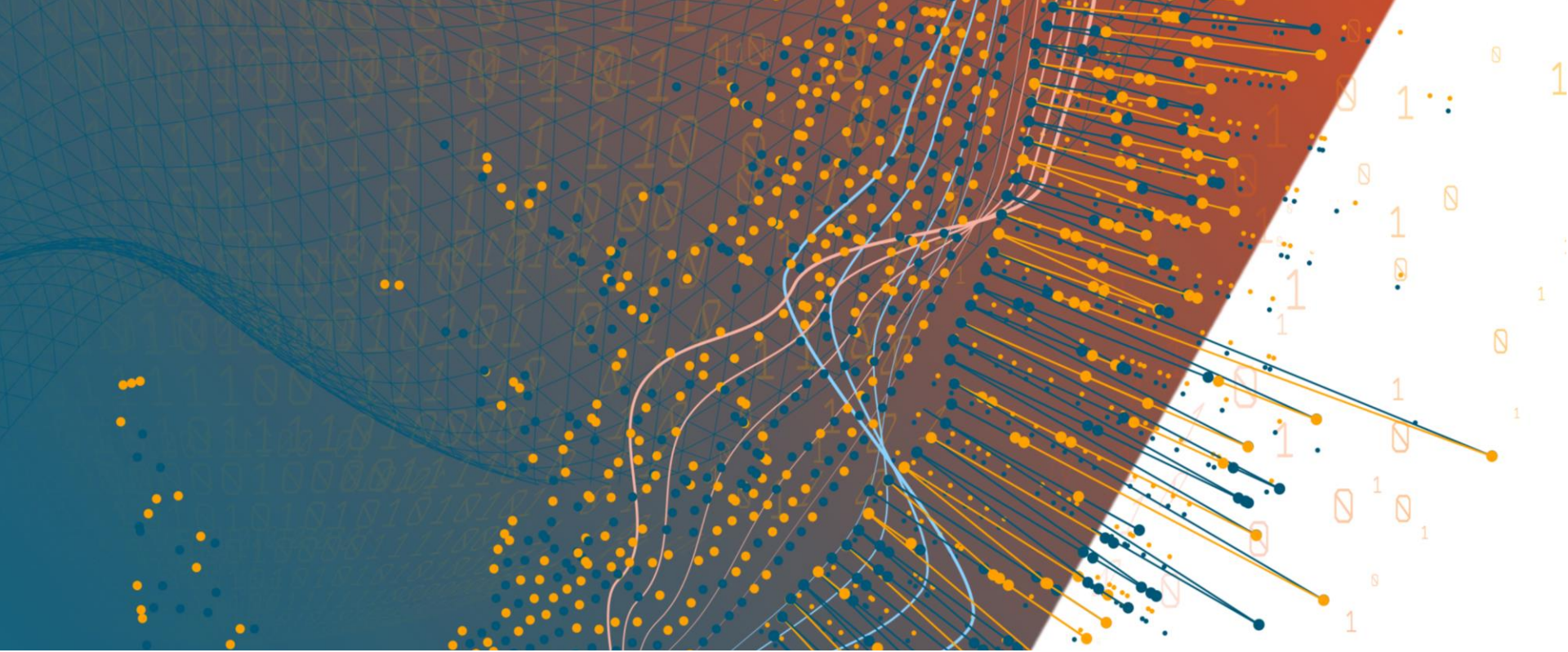

OPTISTRUCT EXPLICIT ANALYSIS SHOWCASE

Mohan Parthasarathy, 10/27/2023

OptiStruct Explicit Analysis Showcase

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Introduction

- The purpose of this document is to showcase some of the capabilities of OptiStruct explicit analysis.
- The intention is not to present an exhaustive set of examples covering all the capabilities.
- Some commonly used applications like analysis of Hyperelastic materials and snap fit analyses are presented. Three examples are presented namely
  - 1) Rubber Ring – Problem taken from Radioss and OptiStruct Example Guides
  - 2) Snap Fit1 – CAD of the snap fit taken from the public domain www.grabcad.com
  - 3) Snap Fit2 – Geometry taken from OS-E:0155 and modified to include sharp corners
- The results from the OptiStruct explicit analysis are compared with the results from OptiStruct implicit static analysis, OptiStruct implicit transient analysis and Radioss explicit analysis, whenever applicable.
- Unless mentioned otherwise, the version used for all OptiStruct and Radioss runs in this study is 2022.3

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Rubber Ring

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Rubber Ring – Original Model Description

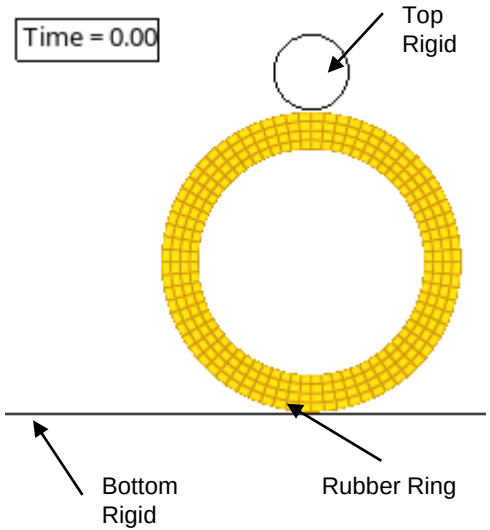
- The Rubber Ring example is presented in both Radioss and OptiStruct Example Guides.

