



coreform

**Better simulation through
better geometry**

Short Course Example Problems

Problem 3: Two-part contact with plasticity, deformation on both parts and elastic recovery

Summary of changes from problem 2:

- The mesh for the disc has been refined to better capture the deformation of the disc. While smooth splines allow for coarse meshes to capture geometry, refinement is sometimes necessary to capture the correct physics.
- Yield stress has been increased from 2 to 30. This is to allow for more elastic deformation, making the elastic recovery easier to visualize
- Analysis type changed from quasistatic to implicit dynamic – this to maintain a stable simulation while also representing springback which is a dynamic phenomenon. The timestep has also been reduced to 0.005
- Time of the simulation (and temporal functions) have been lengthened to 13 to allow for simulation of springback.

Notes:

- The disc will not deform as much as the block due to its geometry.
- Lowering the yield stress (to 2 for example) will make it easier to visualize the deformation in the disc. Raising the yield stress will produce a larger springback effect.

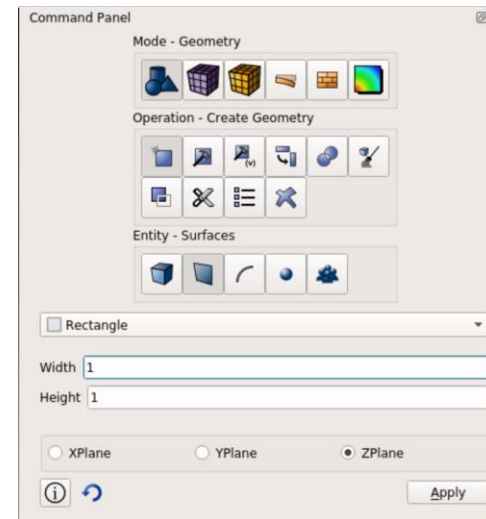
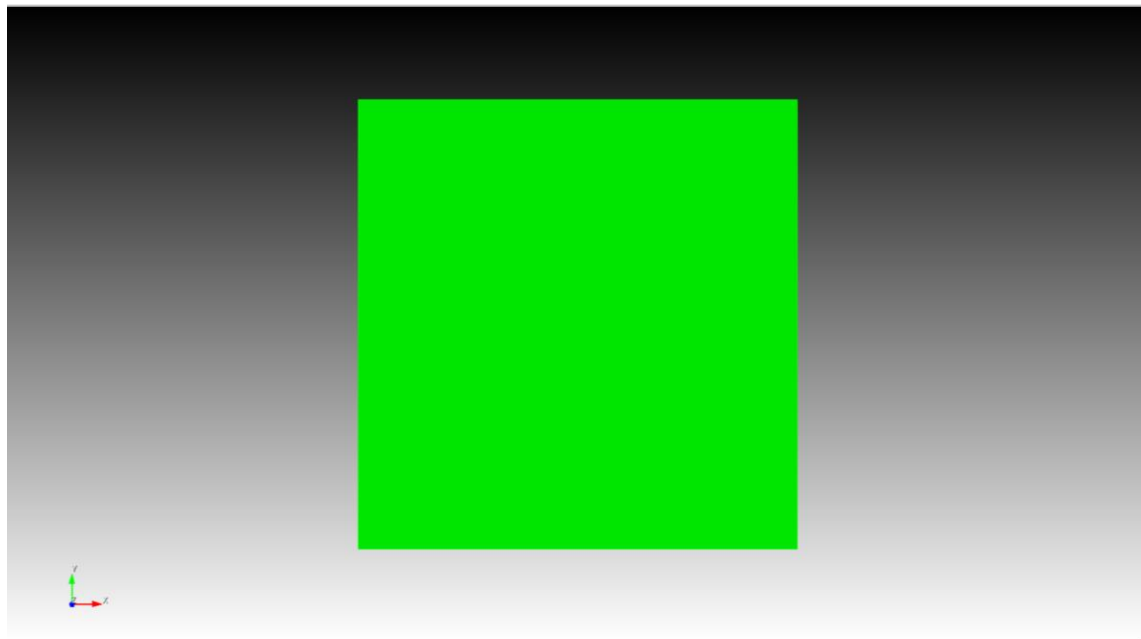


Problem 2: Learning Objectives

Tutorial participants will learn how to

- Mesh primitive geometry and create sets in Trelis
- Import Cubit file into Coreform process
- Set up simulation with multiple parts
- Impose displacement boundary conditions
- Use material model with plasticity
- Set up spline-based simulation contact definition

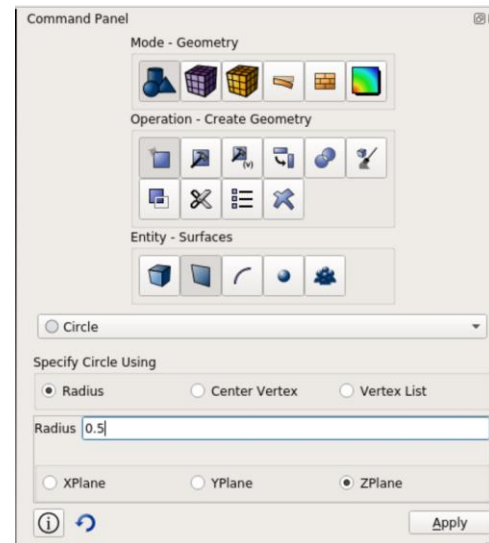
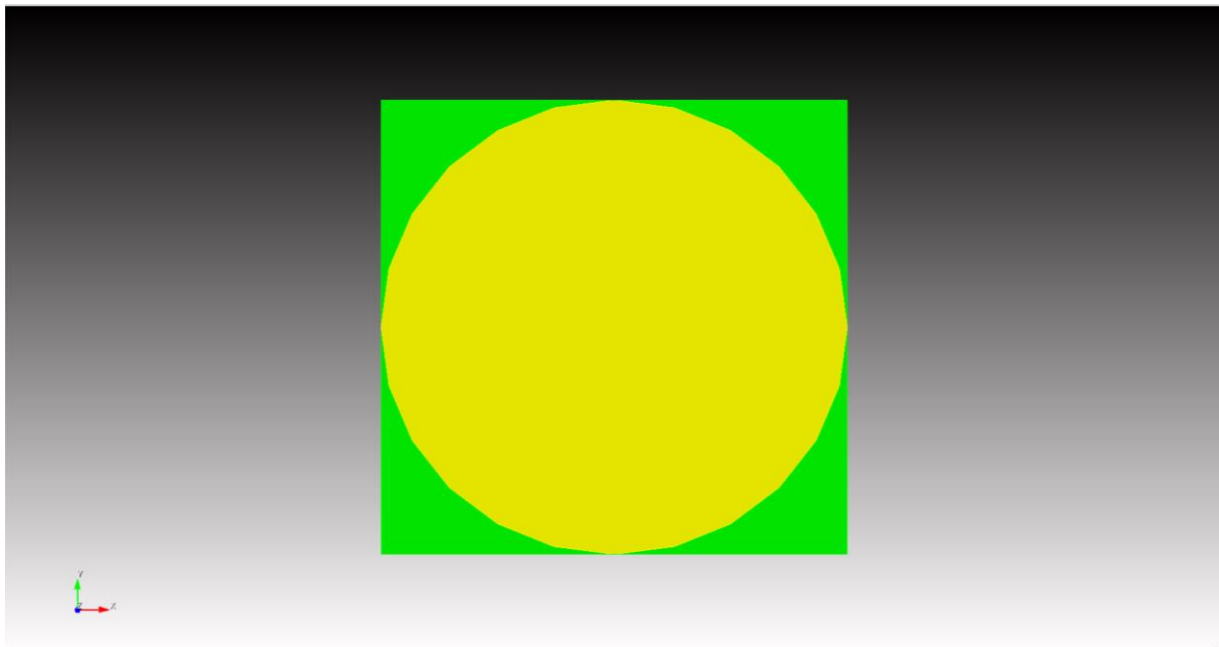
Create block



