

Chrono Default Demo Outputs

Chrono (CH) Demos:

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3. demo_CH_coords
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6. demo_CH_functions
7. demo_CH_linalg
8. demo_CH_math
9. demo_CH_matrix_ref
10. demo_CH_powertrain
11. demo_CH_solver

Co-simulation (COSIM) Demos (cannot be run without MathWorks Simulink):

1. demo_COSIM_data_exchange
2. demo_COSIM_hydraulics
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Finite Element Analysis (FEA) Demos:

1. demo_FEA_basic:

Chrono (CH) Demos:

demo_CH_archive:

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Chrono version: 9.0.1

CHRONO foundation classes demo: archives (serialization)

Some results of deserialization I/O:

test string

-123

0.123456

-0.012834 0.94555 -0.414966

0.542715 0.05349 0.5398280.5 0.6 0.70.1 0.2 0.3 0.4hey! stl string

container of 3 items, [St6vectorIdSaldEE]

[

2.3

45.3

66.44

]

[N6chrono10_wrap_pairlidEE]

120

0.99

container of 3 items, [St13unordered_maplidSt4hashliESt8equal_toliESalSt4pairKidEEE]

[

[N6chrono10_wrap_pairlidEE]

12

11.2

[N6chrono10_wrap_pairlidEE]

41

44.8

[N6chrono10_wrap_pairlidEE]

34

33.6

]

```
[14myEmployeeBoss]
```

```
 53
```

```
 12000.3
```

```
"fatty"
```

```
 1
```

```
[10myEmployee]
```

```
 21
```

```
 300
```

```
"ATHLETIC"
```

We loaded an obj inherited from myEmployee class:

```
0x1aac7e0
```

We loaded a 2nd obj inherited from myEmployee class (referencing the 1st):

```
0x1aac7e0
```

We loaded a 3rd obj inherited from myEmployee class:

```
0x1aaccd0(This object is handled by shared pointers, with ref.count=3)
```

We tried to load a 4th obj with shared pointer, and was null as expected.

We loaded a 5th object with non-default constructor with 2 parameters.

```
0x1ac84a0
```

We loaded a 6th object where sub-objects were unbind/rebind using IDs:

```
container of 2 items, [St6vectorIPN6chrono9ChVector3IdEESaIS3_EE]
```

```
[
```

```
]
```

```
5 6 77 8 7
```

```
loaded object is a myEmployee? :1
```

```
loaded object is a myEmployeeBoss? :1
```

Some results of deserialization I/O:

```
test string
```

```
-123
```

```
0.123456
```

```
-0.959954 -0.0845965 -0.873808
```

```
-0.52344 0.941268 0.8044160.5 0.6 0.70.1 0.2 0.3 0.4hey! stl string
```

```
container of 3 items, [St6vectorIdSaldEE]
```

```
[
```

```
 2.3
```

```
 45.3
```

```
 66.44
```

```
]
```

```
[N6chrono10_wrap_pairlidEE]
```

```
 120
```

```

0.99
container of 3 items, [St13unordered_mapidSt4hashliESt8equal_toliESalSt4pairlKidEEE]
[
    [N6chrono10_wrap_pairlidEE]
        12
        11.2
    [N6chrono10_wrap_pairlidEE]
        41
        44.8
    [N6chrono10_wrap_pairlidEE]
        34
        33.6
]
[14myEmployeeBoss]
53
12000.3
"fatty"
1
[10myEmployee]
21
300
"ATHLETIC"

```

We loaded an obj inherited from myEmployee class:

0x1aac5d0

We loaded a 2nd obj inherited from myEmployee class (referencing the 1st):

0x1aac5d0

We loaded a 3rd obj inherited from myEmployee class:

0x1aacc20(This object is handled by shared pointers, with ref.count=3)

We tried to load a 4th obj with shared pointer, and was null as expected.

We loaded a 5th object with non-default constructor with 2 parameters.

0x1ac8c40

We loaded a 6th object where sub-objects were unbind/rebind using IDs:

container of 2 items, [St6vectorIPN6chrono9ChVector3IdEESalS3_EE]

```

[
]
5 6 77 8 7
loaded object is a myEmployee? :1
loaded object is a myEmployeeBoss? :1

```

Some results of deserialization I/O:

```

test string
-123
0.123456
0.279958 -0.291903 0.375723
-0.668052 -0.119791 0.760150.5 0.6 0.70.1 0.2 0.3 0.4hey! stl string
container of 3 items, [St6vectorIdSaldEE]
[
    2.3
    45.3
    66.44
]
[N6chrono10_wrap_pairlidEE]
120
0.99
container of 3 items, [St13unordered_maplidSt4hashliESt8equal_toliESalSt4pairlKidEEE]
[
    [N6chrono10_wrap_pairlidEE]
        12
        11.2
    [N6chrono10_wrap_pairlidEE]
        41
        44.8
    [N6chrono10_wrap_pairlidEE]
        34
        33.6
]
[14myEmployeeBoss]
53
12000.3
"fatty"
1
[10myEmployee]
21
300
"ATHLETIC"

```

We loaded an obj inherited from myEmployee class:

0x1aac7e0

We loaded a 2nd obj inherited from myEmployee class (referencing the 1st):

0x1aac7e0

We loaded a 3rd obj inherited from myEmployee class:

0x1aaccd0(This object is handled by shared pointers, with ref.count=3)

We tried to load a 4th obj with shared pointer, and was null as expected.

We loaded a 5th object with non-default constructor with 2 parameters.

0x1ac8d20

We loaded a 6th object where sub-objects were unbind/rebind using IDs:

container of 2 items, [St6vectorIPN6chrono9ChVector3IdEESaIS3_EE]

[

]

5 6 77 8 7

loaded object is a myEmployee? :1

loaded object is a myEmployeeBoss? :1

Serialization test ended with success.

Serialization of ChSystem ended with success.

Property explorer : retrieved 'wages'=42000.4

Property explorer : retrieved 'slave':

age 21

wages 300

body "ATHLETIC"

Property explorer : retrieved 'slave/age'=21

Property explorer : cannot retrieve 'int foo'!