- Original example RD-E: 4200 in the Radioss Example Guide.
  The model in this example uses the Ogden hyper-elastic material law with user defined coefficients. The analysis type is non-linear implicit static, and the contact used is TYPE7. There are two load steps. In the first load step, the Top Rigid is pushed down until the self-contact of the Rubber Ring is just initiated. The second load step involves rotating and translating the Top Rigid so that the compressed Rubber Ring rolls along the surface of the Bottom Rigid.

- Original example OS-E: 0185 in the OptiStruct Example Guide.
  The model in this example uses the same loading sequence as in the Radioss example but employs the Arruda-Boyce hyper-elastic material law using uniaxial, biaxial and shear test data. The analysis type is non-linear implicit static. Thickness padding (GPAD) is not used for the contacts in this example. The contacts used are N2S (Top Rigid to Rubber Ring, Base Rigid to Rubber Ring) and S2S (Rubber Ring self-contact).

- More details regarding the above two examples can be obtained from the corresponding manual pages of Radioss and OptiStruct Example Guides and the models provided with the software installations.

Original Radioss Example: RD-E: 4200 Animation



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Rubber Ring – Model Modifications

It is typical for a hyper-elastic material to be subjected to strains in excess of 100%. The loading sequence in the original OptiStruct example OS-E: 0185 results in a maximum principal strain of about 44%. In this study, the original OptiStruct example OS-E: 0185 is modified as follows:

- Run1 (OptiStruct):
  - The mesh of the Rubber Ring at the contact areas is refined.
  - The N2S contacts in the original OptiStruct example are switched to S2S.
  - ALM (Augmented Lagrange Multiplier) method is used for the contacts with default contact stiffness.
  - Shell thickness gap is included (GPAD=THICK)
  - The value of the enforced displacement is increased to 7.25mm
  - The material model used for the Rubber Ring is Arruda-Boyce with the same test data as in the original OptiStruct example.
  - The analysis type is non-linear implicit static.

- Run2 (OptiStruct) : Model used is same as that used in Run1 and the analysis type is non-linear implicit transient.

- Run3 (OptiStruct) : Model used is same as that used in Run1 and analysis type is explicit dynamic with AUTO contact. Shell thickness gap is included.

- Run4 (Radioss): The model used is same as that used in Run1. The material law used for the Rubber Ring is Arruda-Boyce (LAW92) with the coefficients obtained from the fit used for the OptiStruct runs. The analysis is explicit dynamic. Isolid=24, Ismstr=10, Icpre=1. Contact used is TYPE24 with Stfac=5 for the Rubber Ring self-contact.

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Rubber Ring – Summary of Runs

Run	Solver	Analysis Type	Element Formulation	Contact Type	Contact Parameters
Run1	OptiStruct	Implicit Static	Default	S2S, CONSLI	GPAD = THICK, MU1 = 0.1 CONTPRM, ALM,YES CONTPRM, ALMPTOL, 0.01
Run2	OptiStruct	Implicit Transient	Default	S2S, CONSLI	
Run3	OptiStruct	Explicit	ISOPE=AURI	AUTO Contact	GPAD = THICK, MU1 = 0.1
Run4	Radioss	Explicit	Isolid = 24, Icpre = 1, Ismstr = 10	TYPE24	Fric = 0.1, Stfac = 5 for Rubber Ring self contact

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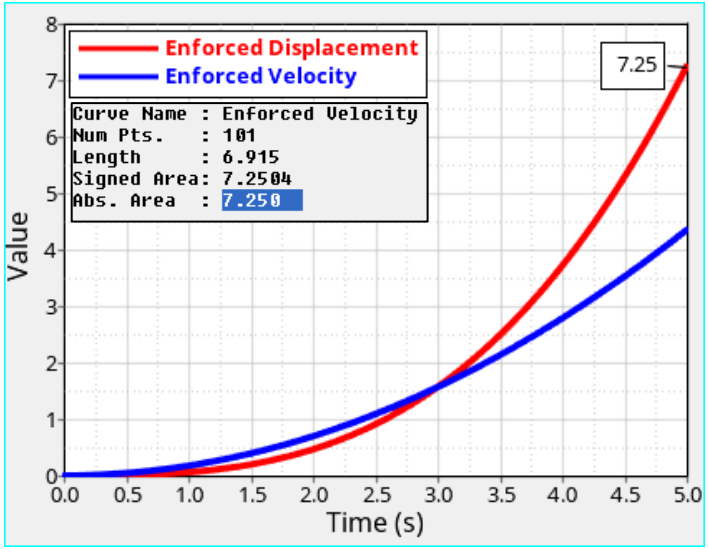
Rubber Ring – Load Curve

Enforced Motion Curves



Enforced displacement was used for the implicit runs (Run1 & Run2)
Enforced velocity was used for the explicit runs (Run3 & Run4). It is preferable to use enforced velocity in an explicit analysis instead of enforced displacement, to avoid any spikes in the force results.