- or -

Create surface rectangle width 1 height 1 zplane

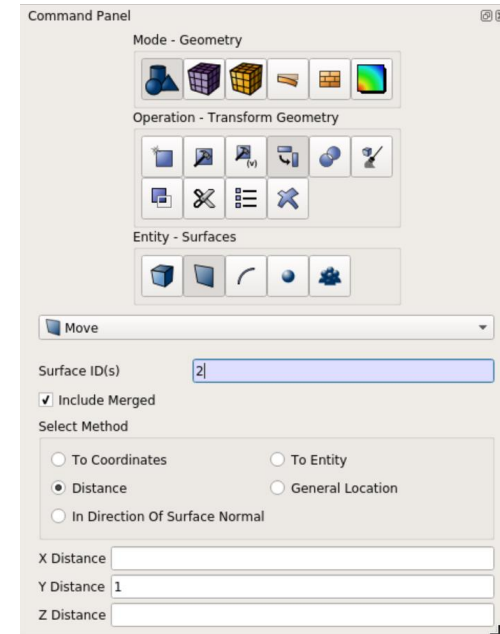
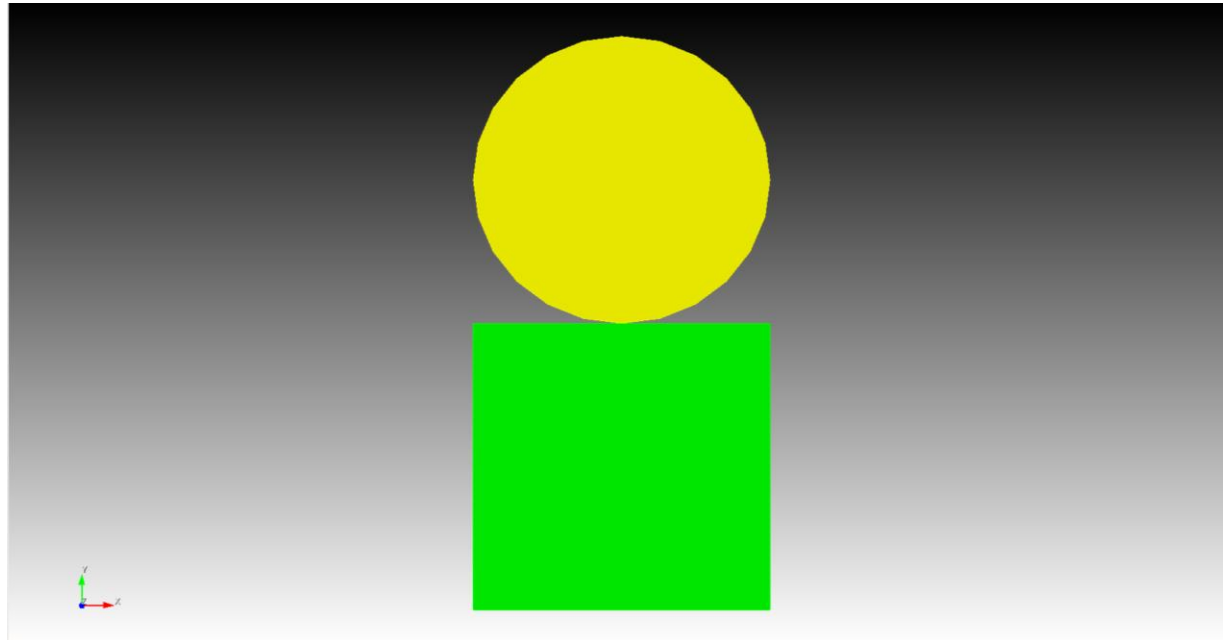
Create disc



- or -

Create surface circle radius 0.5 zplane

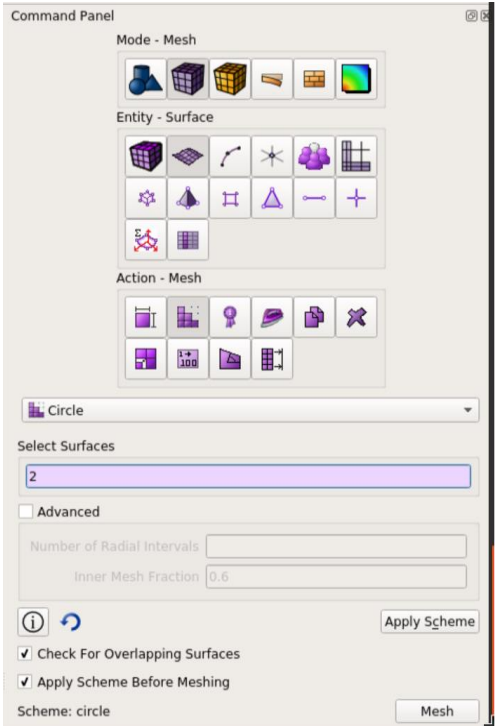
Move disc



- or -

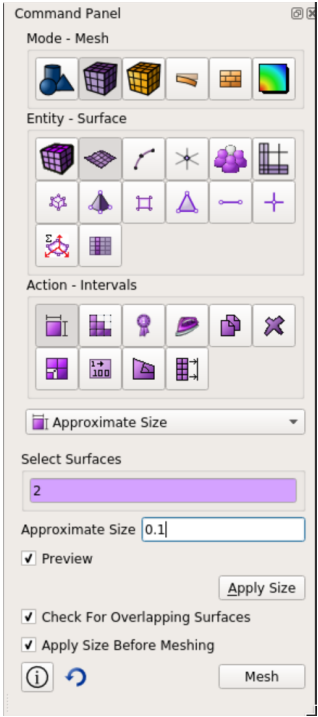
This geometry is available for download at this address:
https://coreform.com/shortcourse/deep_rolling_init.cub

Mesh disc



- or -

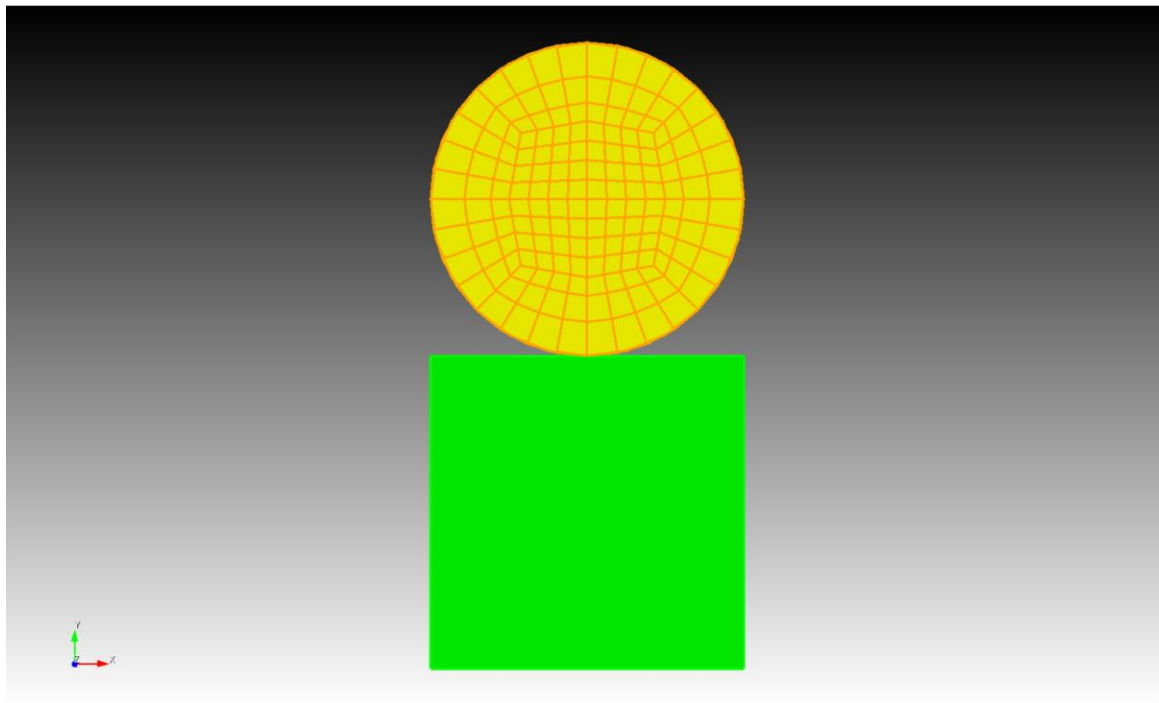
Surface 2 scheme circle



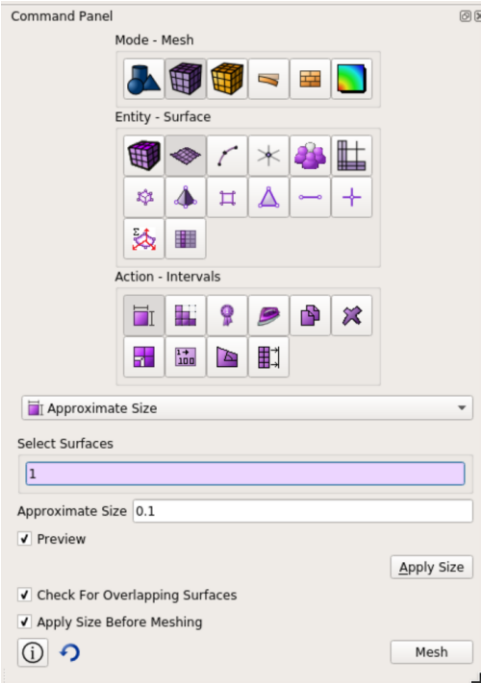
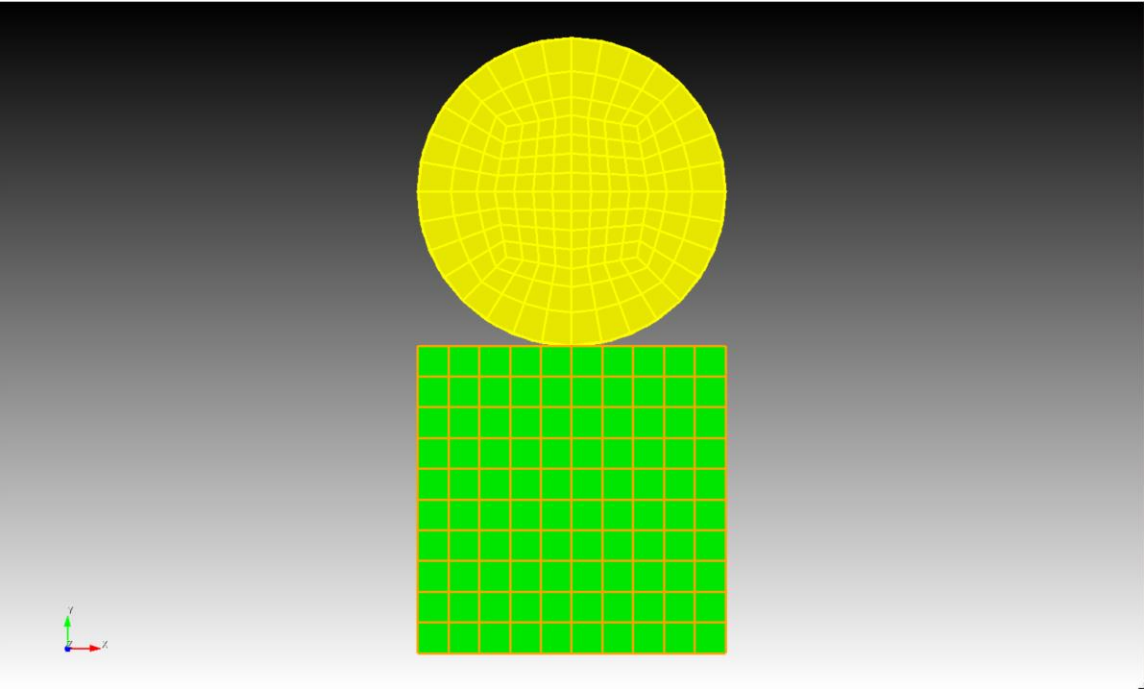
- or -

