

COLE Better simulation through better geometry

Short Course Example Problems

Coreform

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

Summary of changes from problem 2:

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- 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 implict dynamic this to maintain a stable simulation while also respresenting 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 yeild stress will produce a larger springback effect.



Problem 2: Learning Objectives

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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

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Command Panel		0
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E	ntity - Surfaces	
	3 4 7 2 4	
Rectangle		*
Width 1		
Height 1		
O XPlane	O YPlane	
(i) ?		Apply

- or -

Create surface rectangle width 1 height 1 zplane



Create disc

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Command Pane	I						Ø
	Mode -	Geome	try				
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	Operati	on - Cr	eate G	eometr	y		
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Radius 0.5							
1.00103							
O XPlane		<u>о</u> ү	Plane		() ZPlar	ie

- or -

Create surface circle radius 0.5 zplane



Move disc

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Command Panel	0
Mode - Geometry	
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Operation - Transform Geometry	
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Entity - Surfaces	
Move	•
Surface ID(s) 2	
✓ Include Merged	
Select Method	
○ To Coordinates ○ To Entity	
Distance General Location	
O In Direction Of Surface Normal	
X Distance	
Y Distance 1	
Z Distance	

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



Mesh disc

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- Ol -Surface 2 scheme circle



- or -

Surface 2 size 0.1 Mesh surface 2



Mesh disc

WORK INTEGRATION



Coreform

Mesh block

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Entity - Surface	
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54 🔳	
Action - Intervals	
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Approximate Size	•
Select Surfaces	
Approximate Size 0.1	
✓ Preview	
	<u>A</u> pply Size
 Check For Overlapping Surfaces 	
 Apply Size Before Meshing 	
 O 	Mesh

- Or -Surface 1 size 0.1 Mesh surface 1



Create block sets - disc

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Command Panel Mode - Analysis Groups and Materials 👗 🗊 🌐 🤜 🗃 🌅 Entity - Blocks Action - Create 1 🔁 🦄 21 Treate block Block ID 1 Select O Tet Group Volume O Face O Tri Surface O Edge Curve O Node Vertex Hex ID(s) 2 Allow Blocks to Contain Duplicate Elements Reset All Blocks (i) • Apply

> - Or -Block 1 add surface 2



Create block sets - block



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	H H	
	Action - Create	
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ID(s) 1		
Allow Blocks	to Contain Duplicate Elements	
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Create side sets – bottom of block







Create side sets – top of block



Command Panel		0
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Split disc curve

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Coreform





Create side sets – bottom of disc

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- OC -Sideset 3 add curve 6

Coreform

Create side sets – top of disc

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WORK INTEGRATION







Export .cub file

<u>File Edit View D</u> isplay Tools <u>H</u> el	р
New	Ctrl+N
<u>Open</u>	Ctrl+O
Save	Ctrl+S
Save As	
Recent Imports	
Import	
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Set Directory	
1 //Tutorial1_start_test.trelis	
2 //Desktop/ShortCourse/tut3.cub	
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4 //CylinderForLattice.trelis)	
5 //ShortCourse/Tutorial1_start.treli	s)
Exit	



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

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Imported Cubit File

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Rename subdomians

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WORK INTEGRATION

Click on "Selections" pane

⊖ Cards 🛽 ⊖ Selections 🗳 ⊖ Feature Tree 😂





Material definition

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materia	l isotropic elastoplastic logarithmic@
	desc - optional Material for both parts <
	material_id 1
•	
	<u> </u>
E_time_de	pendent_function_temporal_id
 Etempera	ture_dependent_function_temporal_id
	nu 0.3 🧲
	rho 4e-5 🧲
material	yield_surface_properties_id 1 💭 🔻







Element Formulation

desc - optional	Solid formulation for both parts <	
formulation_id	1	
formulation_type	solid_2d	۲
quadrature	QP1 - default	۲
material id	1 📛	



Parts

<u>part</u> ?		
	desc - optional Disc	
	part_id 1	
	formulation_id 1	
	subdomain_ids	
+ Add	🖌 Free Edit	
1	*	
temp	erature_id - optional	

part?		
	desc - optional	Block
	part_id	2
	formulation_id	1 🗲
	subdomain_ids	
🛨 Add	🖌 Free Edit	
2	9	
tem	perature id - optional	



Control Timestep

control timestep implicit	<u>dynamic 2nd order</u>
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

newmark?	ontrol time integration
time integration <	desc - optional
1	control_time_integration_id
0.25 <	beta
0.5 <	gamma



Problem and Control Model

desc - option	al deep rolling contact
problem_	<u>id</u> 1
part_i	ds
🖶 Add 🛛 🥒 Free Edit	
— I	
	
control_timestep_	
coupled_problems - optior	nal
🖶 Add 🛛 🖌 Free Edit	
control_linear_solver	
options_from_command_line - op	tional false - default
solver type - op	tional superlu - default