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Initial portion of the simulation is not shown

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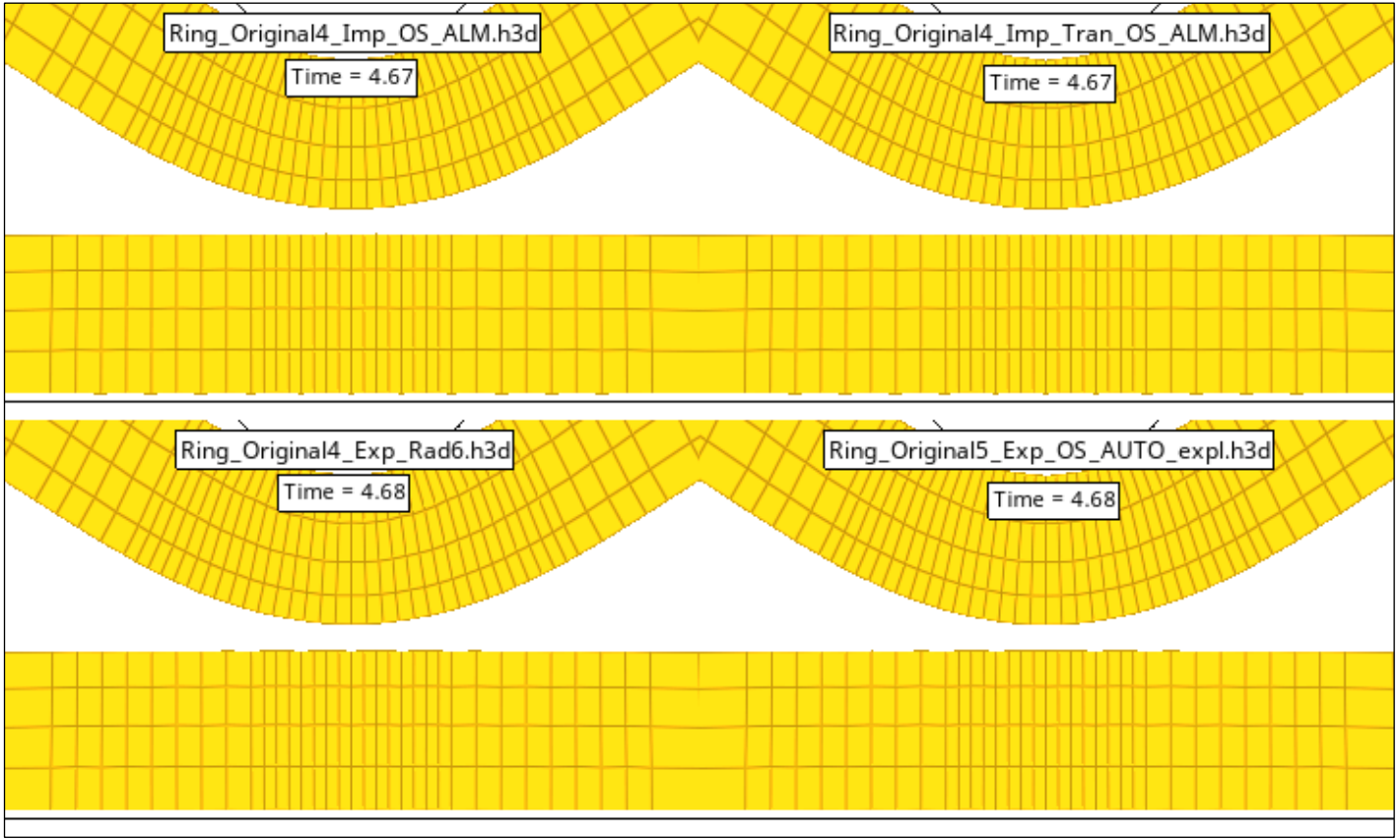
Rubber Ring – Animations

Run1: OptiStruct Implicit Static (S2S, ALM)

Run2: OptiStruct Implicit Transient (S2S, ALM)



Run3: Radioss Explicit (TYPE24, Stfac=5)

Run4: OptiStruct Explicit (AUTO Contact)

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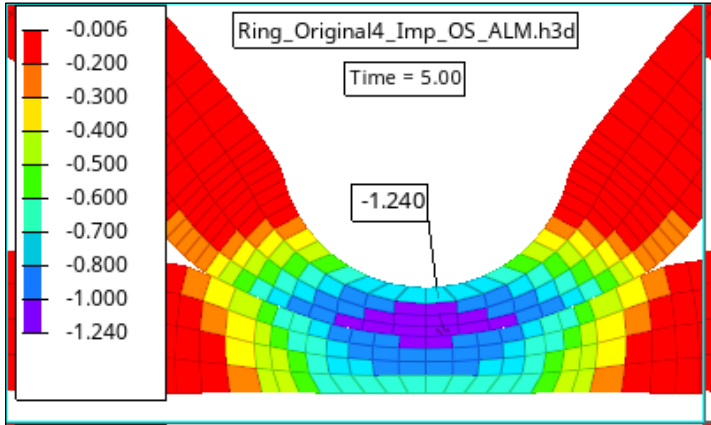
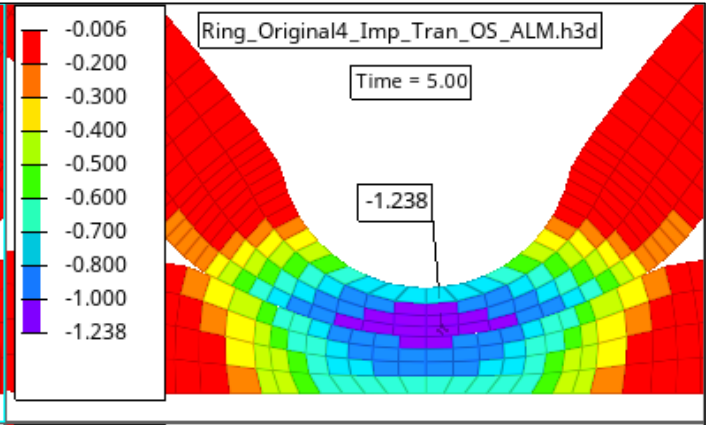
Rubber Ring – Minor Principal Strain (True)