Surface 2 size 0.1
Mesh surface 2

Mesh disc



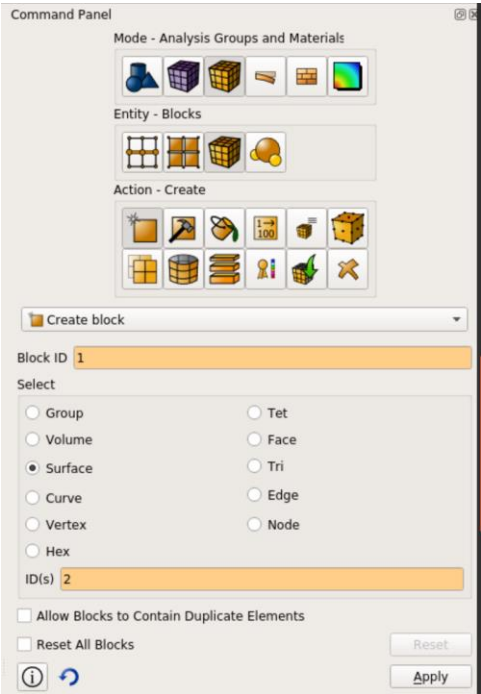
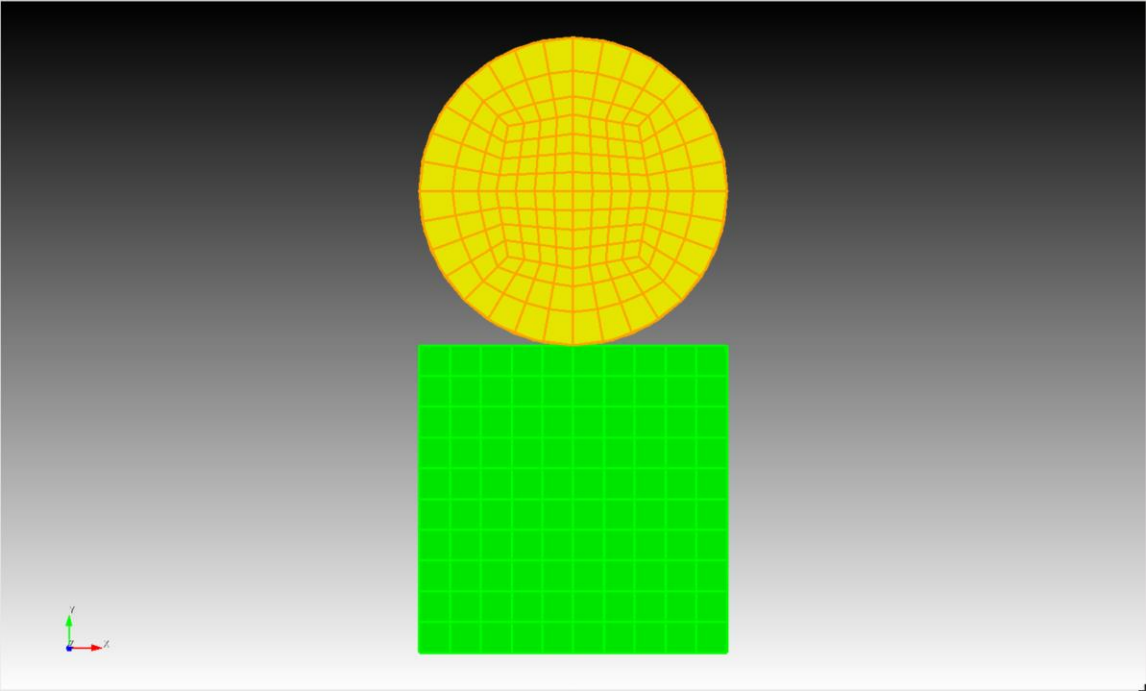
Mesh block



- or -

Surface 1 size 0.1
Mesh surface 1

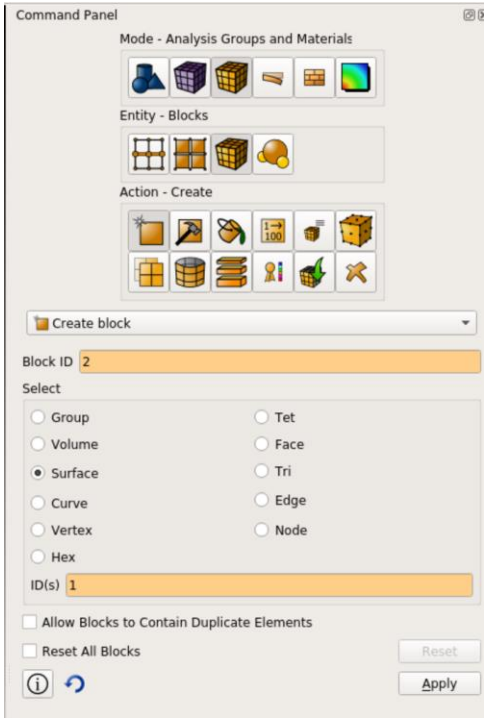
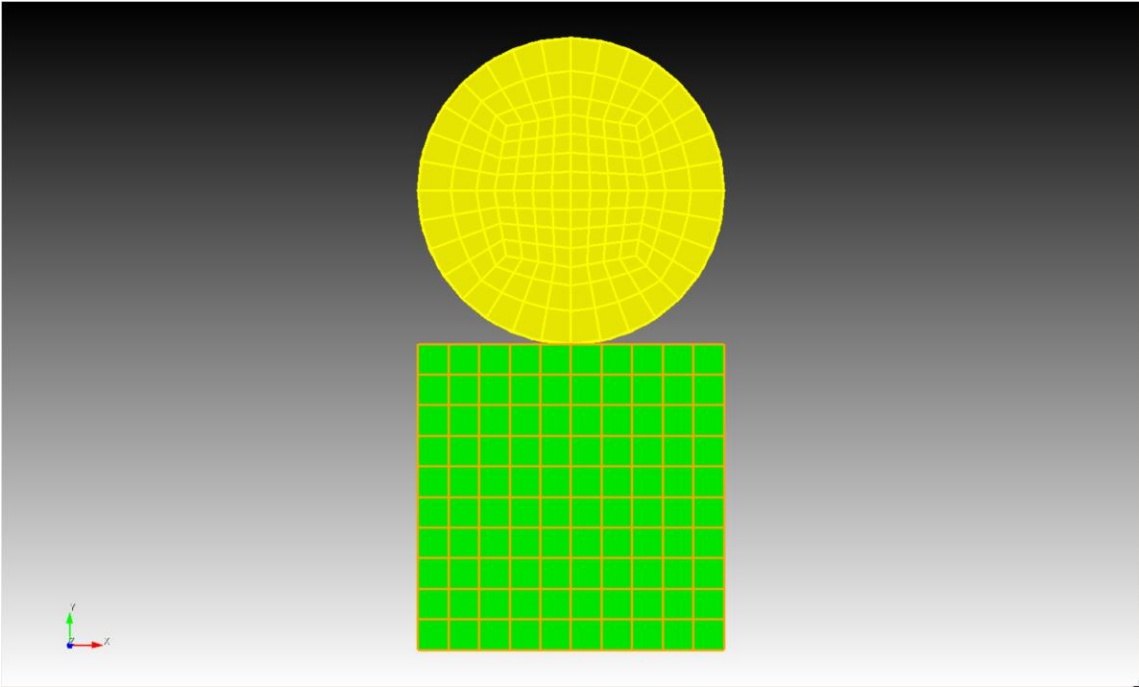
Create block sets - disc