Property explorer : retrieved from element number in container '1':

age 29

wages 5000

body "ATHLETIC"

Property explorer : retrieved from element container name 'Marie':

age 31

wages 6000

body "ATHLETIC"

This has sub properties? : 1

This has sub properties? : 0

List of fetched properties in std::vector of employees:

val: 0, reg.class: myEmployee, typeid: 10myEmployee

val: age, reg.class: , typeid: i

val: wages, reg.class: , typeid: d

val: body, reg.class: , typeid: NSt7__cxx1112basic_stringIcSt11char_traitsIcESalcEEE

val: 1, reg.class: myEmployee, typeid: 10myEmployee

val: age, reg.class: , typeid: i

val: wages, reg.class: , typeid: d

val: body, reg.class: , typeid: NSt7__cxx1112basic_stringIcSt11char_traitsIcESalcEEE

val: 2, reg.class: myEmployee, typeid: 10myEmployee

```
val: age, reg.class: , typeid: i
val: wages, reg.class: , typeid: d
val: body, reg.class: , typeid: NSt7__cxx1112basic_stringIcSt11char_traitsIcESalcEEE
Reflection test ended with success.
```

demo CH buildsystem:

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Chrono version: 9.0.1

Example: create a physical system...

Here's the system hierarchy which you built:

List of the 3 added rigid bodies:

```
BODY: 3
MARKER: 6
MARKER: 7
FORCE: 10
FORCE: 11
BODY: 4
MARKER: 8
MARKER: 9
BODY: 5
```

List of the 0 added shafts:

List of the 0 added links:

List of the 0 added meshes:

List of other 0 added physic items:

Here's the system hierarchy after modifications:

List of the 2 added rigid bodies:

```
BODY: 4
MARKER: 8
MARKER: 9
MARKER: 6 JohnFoo
MARKER: 7
FORCE: 10
FORCE: 11
BODY: 5
```

List of the 0 added shafts:

List of the 0 added links:

List of the 0 added meshes:

List of other 0 added physic items:

Example: create a slider-crank system:

Here's the system hierarchy for slider-crank:

List of the 3 added rigid bodies:

BODY: 14 truss
MARKER: 22 truss_pointline
BODY: 15 crank
MARKER: 17 crank_rev
BODY: 16 rod
MARKER: 18 rod_rev
MARKER: 21 rod_poinline

List of the 0 added shafts:

List of the 3 added links:

LINK: 19 REVOLUTE crank-rod [N6chrono18ChLinkLockRevoluteE]
marker1: 17 crank_rev
marker2: 18 rod_rev
LINK: 20 POINTLINE rod-truss [N6chrono19ChLinkLockPointLineE]
marker1: 21 rod_poinline
marker2: 22 truss_pointline
LINK: 23 MOTOR truss-crank [N6chrono24ChLinkMotorRotationSpeedE]

List of the 0 added meshes:

List of other 0 added physic items:

Now use an iterator to scan through already-added constraints:

Link class: N6chrono18ChLinkLockRevoluteE
Link class: N6chrono19ChLinkLockPointLineE
Link class: N6chrono24ChLinkMotorRotationSpeedE

Time: 0.05 Steps: 5 Slider X position: 5.96433 Engine torque: -13.2644
Time: 0.1 Steps: 10 Slider X position: 5.85521 Engine torque: -5.84936
Time: 0.15 Steps: 15 Slider X position: 5.6786 Engine torque: 0.0077132
Time: 0.2 Steps: 20 Slider X position: 5.44222 Engine torque: 3.50853
Time: 0.25 Steps: 25 Slider X position: 5.15649 Engine torque: 4.28259
Time: 0.3 Steps: 30 Slider X position: 4.83408 Engine torque: 2.49148
Time: 0.35 Steps: 35 Slider X position: 4.48921 Engine torque: -1.14945
Time: 0.4 Steps: 40 Slider X position: 4.13669 Engine torque: -5.48727
Time: 0.45 Steps: 45 Slider X position: 3.79069 Engine torque: -9.21567
Time: 0.5 Steps: 50 Slider X position: 3.46354 Engine torque: -11.267
Time: 0.55 Steps: 55 Slider X position: 3.16464 Engine torque: -11.1384
Time: 0.6 Steps: 60 Slider X position: 2.9 Engine torque: -8.96845
Time: 0.65 Steps: 65 Slider X position: 2.67234 Engine torque: -5.33944
Time: 0.7 Steps: 70 Slider X position: 2.48176 Engine torque: -0.965409
Time: 0.75 Steps: 75 Slider X position: 2.32665 Engine torque: 3.54586
Time: 0.8 Steps: 80 Slider X position: 2.20454 Engine torque: 7.78573
Time: 0.85 Steps: 85 Slider X position: 2.11281 Engine torque: 11.5312
Time: 0.9 Steps: 90 Slider X position: 2.0491 Engine torque: 14.6912
Time: 0.95 Steps: 95 Slider X position: 2.01163 Engine torque: 17.2559
Time: 1 Steps: 100 Slider X position: 1.99926 Engine torque: 19.2613
Time: 1.05 Steps: 105 Slider X position: 2.01163 Engine torque: 20.7697
Time: 1.1 Steps: 110 Slider X position: 2.04911 Engine torque: 21.8572
Time: 1.15 Steps: 115 Slider X position: 2.11281 Engine torque: 22.6027
Time: 1.2 Steps: 120 Slider X position: 2.20455 Engine torque: 23.0715
Time: 1.25 Steps: 125 Slider X position: 2.32666 Engine torque: 23.2853
Time: 1.3 Steps: 130 Slider X position: 2.48177 Engine torque: 23.1756
Time: 1.35 Steps: 135 Slider X position: 2.67234 Engine torque: 22.5251
Time: 1.4 Steps: 140 Slider X position: 2.9 Engine torque: 20.9291
Time: 1.45 Steps: 145 Slider X position: 3.16463 Engine torque: 17.8338
Time: 1.5 Steps: 150 Slider X position: 3.46353 Engine torque: 12.7137
Time: 1.55 Steps: 155 Slider X position: 3.79067 Engine torque: 5.36828
Time: 1.6 Steps: 160 Slider X position: 4.13666 Engine torque: -3.81343
Time: 1.65 Steps: 165 Slider X position: 4.48918 Engine torque: -13.8134
Time: 1.7 Steps: 170 Slider X position: 4.83405 Engine torque: -23.2309
Time: 1.75 Steps: 175 Slider X position: 5.15646 Engine torque: -30.677
Time: 1.8 Steps: 180 Slider X position: 5.4422 Engine torque: -35.1197
Time: 1.85 Steps: 185 Slider X position: 5.67858 Engine torque: -36.0702
Time: 1.9 Steps: 190 Slider X position: 5.8552 Engine torque: -33.6118
Time: 1.95 Steps: 195 Slider X position: 5.96433 Engine torque: -28.3254
Time: 2 Steps: 200 Slider X position: 6.00123 Engine torque: -21.1574
Time: 2.05 Steps: 205 Slider X position: 5.96433 Engine torque: -13.2647
Time: 2.1 Steps: 210 Slider X position: 5.85521 Engine torque: -5.84936
Time: 2.15 Steps: 215 Slider X position: 5.6786 Engine torque: 0.0077132
Time: 2.2 Steps: 220 Slider X position: 5.44222 Engine torque: 3.50853