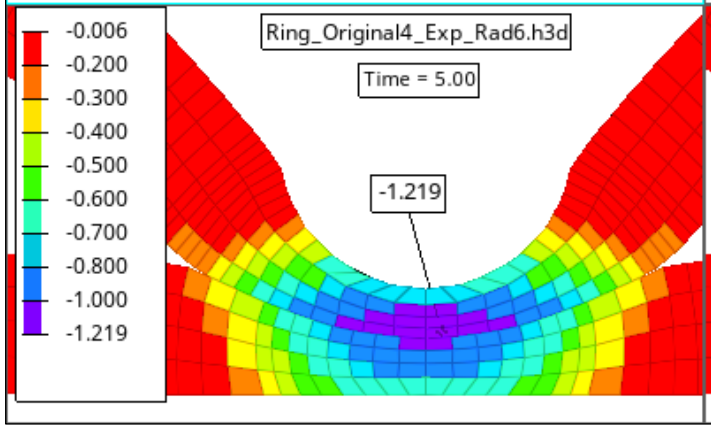
Run1: OptiStruct Implicit Static (S2S, ALM)



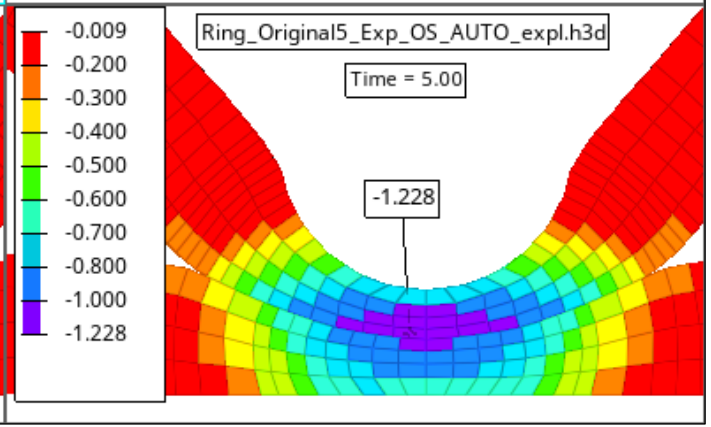
Run2: OptiStruct Implicit Transient (S2S, ALM)



Run3: Radioss Explicit (TYPE24, Stfac=5)



Run4: OptiStruct Explicit (AUTO Contact)



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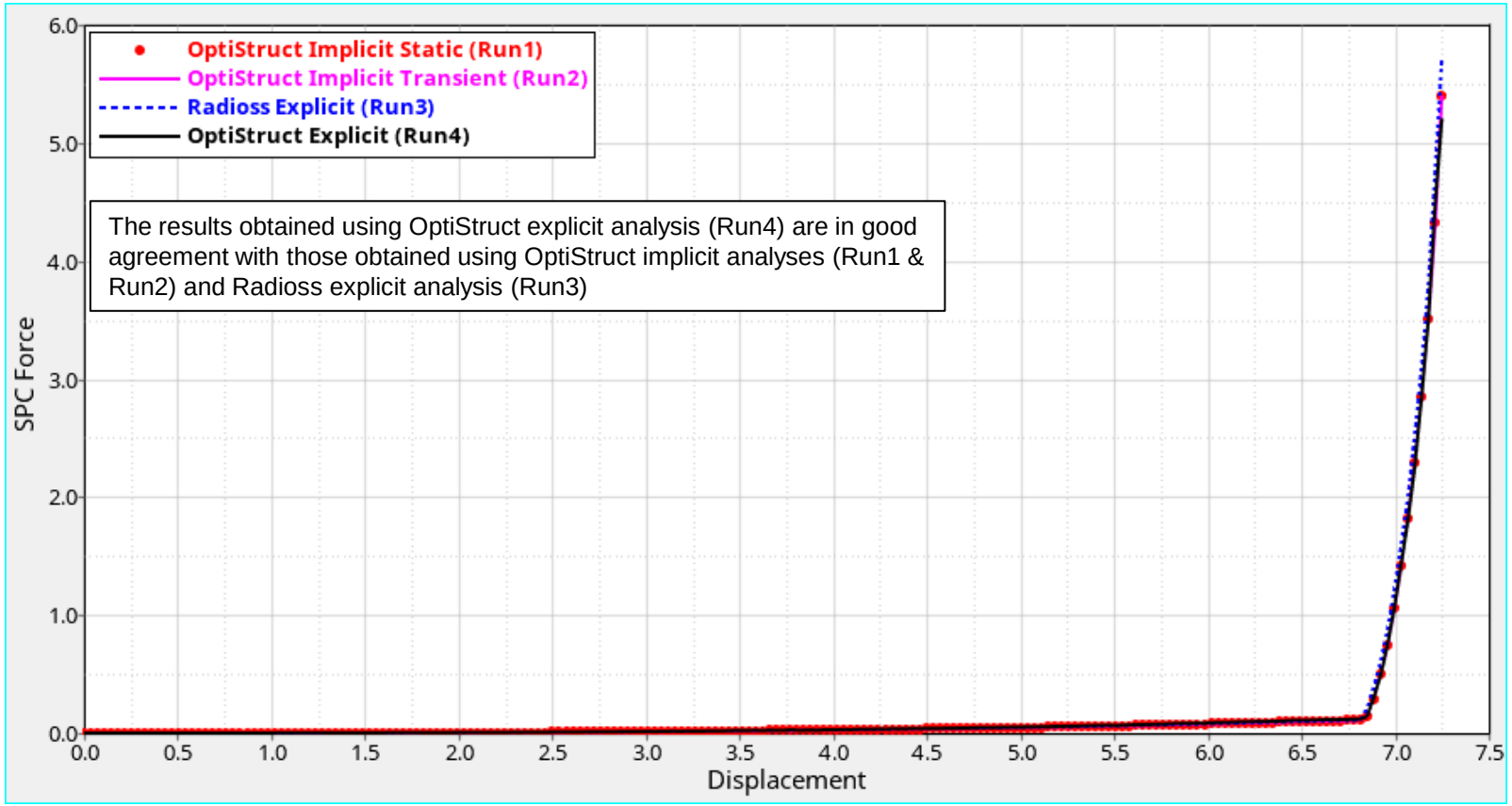
Rubber Ring – Force vs Displacement Curve