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
control_problem 1
enable_parent_basis - optional false - default
enable_output - optional true - default
enable_output_restart - opuional faise - default
output_restart_nie_name_prenx =
output_restart_delta_t - optional 0.0
output_restart_delta_time_step - optional 1
output_restart_based_on_time_step - optional_false - default



Downward displacement of disc

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subd	omain nodal dva					function ter	<u>nporal linear interpolati</u>	ion?
	desc - optional	downward displacement of disc <						
	subdomain_nodal_value_id		_				desc - optional downward displace	ement of disc
	subdomain_id	6					function_temporal_id 1	
	dof_type	UY	•				birth 0.0	
	dva_type	DISPLACEMENT	•				death 1e10	
	nodal_value_spatial						tol 1e-10	
UX	UY	UZ	RX	RY	RZ			
-1	-0.075	-1	-1	-1	-1		Graph H Add	
	function_temporal_id	1	•			t	f(t)	
						 9 0	0	





Right displacement of disc

subdomain nodal dva					
desc - optional	right displacement of disc 🗸				
subdomain_nodal_value_id	2				
subdomain_id	· 🦛				
dof_type	UX				
dva_type	DISPLACEMENT	•			
nodal_value_spatial					
UX UY	UZ	RX	RY	RZ	
0.075	-1	-1	-1	-1	
function_temporal_id		•			

	desc -	optional	right displacement of disc <
	function_tem	nporal_id	2
		birth	1 0.0
		death	1e10
		tol	l 1e-10
		Graph	h 🖪 Add
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Û	0	0	
8	1	0	
-	2	1	
~	14	13	3





Clamp bottom of block

subdomain nodal c	va ?				function temporal constant?
desc - subdomain_nodal_ subdo	ptional clamp bottom of block				desc - optional constant value 1 function_temporal_id 3
	a type DISPLACEMENT	•			value 1 birth 0
UX	UY UZ	RX	RY	RZ	death 1e10
All changes saved	0 -1			-1	All changes saved



Problem boundary condition

	desc - optional deep rolling boundary conditions <	
	problem_id 1 <	
subdoma	ain_nodal_value_ids	
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\	*	
	*	

Coreform

Set up contact



contact surface	
desc - optional	disc to block
contact_surface_id	1
formulation_id	2 🔶
slave_subdomain_id	4
master subdomain id	5

_	daaa antional	Provide the second s
	desc - optional	Deep rolling - disc to block
	problem_id	
	contact_surface_ids	
🖪 Add	Free Edit	

Coreform

Output

	desc - optional Displacement and strain	
	subdomain_output_id 1	
	subdomain_ids	
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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 <	
	scho basis ovals - optional true, dofault	
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Final Setup

WORK INTEGRATION

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Run simulation

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



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

Coreform



View Results

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		2 - Block 2 - subdomain_elems	🗹 🗸 🍍
		3 - Side Set 1 - subdomain_elems	🗹 🗸 🋢
		4 - Side Set 2 - subdomain_elems	🗹 🗸 🍍
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		1 - time integration - control_time_integration_newmark	🗹 🗸 🍵
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		control_model	🗹 🗸 🍵
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	_	1 - downward displacement of disc - function_temporal_linear_interpolation	🗹 🗸 🍍
 Source 		2 - right displacement of disc - subdomain_nodal_dva	🗹 🗸 🋢
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		1 - deep rolling boundary conditions - problem_boundary_condition	🛛 🗹 🍍
		2 - Disc to Blook - formulation_contact	🗹 🗸 🋢
		1 - disc to block - contact_surface	🗹 🗸 🍍
		1 - Deep rolling disc to block - problem_contact_surface	- 🗹 🗸 🋢
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displacement	_		
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View results

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



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

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View results

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

Click the circling arrows to correctly scale the colormap.



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

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Coreform

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Displacements

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displacement	•	1 - downward displacement of disc - subdomain_nodal_dva	🗹 🗸 🍵
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		2 - right displacement of disc - function_temporal_linear_interpolation	🗹 🗸 🋢
1		3 - clamp bottom of block - subdomain_nodal_dva	🗹 🗸 🍵
		3 - constant value 1 - function_temporal_constant	🗹 🗸 🍵
+ Representation		1 - deep rolling boundary conditions - problem_boundary_condition	🗹 🗸 🋢
▲ Viow		2 - Disc to Blcok - formulation_contact	🗹 🗸 🍵
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		1 - Deep rolling disc to block - problem_contact_surface	🗹 🗸 🋢
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EPS

WORK INTEGRATION

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