Time: 2.25 Steps: 225 Slider X position: 5.15649 Engine torque: 4.28259
Time: 2.3 Steps: 230 Slider X position: 4.83408 Engine torque: 2.49148
Time: 2.35 Steps: 235 Slider X position: 4.48921 Engine torque: -1.14945
Time: 2.4 Steps: 240 Slider X position: 4.13669 Engine torque: -5.48727
Time: 2.45 Steps: 245 Slider X position: 3.79069 Engine torque: -9.21567
Time: 2.5 Steps: 250 Slider X position: 3.46354 Engine torque: -11.267

demo CH coords:

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Chrono version: 9.0.1

CHRONO demo about coordinate transformations:

```
7.58824 9 10.6471 ..using linear algebra
7.58824 9 10.6471 ..using quaternion rotation
7.58824 9 10.6471 ..using a ChChCoordsys<> object
7.58824 9 10.6471 ..using a ChChCoordsys<> '>>' operator
7.58824 9 10.6471 ..using a ChChCoordsys<> '*' operator
7.58824 9 10.6471 ..using a ChFrame object function
7.58824 9 10.6471 ..using a ChFrame '>>' operator
7.58824 9 10.6471 ..using a ChFrame '*' operator
14.7344 11.5844 7.59308 ..triple trsf. using linear algebra
14.7344 11.5844 7.59308 ..triple vector trsf. with ChFrame '>>' operator
14.7344 11.5844 7.59308 ..triple vector trsf. with ChFrame '*' operator
14.7344 11.5844 7.59308 ..triple vector trsf. with ChFrame '*' operator
14.7344 11.5844 7.59308
-0.832833 0.151032 -0.32364 0.422889 ..triple frame trsf. with ChFrame '>>' operator
14.7344 11.5844 7.59308
-0.832833 0.151032 -0.32364 0.422889 ..triple frame trsf. with ChFrame '*' operator
14.7344 11.5844 7.59308
-0.832833 0.151032 -0.32364 0.422889 ..triple frame trsf. with ChCoordsys '>>' operator
14.7344 11.5844 7.59308
-0.832833 0.151032 -0.32364 0.422889 ..triple frame trsf. with ChCoordsys '*' operator
2 3 4 ..mvect1
2 3 4 ..inv, using linear algebra
2 3 4 ..inv, using quaternion rotation
2 3 4 ..inv, using a ChChCoordsys<> object
2 3 4 ..inv, using a ChFrame object function
2 3 4 ..inv, using a ChFrame inverse and '>>' operator
2 3 4 ..inv, using a ChFrame inverse and '*' operator
2 3 4 ..inv, using a ChFrame '/' operator
2 3 4 ..inv, using an inverted ChFrame
2 3 4 ..inv three transf
2 3 4 ..inv three transf (another method)
2 3 4 ..inv three transf (another method)
```

2 3 4 ..inv three transf (another method)

5 6 7

0.140028 0.420084 0.560112 0.70014a moving frame

6.6098 5.76667 9.86078

0.140028 0.420084 0.560112 0.70014 transform loc->abs

TEST 1e6 calls to ChFrameMoving::TransformLocalToParent. Time = 2.82591

TEST 1e6 calls of mvect2 = mvect1 >> mframeA. Time = 3.32166

TEST 1e6 calls to PointAccelerationParentToLocal. Time = 6.38441

demo CH EulerAngles:

Rotations about frame axes:

Rotation about X of 10.0000 deg. eu = {10.0000 -0.0000 0.0000}

Rotation about Y of 11.0000 deg. eu = {0.0000 11.0000 0.0000}

Rotation about Z of 12.0000 deg. eu = {0.0000 -0.0000 12.0000}

Rotation about X of -17.3000 deg. eu = {-17.3000 -0.0000 0.0000}

Rotation about Y of -41.0000 deg. eu = {0.0000 -41.0000 0.0000}

Rotation about Z of -0.7000 deg. eu = {0.0000 -0.0000 -0.7000}

Quaternion from Euler angles:

Input = {10.0000 11.0000 12.0000} q = {0.9870 0.0763 0.1040 0.0953} Output = {10.0000 11.0000 12.0000}

Input = {-17.3000 -41.0000 -0.7000} q = {0.9257 -0.1430 -0.3454 -0.0583} Output = {-17.3000 -41.0000 -0.7000}

Euler angles -> Quaternion -> Euler angles (using free functions):

Input = {10.0000 11.0000 12.0000} q = {0.9870 -0.0763 -0.1040 -0.0953} 10.0000 11.0000 12.0000

Input = {-17.3000 -41.0000 -0.7000} q = {0.9257 0.1430 0.3454 0.0583} -17.3000 -41.0000 -0.7000

Rotation matrix for sequence (90, 90, 90)

0.9992 0.0274 -0.0274

-0.0267 0.9993 0.0274

0.0281 -0.0267 0.9992

demo_CH_filesystem:

0

/dir 1/dir 2

/dir 1/dir 2/dir 3

/dir 1/dir 2

/dir 1

/

/

..