- or -

Block 1 add surface 2

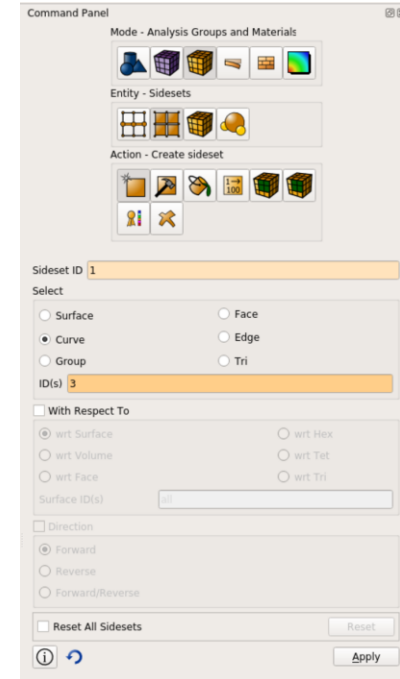
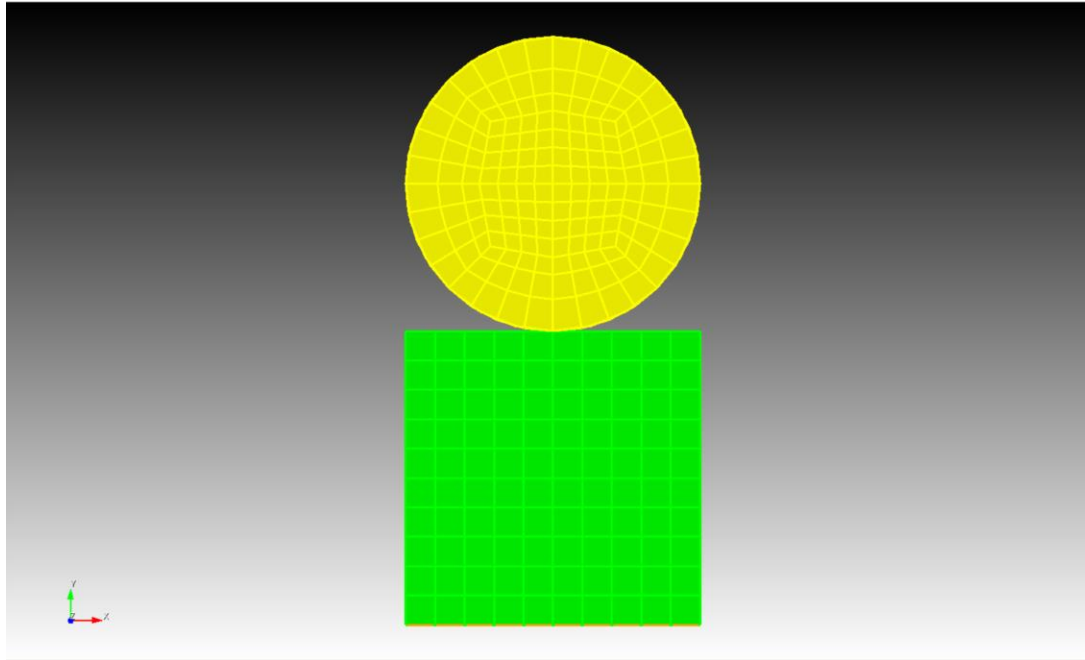
Create block sets - block



- or -

Block 2 add surface 1

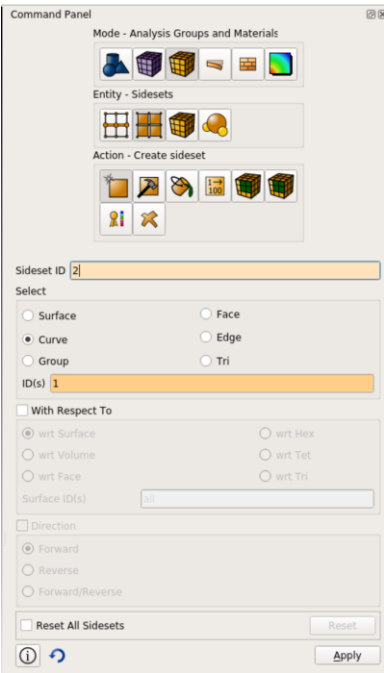
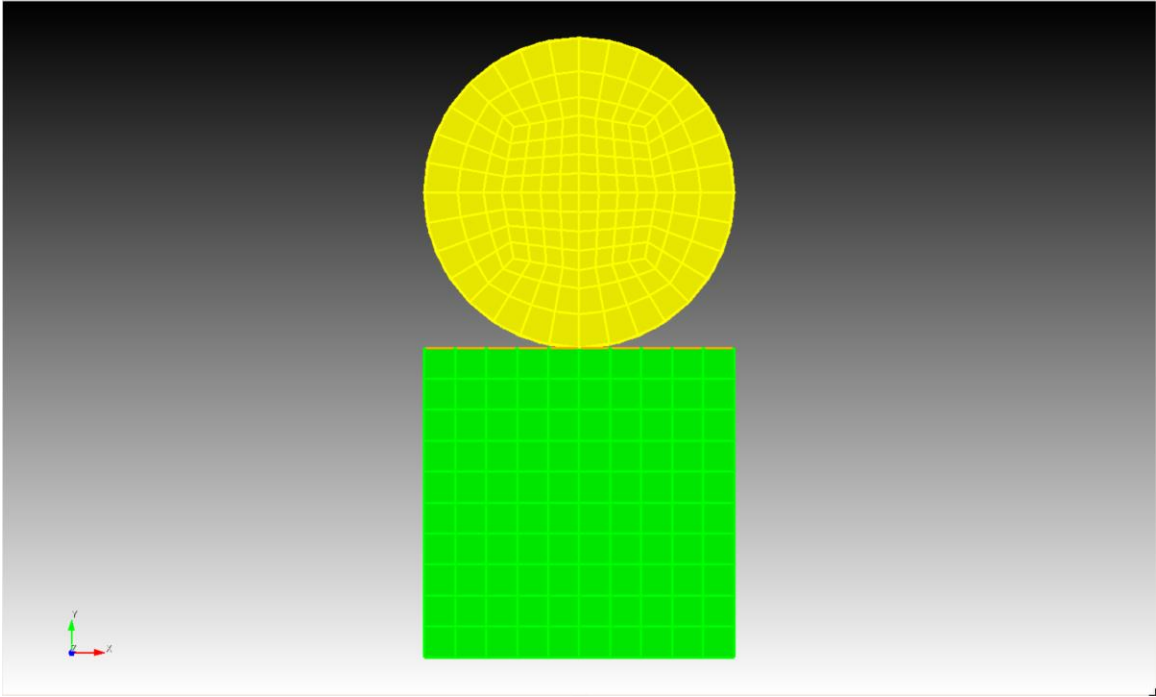
Create side sets – bottom of block