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Snap Fit1

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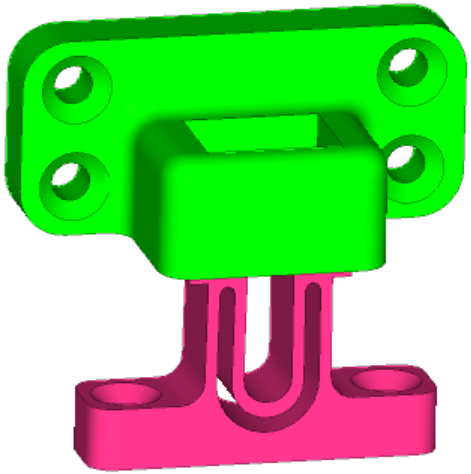
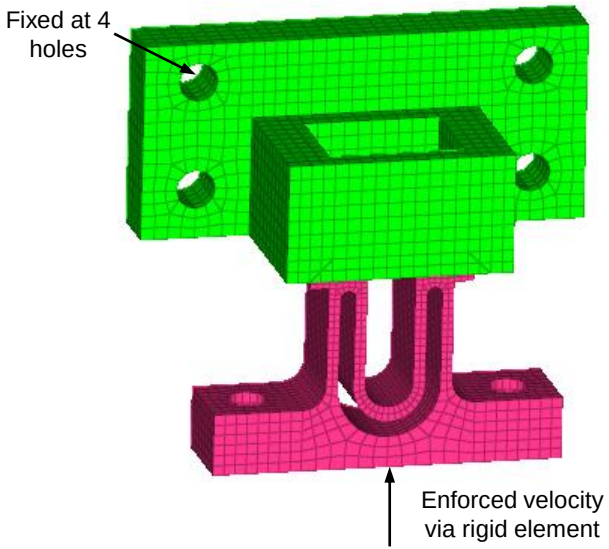
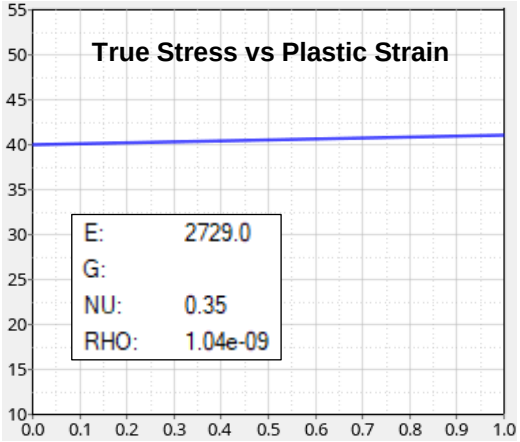
Snap Fit1 – CAD From www.grabcad.com

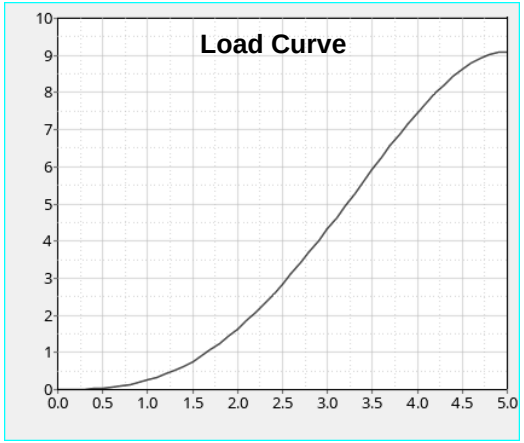
Original CAD
From www.grabcad.com



Defeatured Model







OptiStruct Explicit: Auto Contact, STIFF=AUTO, PSURF, friction =0.1, ISOPE = AURI

Radioss Explicit: TYPE24, friction = 0.1, Isolid = 24, Ismstr = 4

Results obtained using OptiStruct and Radioss explicit analyses show a good correlation as can be seen in the next slides.