Current directory = /nfs/home/derrowjb/CS470/Chrono/chrono/build/bin

Create output directory; out_dir = DEMO_OUTPUT/DEMO_FILESYSTEM

out_dir exists? 0

...Created output directory

out_dir exists? 1

out_dir is directory? 1

path of out_dir: DEMO_OUTPUT/DEMO_FILESYSTEM

abs. path of out_dir:

/nfs/home/derrowjb/CS470/Chrono/chrono/build/bin/DEMO_OUTPUT/DEMO_FILESYSTEM

Create output file; out_file = DEMO_OUTPUT/DEMO_FILESYSTEM/foo.txt

out_file exists? 0

...Created output file

out_file exists? 1

out_file is file? 1

path of out_file: DEMO_OUTPUT/DEMO_FILESYSTEM/foo.txt

file location: DEMO_OUTPUT/DEMO_FILESYSTEM

abs. path of out_file:

/nfs/home/derrowjb/CS470/Chrono/chrono/build/bin/DEMO_OUTPUT/DEMO_FILESYSTEM/foo.txt

Create nested directories; nested = DEMO_OUTPUT/DEMO_FILESYSTEM/child/grandchild

nested (as path) = DEMO_OUTPUT/DEMO_FILESYSTEM/child/grandchild

length of nested = 4

nested exists? 0

...Created nested subdirectories

nested exists? 1

nested is directory? 1

path of nested: DEMO_OUTPUT/DEMO_FILESYSTEM/child/grandchild

abs. path of nested:

/nfs/home/derrowjb/CS470/Chrono/chrono/build/bin/DEMO_OUTPUT/DEMO_FILESYSTEM/child/grandchild

```
some/path.ext:operator==( ) = 1
some/path.ext:operator==( )(unequal) = 0
nonexistant:exists = 0
nonexistant:is_file = 0
nonexistant:is_directory = 0
nonexistant:filename = nonexistent
nonexistant:extension =

out_file:exists = 1
out_file:is_file = 1
out_file:is_directory = 0
out_file:filename = foo.txt
out_file:stem = foo
out_file:extension = txt
out_file:make_absolute =
/nfs/home/derrowjb/CS470/Chrono/chrono/build/bin/DEMO_OUTPUT/DEMO_FILESYSTEM/foo
.txt

out_dir:exists = 1
out_dir:is_file = 0
out_dir:is_directory = 1
out_dir:filename = DEMO_FILESYSTEM
out_dir:stem = DEMO_FILESYSTEM
out_dir:extension =
out_dir:make_absolute =
/nfs/home/derrowjb/CS470/Chrono/chrono/build/bin/DEMO_OUTPUT/DEMO_FILESYSTEM

resolve(out_file) =
/nfs/home/derrowjb/CS470/Chrono/chrono/build/bin/DEMO_OUTPUT/DEMO_FILESYSTEM/foo
.txt
resolve(nonexistant) = nonexistent
```

demo CH functions:

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Chrono version: 9.0.1
==== Test 1...

ChFunctionRamp at x=0: y=1.4 dy/dx=0.1

==== Test 2...

==== Test 3...

==== Test 4...

===== Test 5...

demo_CH_linalg:

==== Creation and assignment ===

```
0.1 0.1 0.1 0.1  
0.1 0.1 0.1 0.1  
0.1 0.1 0.1 0.1  
0.1 0.1 0.1 0.1
```

==== Matrix operations ===

```
0.485744 -0.12834  9.4555  
-4.14966  5.42715  0.5349  
0.485744 -0.12834  9.4555  
-4.14966  5.42715  0.5349  
rot * matrix  
0 0  
0 0  
0 0  
matrix * rot  
0 0 0  
0 0 0
```

==== Chrono extensions to Eigen::MatrixBase ===

random 2x3 matrix A:

```
0.838053 -0.860489  0.898654  
0.0519907 -0.827888 -0.615572
```

fill diagonal with 10.1:

```
10.1 -0.860489  0.898654  
0.0519907    10.1 -0.615572
```

fill entire matrix with 2.1:

```
2.1 2.1 2.1  
2.1 2.1 2.1
```

matrix B = A with B(1,2) incremented by 0.01

```
2.1 2.1 2.1  
2.1 2.1 2.11  
|A-B| < 0.1?  1  
|A-B| < 0.001? 0  
||v||_wrms, w = 0.783156
```

$\|v + v\|_{\text{wrms}}$, w = 1.56631

v + v + 1: 5

7

9

1 + v: 3

4

5

==== Matrix comparison tests ===

Matrices are exactly equal

Matrices are equal within tol 0.002

==== Pasting matrices and matrix-blocks ===

```
-0.873808 -0.52344  0.941268  0.804416  0.70184 -0.466669
0.0795207 -0.249586  0.520497  0.0250707  0.335448  0.0632129
-0.921439 -0.124725  0.86367   0.86162   0.441905 -0.431413
 0.477069  0.279958 -0.291903  0.375723 -0.668052 -0.119791
```

1 2 3

4 5 6

```
0 0 0 0 0 0
0 10 20 30 0 0 0
0 40 50 60 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
```

```
-0.873808 -0.52344  0.941268  0.804416  0.70184 -0.466669
0.0795207 -0.249586      1      2      3 0.0632129
-0.921439 -0.124725      4      5      6 -0.431413
 0.477069  0.279958 -0.291903  0.375723 -0.668052 -0.119791
```

```
-0.873808 -0.52344  0.941268  0.804416  0.70184 -0.466669
0.0795207 -0.249586      11     22     33 0.0632129
-0.921439 -0.124725      44     55     66 -0.431413
 0.477069  0.279958 -0.291903  0.375723 -0.668052 -0.119791
```

==== 3x3 matrix times vector ===

1 0 0

0 1 0

```
0 0 1  
0.76015 0.658402 -0.339326  
-0.542064 0.786745 -0.29928  
0.37334 0.912937 0.17728  
1.05898 0.133587 2.73105  
0.796043 4.9707 -0.406044
```

==== Custom 3x4, 4x3, and 4x4 matrices ===

```
10 10 10  
2 2 2  
2 2 2  
2 2 2  
2 2 2  
60 60 60 60  
30 30 30 30  
1 0 0  
0 0.866025 -0.5  
0 0.5 0.866025  
1 0 0  
0 0.866025 0.5  
0 -0.5 0.866025  
rot * G:  
1 1 1 1  
0.366025 0.366025 0.366025 0.366025  
1.36603 1.36603 1.36603 1.36603  
rot * (G').transpose:  
2 2 2 2  
0.732051 0.732051 0.732051 0.732051  
2.73205 2.73205 2.73205 2.73205
```

```
G' * rot:  
2 2.73205 0.732051  
2 2.73205 0.732051  
2 2.73205 0.732051  
2 2.73205 0.732051  
G.transpose * rot:
```

```
1 1.36603 0.366025  
1 1.36603 0.366025  
1 1.36603 0.366025  
1 1.36603 0.366025
```

```
Random 4x4 * q:  
52.7706 48.5036 34.1218 6.10537  
4x4 star matrix X:  
1 -2 -3 -4
```

2 1 -4 3
3 4 1 -2
4 -3 2 1

Semi-transpose X:

1 -2 -3 -4
2 1 4 -3
3 -4 1 2
4 3 -2 1

Semi-negate X:

1 2 3 4
2 -1 -4 3
3 4 -1 -2
4 -3 2 -1

==== Frame transformations ===

1
1 1

==== Linear systems ===

matrix A:

1 2 3
4 5 6
7 8 10

vector b:

3
3
4

solution:

-2
1
1

Ax-b:

-4.44089e-16
0
-1.77636e-15

demo_CH_math:

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Chrono version: 9.0.1

==== Computing integrals of functions in 1D/2D/3D ===

Quadrature 1d result: 2 (analytic solution: 2.0)
Quadrature 2d result: 4 (analytic solution: 4.0)
Quadrature 2d matrix result: 2.25 4.5 (analytic solution: 2.25, 4.5)

demo_CH_matrix_ref:

0.753995 0.753995

0.753995 0.753995

-0.329554 0.536459 -0.444451
0.10794 -0.0452059 0.257742

-0.270431 0.0268018 0.904459
0.83239 0.271423 0.434594

1 0.536459 -0.444451
0.10794 -0.0452059 0.257742

1 0.0268018 0.904459
0.83239 0.271423 0.434594

demo_CH_powertrain:

...

Time: 2.99

shaft B rot: 0.0832358 speed: 1.03995 accel: -4.13871
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=6.20806 Tfreewheel=0 Tclutch=0 ratchet vane=3

Time: 3

shaft B rot: 0.0931624 speed: 0.99265 accel: -4.72963
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=7.09444 Tfreewheel=0 Tclutch=0 ratchet vane=4

Time: 3.01

shaft B rot: 0.102559 speed: 0.939714 accel: -5.29367
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=7.94051 Tfreewheel=0 Tclutch=0 ratchet vane=4

Time: 3.02

shaft B rot: 0.111374 speed: 0.881437 accel: -5.82763
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=8.74145 Tfreewheel=0 Tclutch=0 ratchet vane=4

Time: 3.03

shaft B rot: 0.119555 speed: 0.818153 accel: -6.32849
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=9.49273 Tfreewheel=0 Tclutch=0 ratchet vane=4

Time: 3.04

shaft B rot: 0.127058 speed: 0.750219 accel: -6.79338

shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=10.1901 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.05
shaft B rot: 0.133838 speed: 0.678022 accel: -7.21966
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=10.8295 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.06
shaft B rot: 0.139858 speed: 0.601973 accel: -7.60493
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=11.4074 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.07
shaft B rot: 0.145083 speed: 0.522503 accel: -7.94698
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=11.9205 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.08
shaft B rot: 0.149483 speed: 0.440064 accel: -8.24388
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=12.3658 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.09
shaft B rot: 0.153034 speed: 0.355125 accel: -8.49393
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=12.7409 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.1
shaft B rot: 0.155716 speed: 0.268168 accel: -8.69572
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.0436 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.11
shaft B rot: 0.157513 speed: 0.179687 accel: -8.8481
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.2722 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.12
shaft B rot: 0.158415 speed: 0.0901846 accel: -8.9502
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.4253 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.13
shaft B rot: 0.158417 speed: 0.000170157 accel: -9.00145
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.5022 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.14
shaft B rot: 0.157518 speed: -0.0898453 accel: -9.00154
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.5023 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.15
shaft B rot: 0.155725 speed: -0.17935 accel: -8.95049

shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.4257 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.16
shaft B rot: 0.153046 speed: -0.267836 accel: -8.84858
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.2729 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.17
shaft B rot: 0.149498 speed: -0.3548 accel: -8.69639
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=13.0446 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.18
shaft B rot: 0.145101 speed: -0.439748 accel: -8.49479
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=12.7422 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.19
shaft B rot: 0.139879 speed: -0.522197 accel: -8.24491
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=12.3674 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.2
shaft B rot: 0.133862 speed: -0.601679 accel: -7.94819
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=11.9223 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.21
shaft B rot: 0.127085 speed: -0.677742 accel: -7.60631
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=11.4095 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.22
shaft B rot: 0.119585 speed: -0.749954 accel: -7.2212
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=10.8318 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.23
shaft B rot: 0.111406 speed: -0.817904 accel: -6.79506
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=10.1926 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.24
shaft B rot: 0.102594 speed: -0.881208 accel: -6.33031
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=9.49547 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.25
shaft B rot: 0.0931989 speed: -0.939504 accel: -5.82959
shaft C rot: -0.912498 speed: 0 accel: 0
Torque: Tmotor=8.74439 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.26
shaft B rot: 0.0832743 speed: -0.992461 accel: -5.29575

shaft C rot: -0.922035 speed: -0.953705 accel: -95.3705
Torque: Tmotor=413.129 Tfreewheel=405.186 Tclutch=100 ratchet vane=4
Time: 3.27
shaft B rot: 0.0728765 speed: -1.03978 accel: -4.73181
shaft C rot: -0.932433 speed: -1.03978 accel: -8.60737
Torque: Tmotor=134.641 Tfreewheel=127.544 Tclutch=100 ratchet vane=4
Time: 3.28
shaft B rot: 0.0620646 speed: -1.08119 accel: -4.14099
shaft C rot: -0.943245 speed: -1.08119 accel: -4.14099
Torque: Tmotor=119.463 Tfreewheel=113.251 Tclutch=100 ratchet vane=4
Time: 3.29
shaft B rot: 0.0509 speed: -1.11646 accel: -3.52663
shaft C rot: -0.95441 speed: -1.11646 accel: -3.52663
Torque: Tmotor=116.575 Tfreewheel=111.285 Tclutch=100 ratchet vane=4
Time: 3.3
shaft B rot: 0.0394463 speed: -1.14538 accel: -2.89224
shaft C rot: -0.965863 speed: -1.14538 accel: -2.89224
Torque: Tmotor=113.594 Tfreewheel=109.255 Tclutch=100 ratchet vane=4
Time: 3.31
shaft B rot: 0.0277683 speed: -1.16779 accel: -2.24141
shaft C rot: -0.977541 speed: -1.16779 accel: -2.24141
Torque: Tmotor=110.535 Tfreewheel=107.173 Tclutch=100 ratchet vane=4
Time: 3.32
shaft B rot: 0.0159326 speed: -1.18357 accel: -1.57785
shaft C rot: -0.989377 speed: -1.18357 accel: -1.57785
Torque: Tmotor=107.416 Tfreewheel=105.049 Tclutch=100 ratchet vane=4
Time: 3.33
shaft B rot: 0.0040064 speed: -1.19262 accel: -0.905324
shaft C rot: -1.0013 speed: -1.19262 accel: -0.905324
Torque: Tmotor=104.255 Tfreewheel=102.897 Tclutch=100 ratchet vane=4
Time: 3.34
shaft B rot: -0.0079426 speed: -1.1949 accel: -0.227652
shaft C rot: -1.01325 speed: -1.1949 accel: -0.227652
Torque: Tmotor=101.07 Tfreewheel=100.728 Tclutch=100 ratchet vane=4
Time: 3.35
shaft B rot: -0.0198465 speed: -1.19039 accel: 0.451315
shaft C rot: -1.02516 speed: -1.19039 accel: 0.451315
Torque: Tmotor=97.8788 Tfreewheel=98.5558 Tclutch=100 ratchet vane=4
Time: 3.36
shaft B rot: -0.0316376 speed: -1.17911 accel: 1.12772
shaft C rot: -1.03695 speed: -1.17911 accel: 1.12772
Torque: Tmotor=94.6997 Tfreewheel=96.3913 Tclutch=100 ratchet vane=4
Time: 3.37
shaft B rot: -0.0432489 speed: -1.16113 accel: 1.79771