- or -

Sideset 1 add curve 3

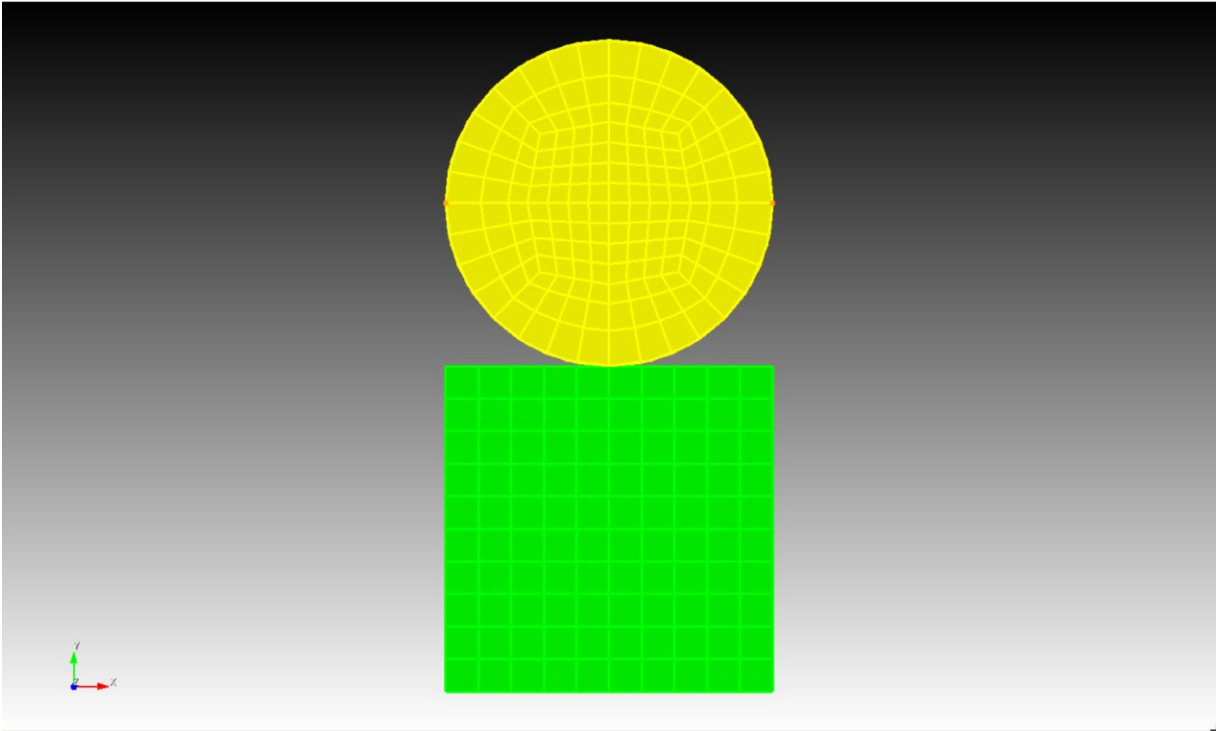
Create side sets – top of block



- or -

Sideset 2 add curve 1

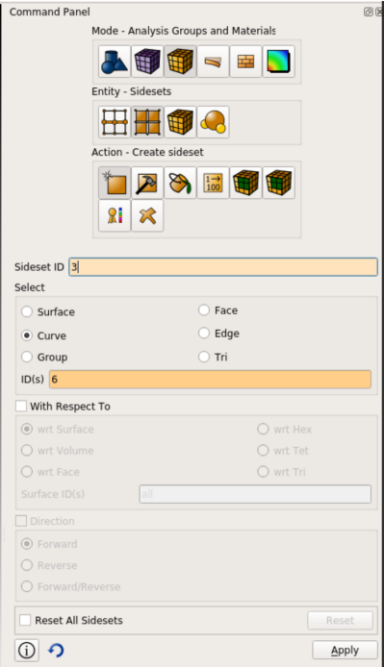
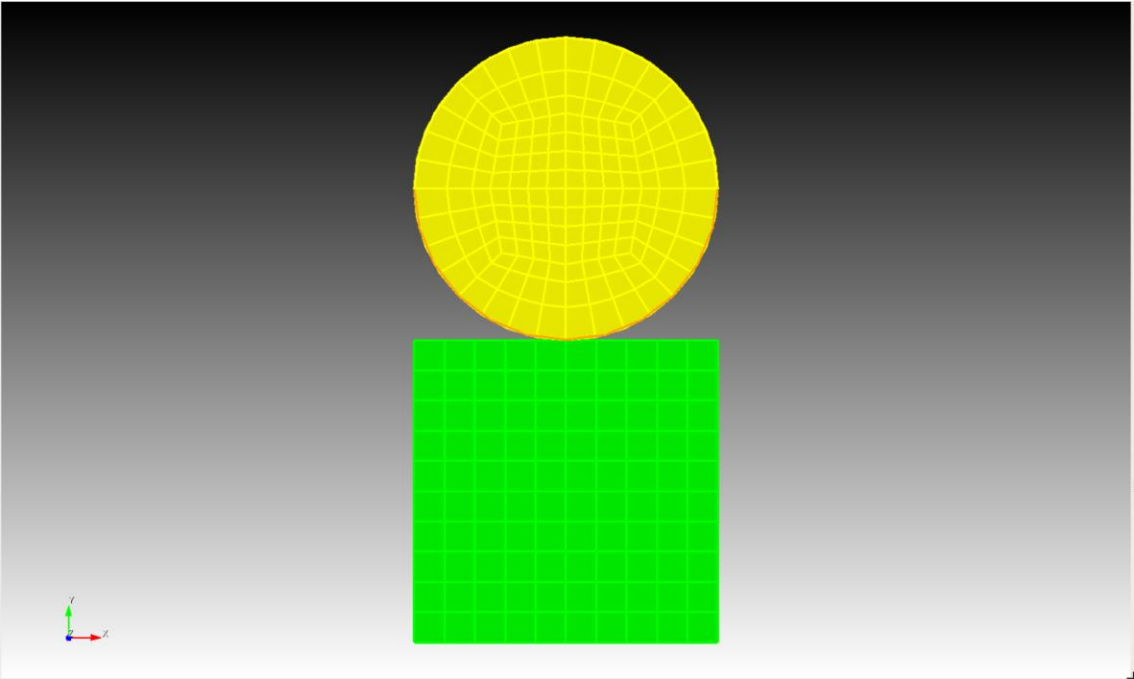
Split disc curve



- or -

Partition create curve 5 node 117

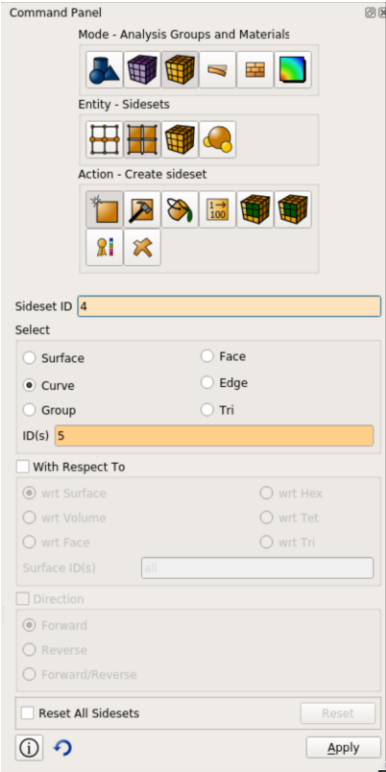
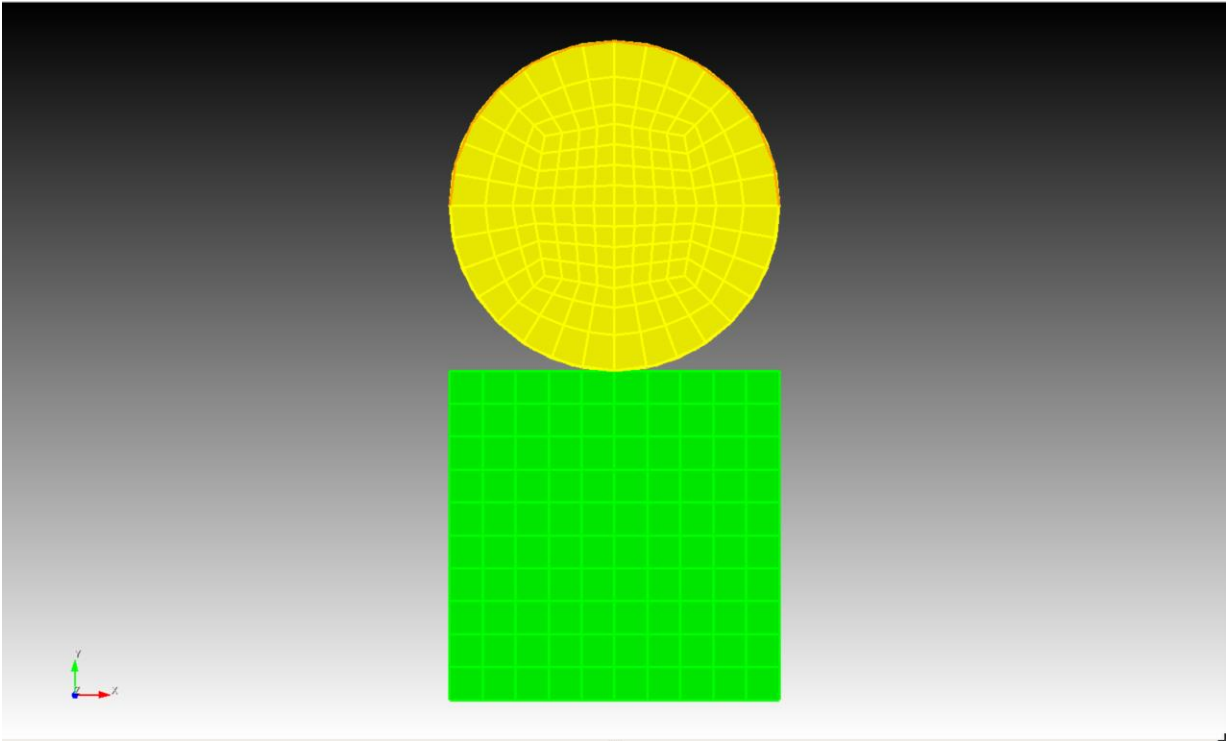
Create side sets – bottom of disc



- or -

Sideset3 add curve 6

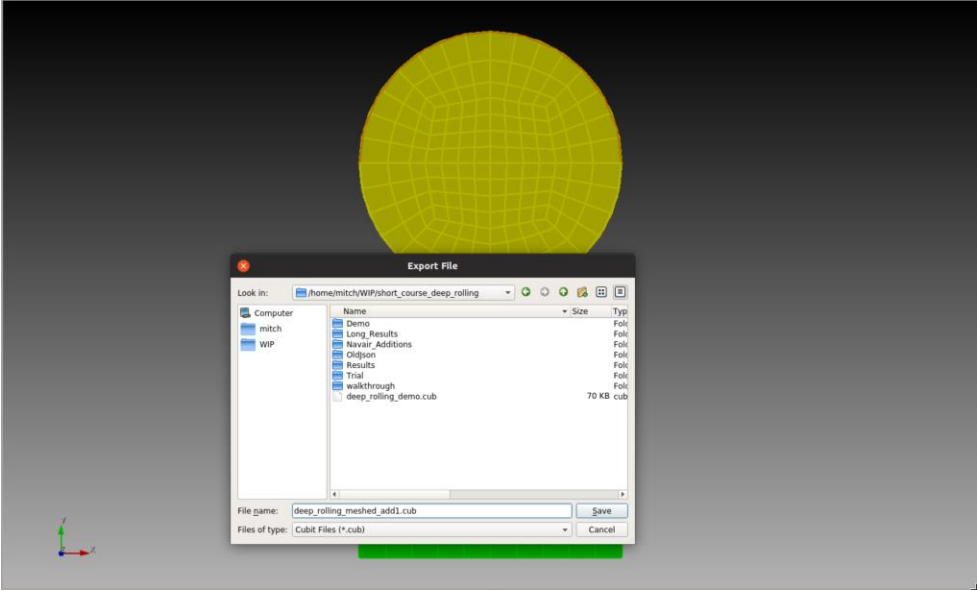
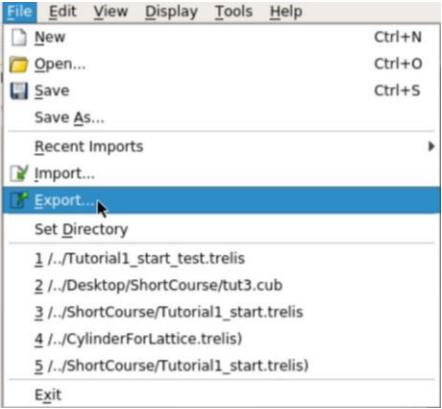
Create side sets – top of disc