OptiStruct Explicit Analysis Showcase

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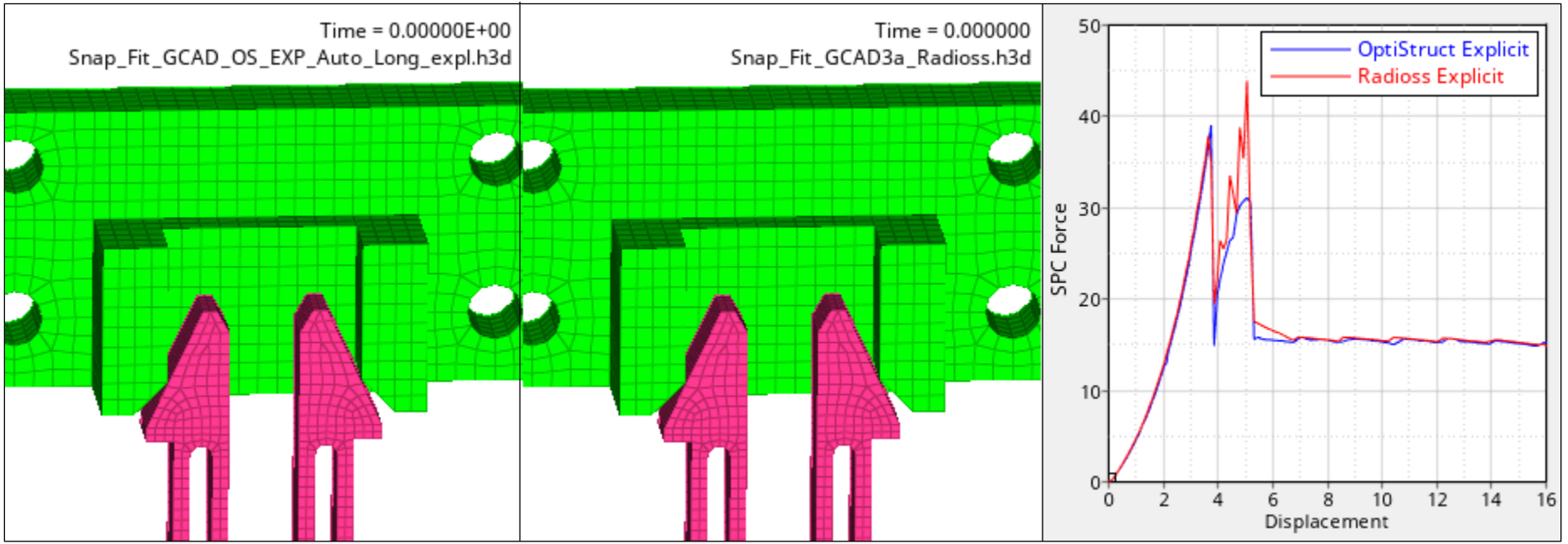
Snap Fit1 – Animation & FD Curve

OptiStruct Explicit (Auto Contact)

Radioss Explicit (Type 24)



Animation is shown with a section cut

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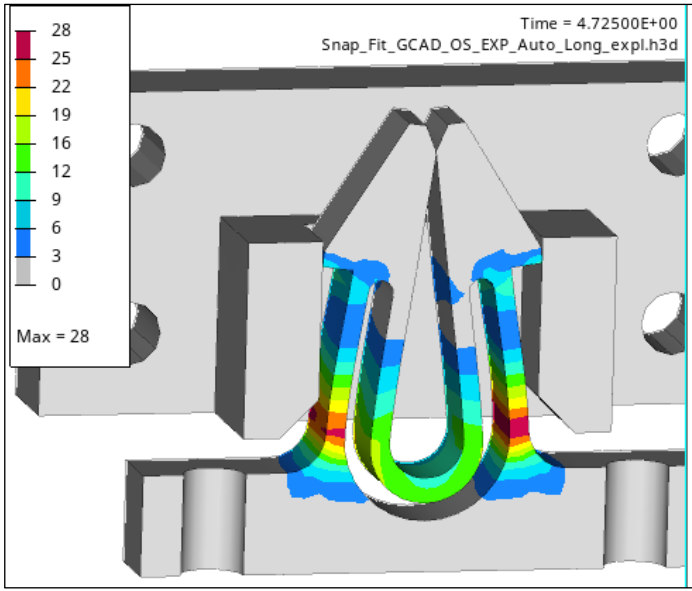
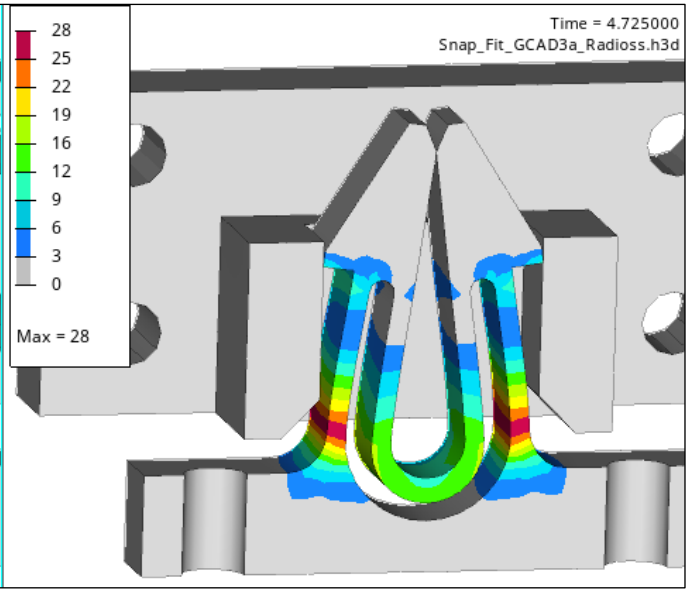
Snap Fit1 – von Mises Stress

OptiStruct Explicit (Auto Contact)



Radioss Explicit (Type 24)