shaft C rot: -1.04856 speed: -1.16113 accel: 1.79771
Torque: Tmotor=91.5508 Tfreewheel=94.2473 Tclutch=100 ratchet vane=4
Time: 3.38
shaft B rot: -0.0546145 speed: -1.13656 accel: 2.45749
shaft C rot: -1.05992 speed: -1.13656 accel: 2.45749
Torque: Tmotor=88.4498 Tfreewheel=92.136 Tclutch=100 ratchet vane=4
Time: 3.39
shaft B rot: -0.0656697 speed: -1.10552 accel: 3.1033
shaft C rot: -1.07098 speed: -1.10552 accel: 3.1033
Torque: Tmotor=85.4145 Tfreewheel=90.0694 Tclutch=100 ratchet vane=4
Time: 3.4
shaft B rot: -0.0763518 speed: -1.06821 accel: 3.73148
shaft C rot: -1.08166 speed: -1.06821 accel: 3.73148
Torque: Tmotor=82.462 Tfreewheel=88.0592 Tclutch=100 ratchet vane=4
Time: 3.41
shaft B rot: -0.0866001 speed: -1.02483 accel: 4.33846
shaft C rot: -1.09191 speed: -1.02483 accel: 4.33846
Torque: Tmotor=79.6092 Tfreewheel=86.1169 Tclutch=100 ratchet vane=4
Time: 3.42
shaft B rot: -0.0963563 speed: -0.975617 accel: 4.92079
shaft C rot: -1.10167 speed: -0.975617 accel: 4.92079
Torque: Tmotor=76.8723 Tfreewheel=84.2535 Tclutch=100 ratchet vane=4
Time: 3.43
shaft B rot: -0.105565 speed: -0.920866 accel: 5.47515
shaft C rot: -1.11087 speed: -0.920866 accel: 5.47515
Torque: Tmotor=74.2668 Tfreewheel=82.4795 Tclutch=100 ratchet vane=4
Time: 3.44
shaft B rot: -0.114174 speed: -0.860882 accel: 5.99841
shaft C rot: -1.11948 speed: -0.860882 accel: 5.99841
Torque: Tmotor=71.8075 Tfreewheel=80.8051 Tclutch=100 ratchet vane=4
Time: 3.45
shaft B rot: -0.122134 speed: -0.796006 accel: 6.48758
shaft C rot: -1.12744 speed: -0.796006 accel: 6.48758
Torque: Tmotor=69.5084 Tfreewheel=79.2397 Tclutch=100 ratchet vane=4
Time: 3.46
shaft B rot: -0.1294 speed: -0.726607 accel: 6.93989
shaft C rot: -1.13471 speed: -0.726607 accel: 6.93989
Torque: Tmotor=67.3825 Tfreewheel=77.7924 Tclutch=100 ratchet vane=4
Time: 3.47
shaft B rot: -0.135931 speed: -0.65308 accel: 7.35276
shaft C rot: -1.14124 speed: -0.65308 accel: 7.35276
Torque: Tmotor=65.442 Tfreewheel=76.4712 Tclutch=100 ratchet vane=4
Time: 3.48
shaft B rot: -0.141689 speed: -0.575841 accel: 7.72385

shaft C rot: -1.147 speed: -0.575841 accel: 7.72385
Torque: Tmotor=63.6979 Tfreewheel=75.2837 Tclutch=100 ratchet vane=4
Time: 3.49
shaft B rot: -0.146642 speed: -0.49533 accel: 8.05106
shaft C rot: -1.15195 speed: -0.49533 accel: 8.05106
Torque: Tmotor=62.16 Tfreewheel=74.2366 Tclutch=100 ratchet vane=4
Time: 3.5
shaft B rot: -0.150762 speed: -0.412005 accel: 8.33251
shaft C rot: -1.15607 speed: -0.412005 accel: 8.33251
Torque: Tmotor=60.8372 Tfreewheel=73.336 Tclutch=100 ratchet vane=4
Time: 3.51
shaft B rot: -0.154026 speed: -0.326339 accel: 8.56662
shaft C rot: -1.15934 speed: -0.326339 accel: 8.56662
Torque: Tmotor=59.7369 Tfreewheel=72.5868 Tclutch=100 ratchet vane=4
Time: 3.52
shaft B rot: -0.156414 speed: -0.238819 accel: 8.75205
shaft C rot: -1.16172 speed: -0.238819 accel: 8.75205
Torque: Tmotor=58.8653 Tfreewheel=71.9934 Tclutch=100 ratchet vane=4
Time: 3.53
shaft B rot: -0.157913 speed: -0.149941 accel: 8.88776
shaft C rot: -1.16322 speed: -0.149941 accel: 8.88776
Torque: Tmotor=58.2275 Tfreewheel=71.5592 Tclutch=100 ratchet vane=4
Time: 3.54
shaft B rot: -0.158516 speed: -0.0602115 accel: 8.97296
shaft C rot: -1.16383 speed: -0.0602115 accel: 8.97296
Torque: Tmotor=57.8271 Tfreewheel=71.2865 Tclutch=100 ratchet vane=4
Time: 3.55
shaft B rot: -0.158217 speed: 0.0298602 accel: 9.00717
shaft C rot: -1.16383 speed: -2.77348e-14 accel: 6.02115
Torque: Tmotor=-13.5108 Tfreewheel=0 Tclutch=19.2677 ratchet vane=4
Time: 3.56
shaft B rot: -0.157019 speed: 0.119762 accel: 8.9902
shaft C rot: -1.16383 speed: -1.13375e-26 accel: 2.77348e-12
Torque: Tmotor=-13.4853 Tfreewheel=0 Tclutch=8.87512e-12 ratchet vane=4
Time: 3.57
shaft B rot: -0.154929 speed: 0.208984 accel: 8.92215
shaft C rot: -1.16383 speed: 6.42275e-39 accel: 1.13375e-24
Torque: Tmotor=-13.3832 Tfreewheel=0 Tclutch=3.628e-24 ratchet vane=4
Time: 3.58
shaft B rot: -0.151959 speed: 0.297018 accel: 8.8034
shaft C rot: -1.16383 speed: 1.88842e-51 accel: -6.42275e-37
Torque: Tmotor=-13.2051 Tfreewheel=0 Tclutch=-2.05528e-36 ratchet vane=4
Time: 3.59
shaft B rot: -0.148126 speed: 0.383364 accel: 8.63463