- or -

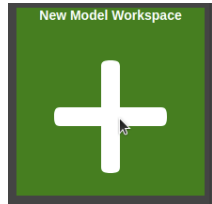
Sideset4 add curve 5

Export .cub file

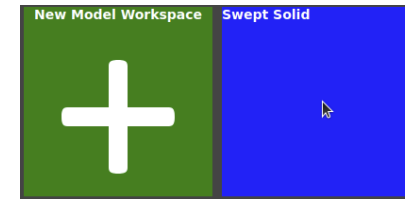
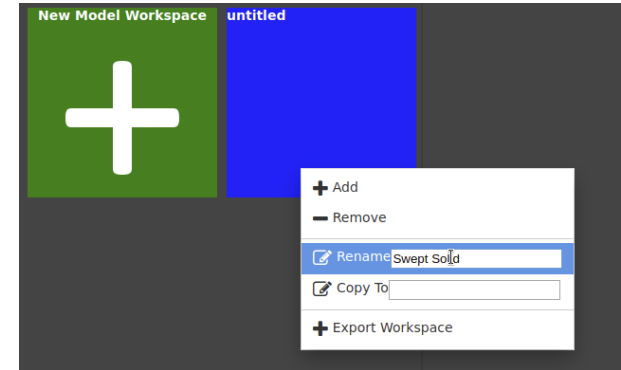


```
export cubit "/home/username/ShortCourse/deep_rolling_meshed_add1.cub" overwrite
```

Open Coreform Process workspace

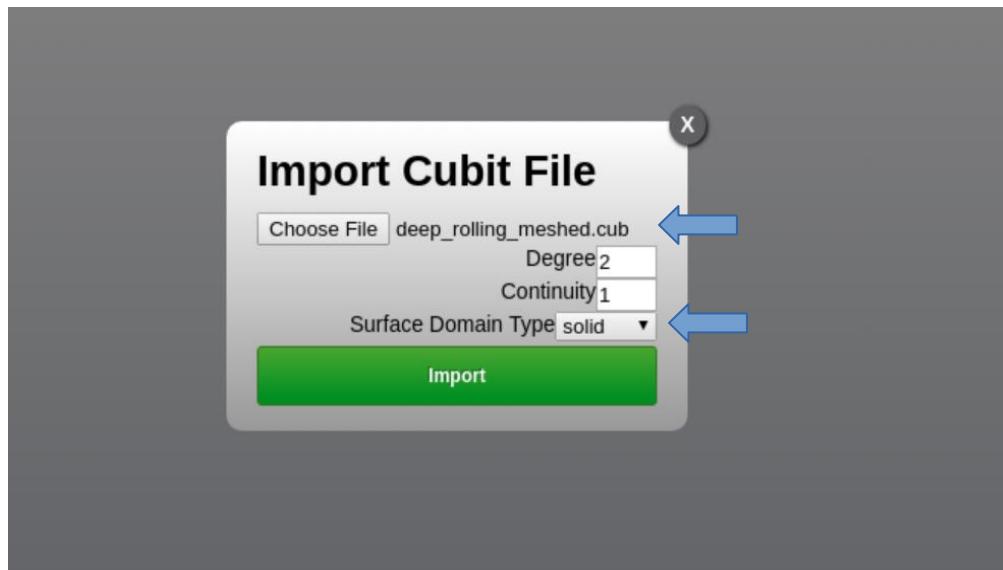


- Click "New Model Workspace"
- Right click the box labelled "untitled"
- Type "Deep Rolling" in the "Rename" box and hit Enter/Return
- Click on "Deep Rolling" to open the workspace

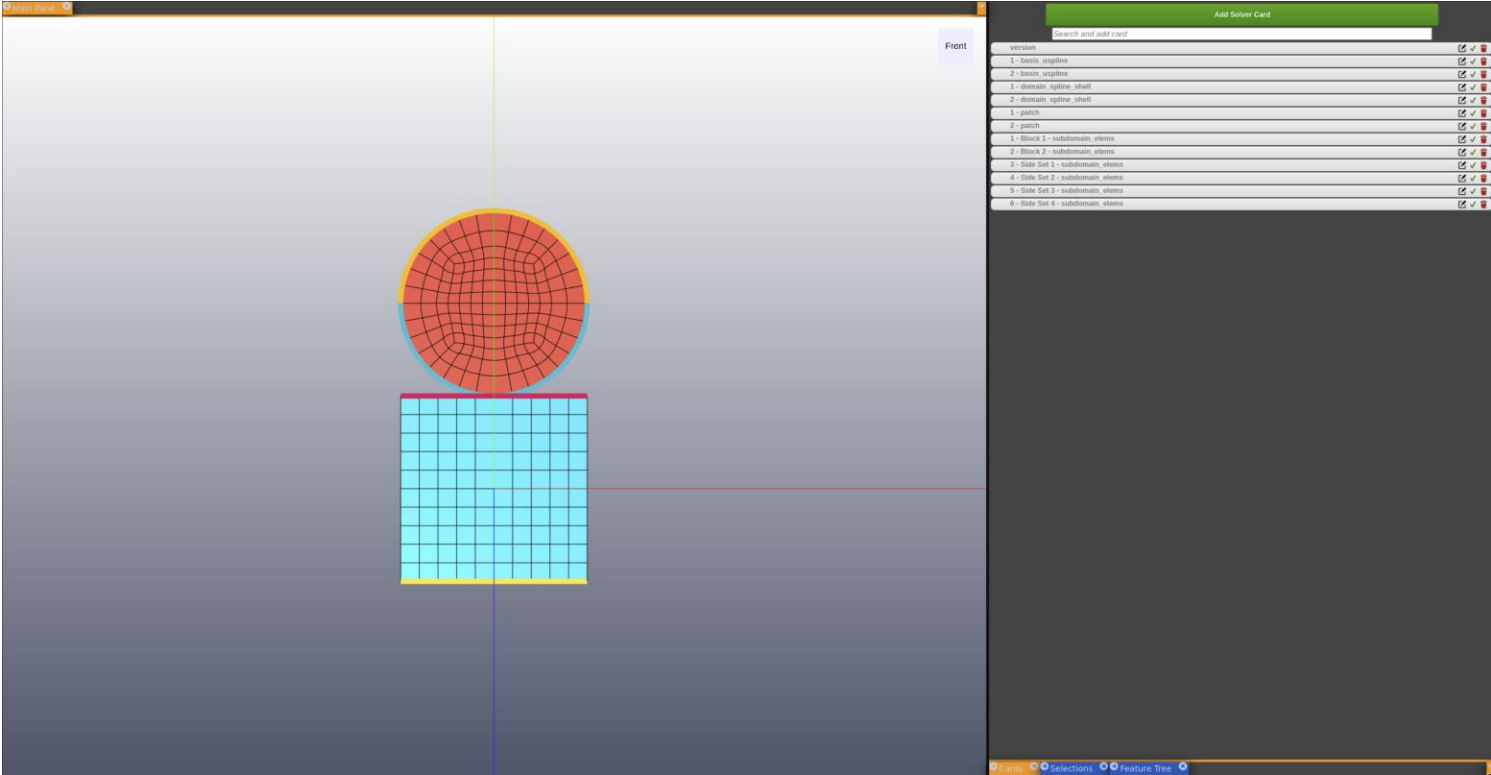


Import Cubit File

SPC - i - c

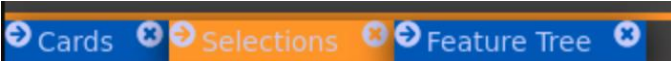


Imported Cubit File



Rename subdomians

Click on “Selections” pane



Material definition

material isotropic elastoplastic logarithmic?

desc - optional

Material for both parts

material_id

1

E

1000

E time dependent function temporal_id

E temperature dependent function temporal_id

nu

0.3

rho

4e-5

material_yield_surface_properties_id

1

material_yield_surface_properties von mises?

desc - optional

Material for both parts

material_yield_surface_properties_id

1

K - optional

0

yield_stress - optional

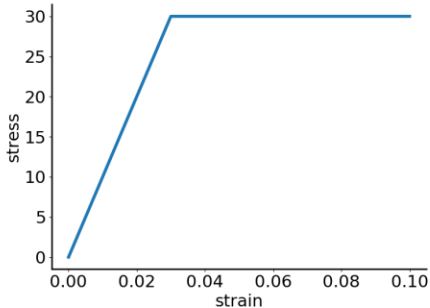
30

saturation_stress - optional

saturation_exponent - optional

0.0

All changes saved



Element Formulation

formulation solid?

desc - optional	Solid formulation for both parts ←
formulation_id	1
formulation_type	solid_2d ← ▾
quadrature	QP1 - default ▾
material_id	1 ←

All changes saved

Parts

part?

desc - optional	Disc
part_id	1
formulation_id	1
subdomain_ids	
<div>+ Add Free Edit</div>	
1	
temperature_id - optional	

part?

desc - optional	Block
part_id	2
formulation_id	1
subdomain_ids	
<div>+ Add Free Edit</div>	
2	
temperature_id - optional	

Control Timestep

control timestep implicit dynamic 2nd order?

desc - optional	Implicit dynamic ←
control timestep id	1 ←
control time integration id	1 ←
predictor_type - optional	CONSTANT_DISPLACEMENT - default ▾
max corrector step n - optional	10
newton_tol_abs - optional	1e-32
newton_tol_rel - optional	1e-6
delta_tol_abs - optional	1e-32
delta_tol_rel - optional	0.001
line_search - optional	true ← ▾
line_search_tol - optional	0.5
line_search_max iterations - optional	10

control time integration newmark?