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Snap Fit2

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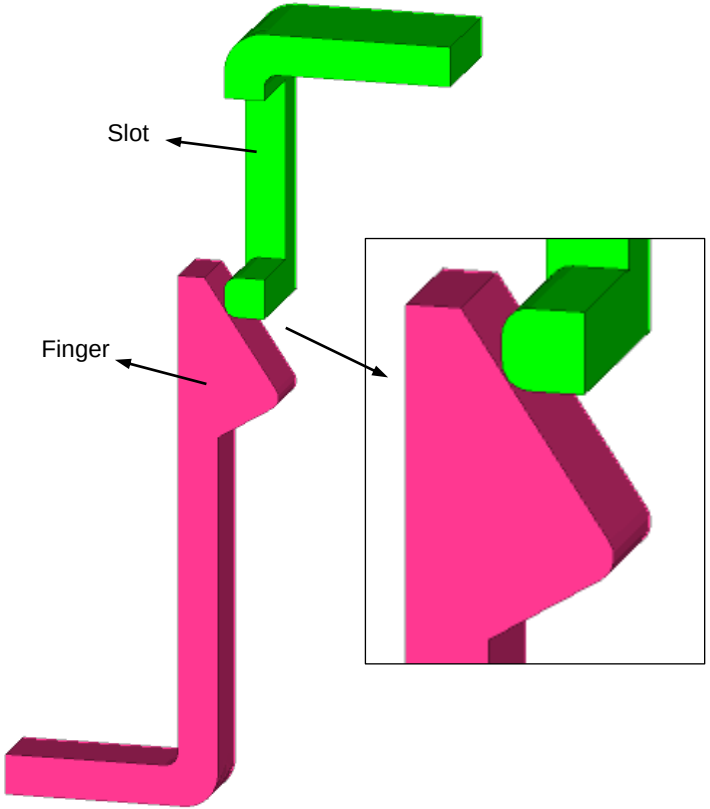
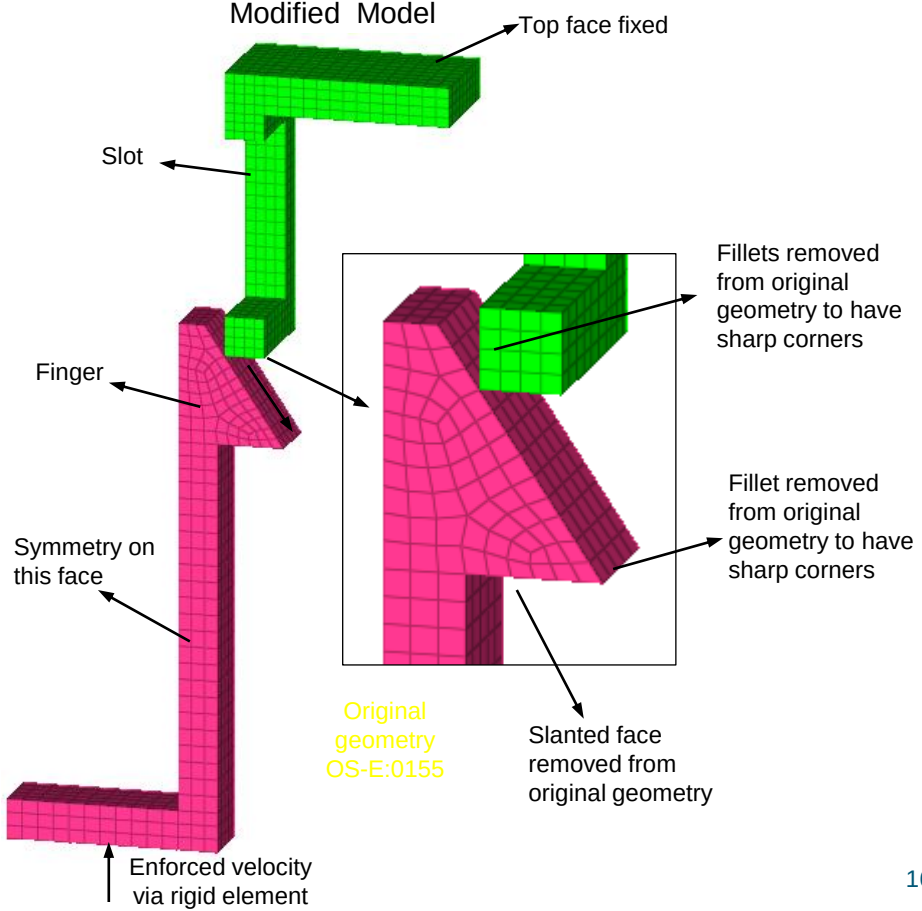
Snap Fit2

Original Geometry (OS-E: 0155)



Modified Model



OptiStruct Explicit Analysis Showcase

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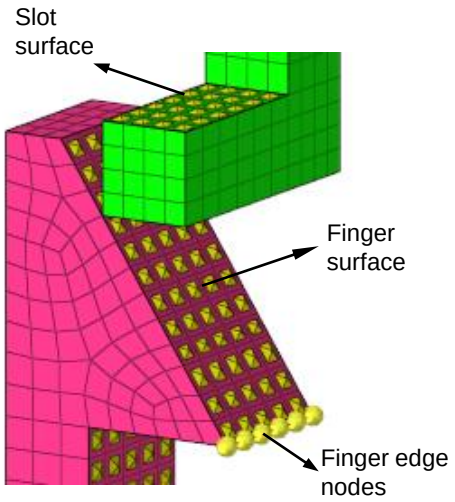
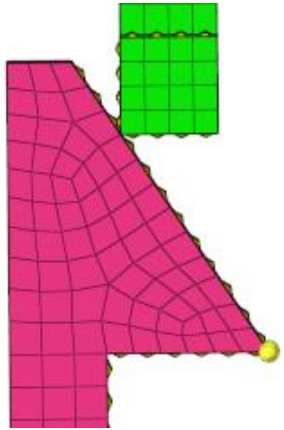
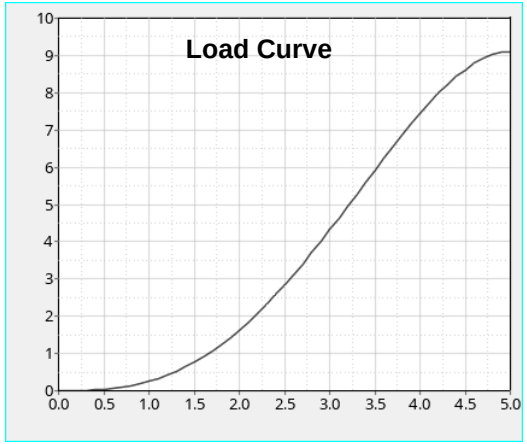
Snap Fit2