shaft C rot: -1.16383 speed: -3.15431e-64 accel: -1.88842e-49
Torque: Tmotor=-12.9519 Tfreewheel=0 Tclutch=-6.04295e-49 ratchet vane=4
Time: 3.6
shaft B rot: -0.14345 speed: 0.467532 accel: 8.41679
shaft C rot: -1.16383 speed: -3.41399e-77 accel: 3.15431e-62
Torque: Tmotor=-12.6252 Tfreewheel=0 Tclutch=1.00938e-61 ratchet vane=4
Time: 3.61
shaft B rot: -0.13796 speed: 0.549043 accel: 8.15113
shaft C rot: -1.16383 speed: 2.88026e-89 accel: 3.41399e-75
Torque: Tmotor=-12.2267 Tfreewheel=0 Tclutch=1.09248e-74 ratchet vane=4
Time: 3.62
shaft B rot: -0.131686 speed: 0.627435 accel: 7.83916
shaft C rot: -1.16383 speed: 2.93351e-102 accel: -2.88026e-87
Torque: Tmotor=-11.7587 Tfreewheel=0 Tclutch=-9.21682e-87 ratchet vane=4
Time: 3.63
shaft B rot: -0.124663 speed: 0.702261 accel: 7.48264
shaft C rot: -1.16383 speed: 1.99784e-114 accel: -2.93351e-100
Torque: Tmotor=-11.224 Tfreewheel=0 Tclutch=-9.38723e-100 ratchet vane=4
Time: 3.64
shaft B rot: -0.116932 speed: 0.773097 accel: 7.0836
shaft C rot: -1.16383 speed: -1.43688e-126 accel: -1.99784e-112
Torque: Tmotor=-10.6254 Tfreewheel=0 Tclutch=-6.39308e-112 ratchet vane=4
Time: 3.65
shaft B rot: -0.108537 speed: 0.83954 accel: 6.64431
shaft C rot: -1.16383 speed: -4.48897e-139 accel: 1.43688e-124
Torque: Tmotor=-9.96646 Tfreewheel=0 Tclutch=4.59802e-124 ratchet vane=4
Time: 3.66
shaft B rot: -0.0995244 speed: 0.901213 accel: 6.16726
shaft C rot: -1.16383 speed: 7.23459e-153 accel: 4.48897e-137
Torque: Tmotor=-9.2509 Tfreewheel=0 Tclutch=1.43647e-136 ratchet vane=4
Time: 3.67
shaft B rot: -0.0899468 speed: 0.957765 accel: 5.65518
shaft C rot: -1.16383 speed: 3.80396e-165 accel: -7.23459e-151
Torque: Tmotor=-8.48277 Tfreewheel=0 Tclutch=-2.31507e-150 ratchet vane=4
Time: 3.68
shaft B rot: -0.079858 speed: 1.00887 accel: 5.11096
shaft C rot: -1.16383 speed: 9.1577e-180 accel: -3.80396e-163
Torque: Tmotor=-7.66643 Tfreewheel=0 Tclutch=-1.21727e-162 ratchet vane=4
Time: 3.69
shaft B rot: -0.0693155 speed: 1.05425 accel: 4.53769
shaft C rot: -1.16383 speed: -5.64391e-192 accel: -9.1577e-178
Torque: Tmotor=-6.80654 Tfreewheel=0 Tclutch=-2.93046e-177 ratchet vane=4
Time: 3.7
shaft B rot: -0.0583792 speed: 1.09364 accel: 3.93865

shaft C rot: -1.16383 speed: -1.57451e-204 accel: 5.64391e-190
Torque: Tmotor=-5.90797 Tfreewheel=0 Tclutch=1.80605e-189 ratchet vane=4