desc - optional	time integration ←
control time integration id	1
beta	0.25 ←
gamma	0.5 ←

Problem and Control Model

problem?

desc - optional

deep rolling contact

problem_id

1

part_ids

+ Add

Free Edit

1

2

control_timestep_id

1

coupled_problems - optional

+ Add

Free Edit

control_linear_solver

_options_from_command_line - optional

false - default

solver_type - optional

superlu - default

All changes saved

control_model?

desc - optional

control_time

initial_time_step - optional

0.005

termination_time - optional

13

adaptive_timestep

iteration_optimal

iteration_window

growth_factor

reduction_factor

delta_t_min

delta_t_max

control_problem

1

enable_parent_basis - optional

false - default

enable_output - optional

true - default

enable_output_restart - optional

false - default

output_restart_file_name_prefix - optional

result

output_restart_delta_t - optional

0.0

output_restart_delta_time_step - optional

1

output_restart_based_on_time_step - optional

false - default

All changes saved

Downward displacement of disc

subdomain nodal dva?

desc - optional	downward displacement of disc
subdomain nodal value id	1
subdomain id	6
dof_type	UY
dva_type	DISPLACEMENT

nodal_value_spatial					
UX	UY	UZ	RX	RY	RZ
-1	-0.075	-1	-1	-1	-1

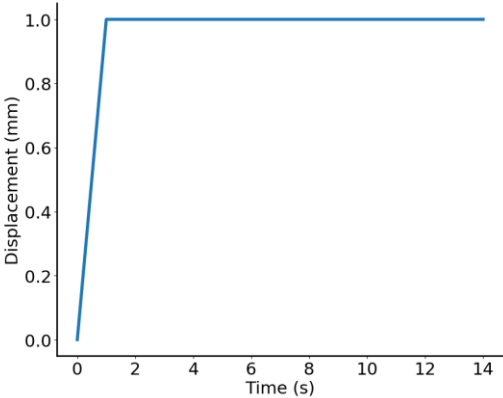
function_temporal_id 1

function temporal linear interpolation?

desc - optional	downward displacement of disc
function_temporal_id	1
birth	0.0
death	1e10
tol	1e-10

Graph + Add

t	f(t)
0	0
1	1
14	1



Right displacement of disc

subdomain nodal dva

desc - optional

right displacement of disc

subdomain_nodal_value_id

2

subdomain_id

6

dof_type

UX

dva_type

DISPLACEMENT

nodal_value_spatial

UX

0.075

UY

-1

UZ

-1

RX

-1

RY

-1

RZ

-1

function_temporal_id

4

function temporal linear interpolation?

desc - optional

right displacement of disc

function_temporal_id

2

birth

0.0

death

1e10

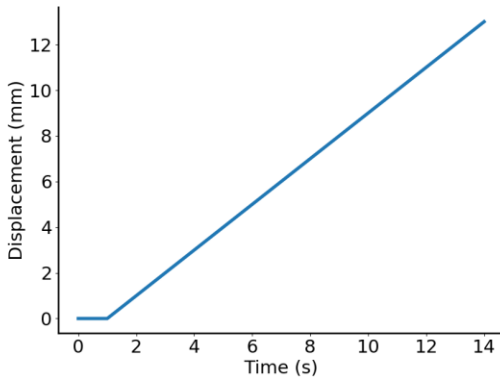
tol

1e-10

Graph

Add

t	f(t)
0	0
1	0
2	1
14	13



Clamp bottom of block

subdomain nodal dva?

desc - optional

clamp bottom of block

subdomain_nodal_value_id

3

subdomain_id

3

dof_type

U2

dva_type

DISPLACEMENT

nodal_value_spatial

UX

0

UY

0

UZ

-1

RX

0

RY

0

RZ

-1

function_temporal_id

3

All changes saved

function temporal constant?

desc - optional

constant value 1

function_temporal_id

3

value

1

birth

0

death

1e10

tol

1e-10

All changes saved

Problem boundary condition

problem boundary condition?

desc - optional

deep rolling boundary conditions

problem_id

1

subdomain_nodal_value_ids

+ Add

Free Edit

1

2

3

Set up contact

formulation contact?

desc - optional	Disc to Block
formulation_id	2
formulation_type	contact_gpts_2d
penalty	100000
use_soft_contact - optional	false - default
gap_tolerance - optional	0.000001
nearest_point_tolerance - optional	1e-12
nearest_point_max_iteration_n - optional	10
master_seed_points_n - optional	10
search_sphere_tolerance - optional	0.1
search_cone_tolerance - optional	0
master_seeds - optional	QP1 - default
slave_quadrature - optional	QP1 - default

contact surface?

desc - optional	disc to block
contact_surface_id	1
formulation_id	2
slave_subdomain_id	4
master_subdomain_id	5

problem contact surface?

desc - optional	Deep rolling - disc to block
problem_id	1
contact_surface_ids	1

Output

subdomain output field?

desc - optional Displacement and strain

subdomain_output_id 1

subdomain_ids

+ Add Free Edit

1

2

function_temporal_id 3

FieldTypes + Add

- optional displacement

- optional eps

delta_time 0.1

delta_step

file_name_prefix - optional results

file_type - optional vtk - default

sample_type - optional UNIFORM5

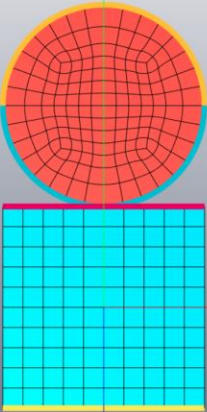
cache_basis_evals - optional true - default

include_elem_outlines - optional true - default

solution_type - optional current - default

Final Setup

LibreOffice Writer



Front

Add Solver Card

Search and add card

version	✓	✓	✓
1 - basis: uspline	✓	✓	✓
2 - basis: uspline	✓	✓	✓
1 - domain: spline_shell	✓	✓	✓
2 - domain: spline_shell	✓	✓	✓
1 - patch	✓	✓	✓
2 - patch	✓	✓	✓
1 - Disc - subdomain: elems	✓	✓	✓
2 - Block - subdomain: elems	✓	✓	✓
3 - Bottom of Block - subdomain: elems	✓	✓	✓
4 - Top of Block - subdomain: elems	✓	✓	✓
5 - Bottom of Disc - subdomain: elems	✓	✓	✓
6 - Top of Disc - subdomain: elems	✓	✓	✓
1 - Material for both parts - material: isotropic_elastoplastic_logarithmic	✓	✓	✓
Material for both parts - material_yield_surface_properties_von_mises	✓	✓	✓
1 - Solid formulation for both parts - formulation: solid	✓	✓	✓
1 - Disc - part	✓	✓	✓
2 - Block - part	✓	✓	✓
1 - logical dynamic - control timestep: implicit_dynamic_2nd_order	✓	✓	✓
1 - time integration - control time integration: newmark	✓	✓	✓
1 - Deep Rolling - problem	✓	✓	✓
control: model	✓	✓	✓
1 - downward displacement of disc - subdomain: nodal_dva	✓	✓	✓
1 - downward displacement of disc - function: temporal_linear_interpolation	✓	✓	✓
2 - right displacement of disc - subdomain: nodal_dva	✓	✓	✓
2 - right displacement of disc - function: temporal_linear_interpolation	✓	✓	✓
2 - clamp bottom of block - subdomain: nodal_dva	✓	✓	✓
1 - constant value 1 - function: temporal_constant	✓	✓	✓
1 - deep rolling boundary conditions - problem: boundary_condition	✓	✓	✓
2 - Disc to Block - formulation: contact	✓	✓	✓
1 - disc to block - contact: surface	✓	✓	✓
1 - Deep rolling disc to block - problem: contact_surface	✓	✓	✓
1 - displacement and strain - subdomain: output_field	✓	✓	✓