Side View





Elastic Material

E:	2700.0
G:	
NU:	0.35
RHO:	1.04e-09

Contact 1 - Nodes to surface contact between the Slot and Finger: N2S (OptiStruct), TYPE25 (Radioss)
Contact 2 - Nodes to surface contact between the Finger edge and Slot: N2S (OptiStruct), TYPE25 (Radioss)

OptiStruct Explicit: N2S Contact with CONSLI, STIFF=AUTO, friction =0.1, ISOPE = AURI

Radioss Explicit: TYPE25, friction = 0.1, Isolid = 24, Ismstr = 4

Results obtained using OptiStruct and Radioss explicit analyses show a good correlation as can be seen in the next slide.

OptiStruct Explicit Analysis Showcase

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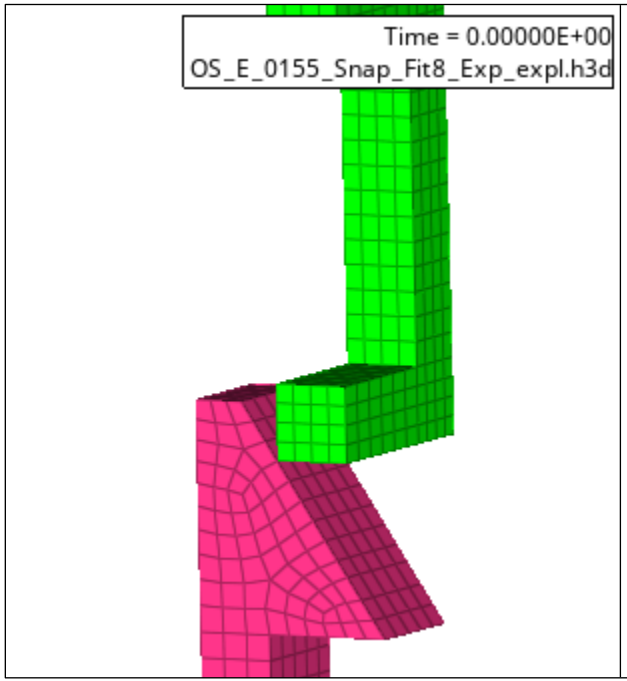
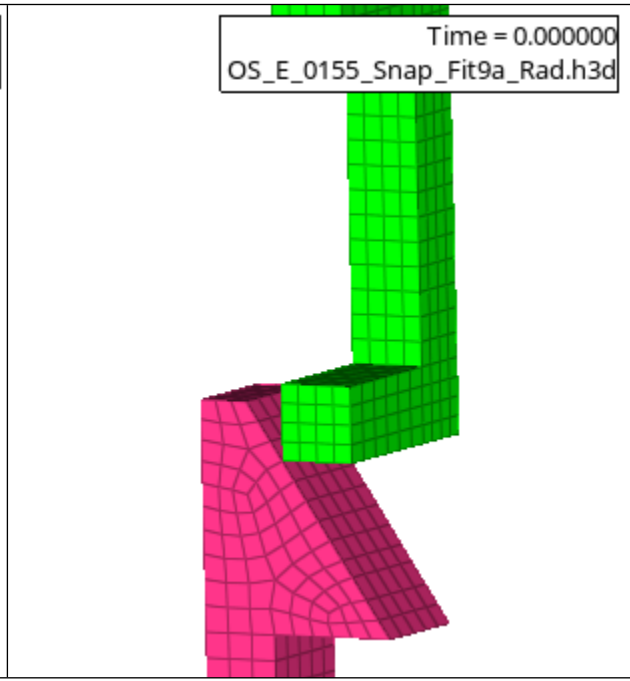
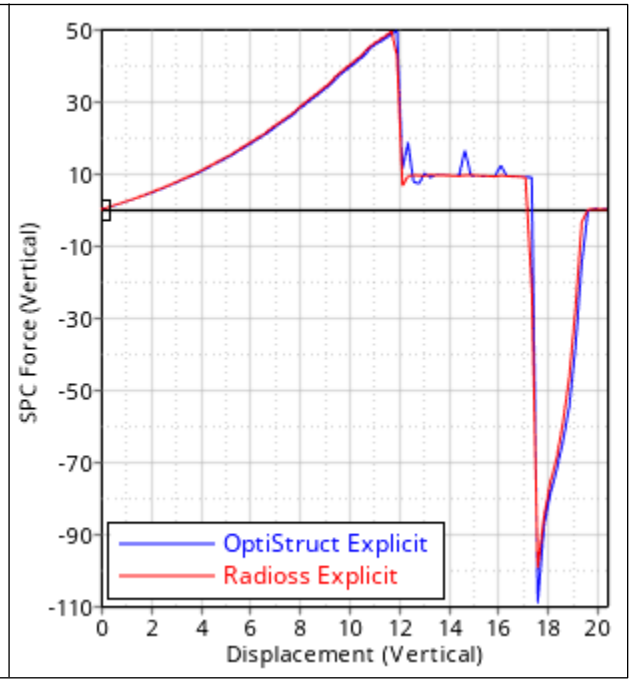
Snap Fit2 – Animation & FD Curve







THANK YOU

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#ONLYFORWARD

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