Run simulation

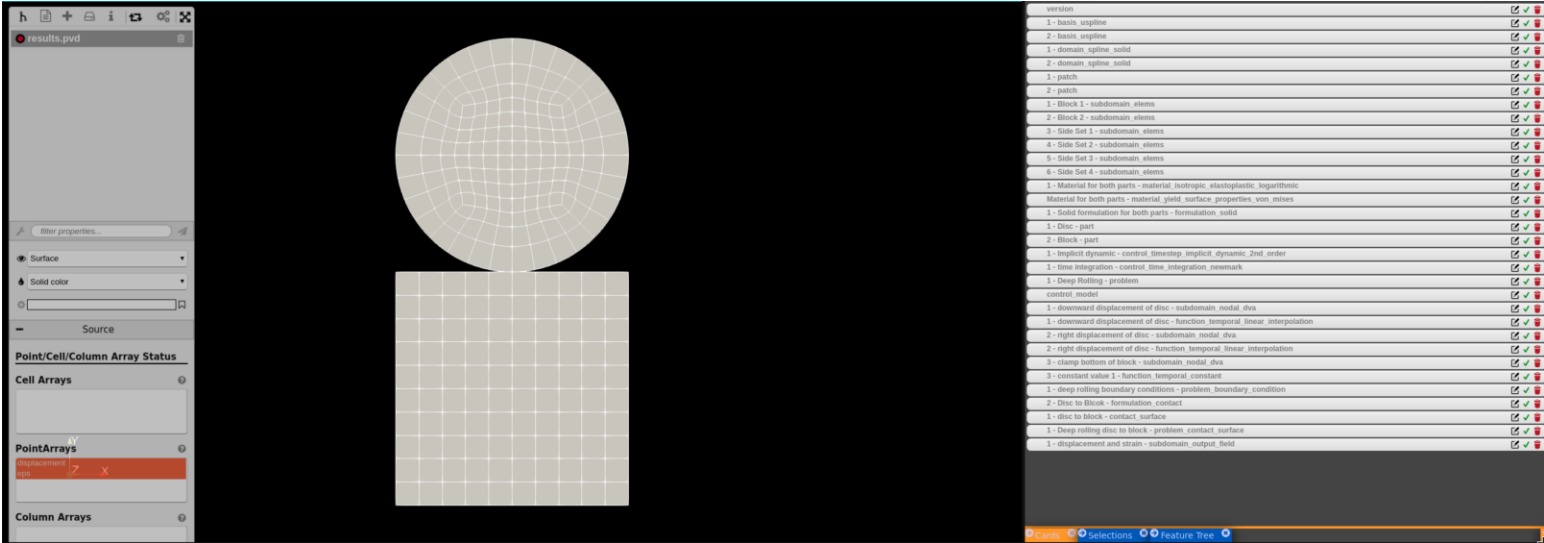
SPC - r - r

A pane will open along the bottom of the screen with information about the running simulation

```
Run Log Pane 2
0%
====> Cached problem partition element configurations on problem 1 in 3.02037 secs
=====
=====> Initializing model state...
=====> Time to initialize model state is 4.50611e-05 secs
2019-08-19 15:22:47+0000: Starting
////////////////////////////////////
=====> STARTING SOLVE
=====
=====> Initializing solver...
=====> Setting initial conditions...
=====> Writing initial output...
```

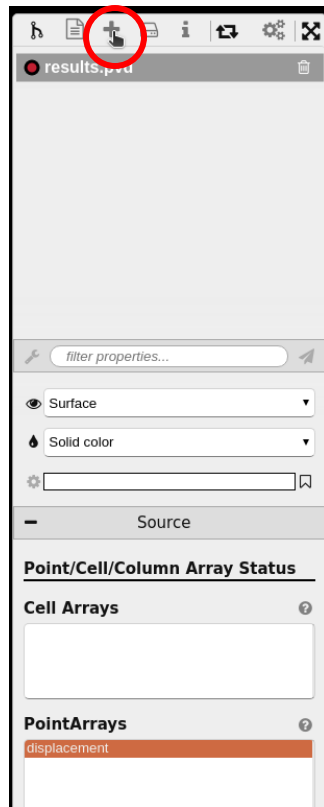
When the simulation is finished, the results will open automatically.

View Results

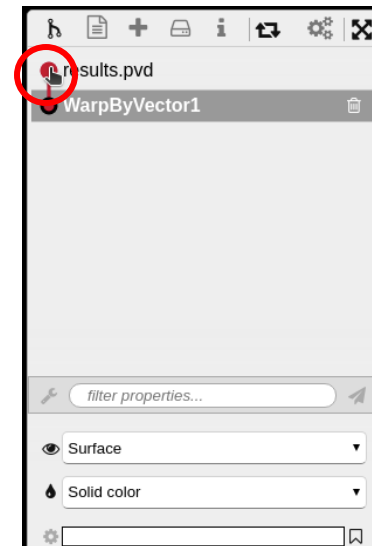


View results

Add a data visualization:
Click the **+** button at the
top of the left pane, then
choose Warp By Vector



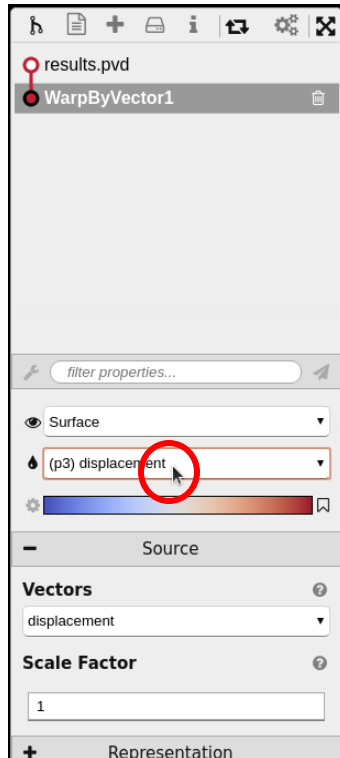
Turn off the base
visualization by clicking the
red circle next to results.pvd



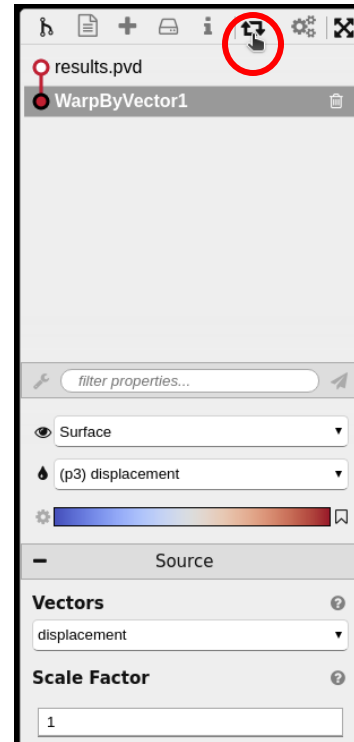
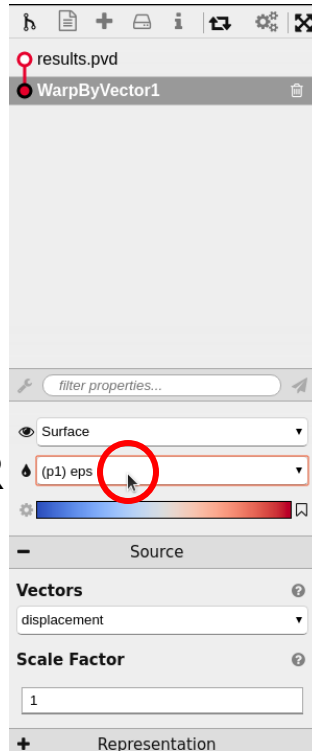
View results

Change the coloring from Solid Color to (p3) displacement or (p1) eps.

Click the circling arrows to correctly scale the colormap.



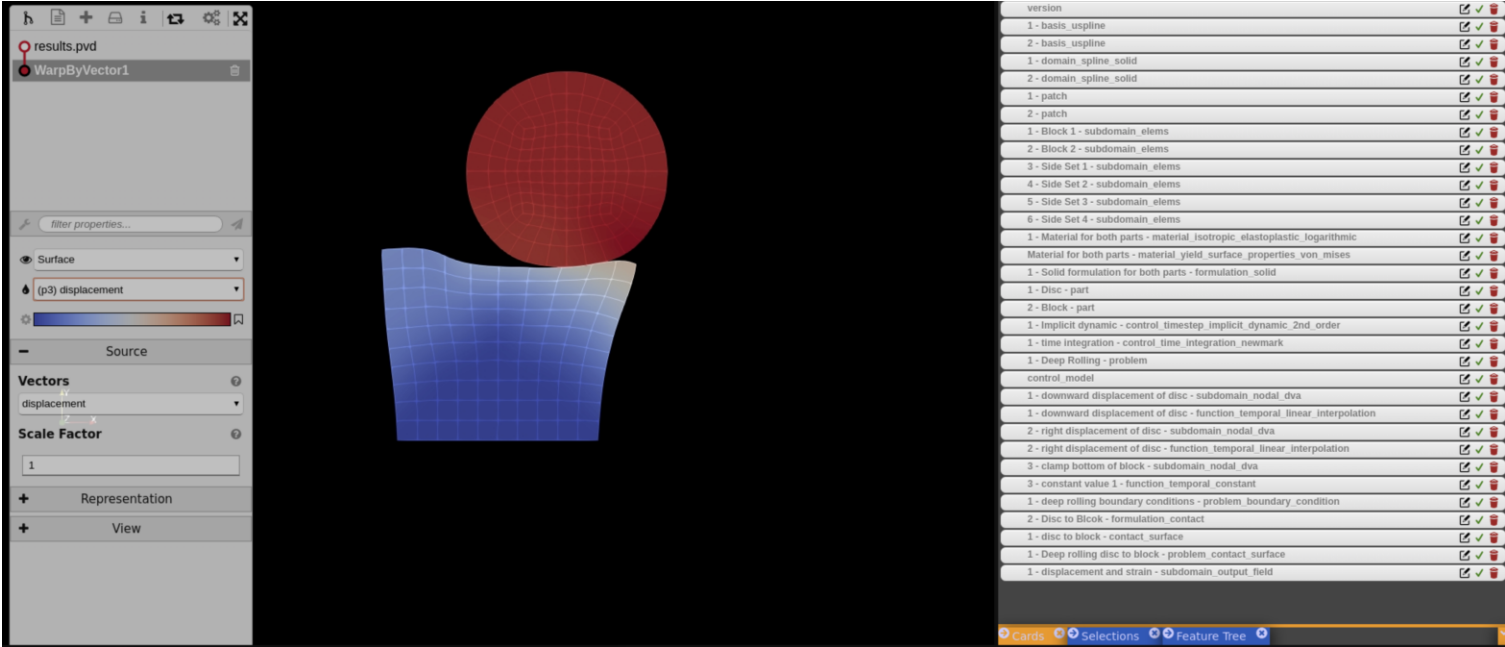
OR



Click the play arrow in the upper right of the results pane to play the results animation.



Displacements



EPS