Time: 3.71

shaft B rot: -0.0471111 speed: 1.12681 accel: 3.31722

shaft C rot: -1.16383 speed: -3.84736e-217 accel: 1.57451e-202

Torque: Tmotor=-4.97583 Tfreewheel=0 Tclutch=5.03842e-202 ratchet vane=4

Time: 3.72

shaft B rot: -0.0355753 speed: 1.15358 accel: 2.67694

shaft C rot: -1.16383 speed: -3.90495e-230 accel: 3.84736e-215

Torque: Tmotor=-4.01542 Tfreewheel=0 Tclutch=1.23116e-214 ratchet vane=4

Time: 3.73

shaft B rot: -0.0238373 speed: 1.17379 accel: 2.02146

shaft C rot: -1.16383 speed: -1.09841e-244 accel: 3.90495e-228

Torque: Tmotor=-3.03219 Tfreewheel=0 Tclutch=1.24958e-227 ratchet vane=4

Time: 3.74

shaft B rot: -0.0119639 speed: 1.18734 accel: 1.35448

shaft C rot: -1.16383 speed: -4.86329e-257 accel: 1.09841e-242

Torque: Tmotor=-2.03173 Tfreewheel=0 Tclutch=3.51491e-242 ratchet vane=4

Time: 3.75

shaft B rot: -2.25731e-05 speed: 1.19414 accel: 0.679815

shaft C rot: -1.16383 speed: 2.36167e-269 accel: 4.86329e-255

Torque: Tmotor=-1.01972 Tfreewheel=0 Tclutch=1.55625e-254 ratchet vane=4

Time: 3.76

shaft B rot: 0.0119189 speed: 1.19415 accel: 0.00128265

shaft C rot: -1.16383 speed: -9.48543e-282 accel: -2.36167e-267

Torque: Tmotor=-0.00192397 Tfreewheel=0 Tclutch=-7.55734e-267 ratchet vane=4

Time: 3.77

shaft B rot: 0.0237927 speed: 1.18738 accel: -0.677257

shaft C rot: -1.16383 speed: -2.66209e-294 accel: 9.48543e-280

Torque: Tmotor=1.01589 Tfreewheel=0 Tclutch=3.03534e-279 ratchet vane=4

Time: 3.78

shaft B rot: 0.0355313 speed: 1.17386 accel: -1.35195

shaft C rot: -1.16383 speed: 3.11858e-307 accel: 2.66209e-292

Torque: Tmotor=2.02792 Tfreewheel=0 Tclutch=8.51869e-292 ratchet vane=4

Time: 3.79

shaft B rot: 0.047068 speed: 1.15367 accel: -2.01896

shaft C rot: -1.16383 speed: -1.81777e-319 accel: -3.11858e-305

Torque: Tmotor=3.02844 Tfreewheel=0 Tclutch=-9.97946e-305 ratchet vane=4

Time: 3.8

shaft B rot: 0.0583372 speed: 1.12692 accel: -2.67449

shaft C rot: -1.16383 speed: 0 accel: 1.81777e-317

Torque: Tmotor=4.01174 Tfreewheel=0 Tclutch=5.81683e-317 ratchet vane=4

Time: 3.81

shaft B rot: 0.0692749 speed: 1.09377 accel: -3.31484

shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=4.97225 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.82
shaft B rot: 0.079819 speed: 1.05441 accel: -3.93634
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=5.90451 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.83
shaft B rot: 0.0899096 speed: 1.00906 accel: -4.53548
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=6.80322 Tfreewheel=0 Tclutch=0 ratchet vane=4
Time: 3.84
shaft B rot: 0.0994893 speed: 0.957968 accel: -5.10884
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=7.66326 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.85
shaft B rot: 0.108504 speed: 0.901436 accel: -5.65318
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=8.47977 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.86
shaft B rot: 0.116901 speed: 0.839782 accel: -6.16539
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=9.24809 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.87
shaft B rot: 0.124635 speed: 0.773357 accel: -6.64258
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=9.96386 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.88
shaft B rot: 0.13166 speed: 0.702537 accel: -7.08201
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=10.623 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.89
shaft B rot: 0.137938 speed: 0.627724 accel: -7.48121
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=11.2218 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.9
shaft B rot: 0.143431 speed: 0.549346 accel: -7.83789
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=11.7568 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.91
shaft B rot: 0.14811 speed: 0.467845 accel: -8.15004
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=12.2251 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.92
shaft B rot: 0.151946 speed: 0.383686 accel: -8.41588

shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=12.6238 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.93
shaft B rot: 0.15492 speed: 0.297347 accel: -8.6339
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=12.9508 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.94
shaft B rot: 0.157013 speed: 0.209319 accel: -8.80286
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.2043 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.95
shaft B rot: 0.158214 speed: 0.120101 accel: -8.9218
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.3827 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.96
shaft B rot: 0.158516 speed: 0.0302004 accel: -8.99004
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.4851 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.97
shaft B rot: 0.157917 speed: -0.0598716 accel: -9.0072
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.5108 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.98
shaft B rot: 0.156421 speed: -0.149603 accel: -8.97318
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.4598 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 3.99
shaft B rot: 0.154036 speed: -0.238485 accel: -8.88817
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.3323 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4
shaft B rot: 0.150776 speed: -0.326012 accel: -8.75266
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=13.129 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.01
shaft B rot: 0.14666 speed: -0.411686 accel: -8.56741
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=12.8511 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.02
shaft B rot: 0.141709 speed: -0.495021 accel: -8.33349
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=12.5002 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.03
shaft B rot: 0.135954 speed: -0.575543 accel: -8.05221

shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=12.0783 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.04
shaft B rot: 0.129426 speed: -0.652795 accel: -7.72517
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=11.5878 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.05
shaft B rot: 0.122163 speed: -0.726337 accel: -7.35424
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=11.0314 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.06
shaft B rot: 0.114205 speed: -0.795752 accel: -6.94152
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=10.4123 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.07
shaft B rot: 0.105599 speed: -0.860646 accel: -6.48936
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=9.73404 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.08
shaft B rot: 0.0963921 speed: -0.920649 accel: -6.00032
shaft C rot: -1.16383 speed: 0 accel: 0
Torque: Tmotor=9.00048 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.09
shaft B rot: 0.0866379 speed: -0.975421 accel: -5.47719
shaft C rot: -1.17 speed: -0.6174 accel: -61.74
Torque: Tmotor=305.784 Tfreewheel=297.568 Tclutch=100 ratchet vane=5
Time: 4.1
shaft B rot: 0.0763914 speed: -1.02465 accel: -4.92294
shaft C rot: -1.18025 speed: -1.02465 accel: -40.725
Torque: Tmotor=237.705 Tfreewheel=230.32 Tclutch=100 ratchet vane=5
Time: 4.11
shaft B rot: 0.0657108 speed: -1.06806 accel: -4.34071
shaft C rot: -1.19093 speed: -1.06806 accel: -4.34071
Torque: Tmotor=120.401 Tfreewheel=113.89 Tclutch=100 ratchet vane=5
Time: 4.12
shaft B rot: 0.0546569 speed: -1.1054 accel: -3.73382
shaft C rot: -1.20198 speed: -1.1054 accel: -3.73382
Torque: Tmotor=117.549 Tfreewheel=111.948 Tclutch=100 ratchet vane=5
Time: 4.13
shaft B rot: 0.0432923 speed: -1.13645 accel: -3.10571
shaft C rot: -1.21334 speed: -1.13645 accel: -3.10571
Torque: Tmotor=114.597 Tfreewheel=109.938 Tclutch=100 ratchet vane=5
Time: 4.14
shaft B rot: 0.0316818 speed: -1.16105 accel: -2.45996

shaft C rot: -1.22496 speed: -1.16105 accel: -2.45996
Torque: Tmotor=111.562 Tfreewheel=107.872 Tclutch=100 ratchet vane=5
Time: 4.15
shaft B rot: 0.0198913 speed: -1.17905 accel: -1.80022
shaft C rot: -1.23675 speed: -1.17905 accel: -1.80022
Torque: Tmotor=108.461 Tfreewheel=105.761 Tclutch=100 ratchet vane=5
Time: 4.16
shaft B rot: 0.00798769 speed: -1.19036 accel: -1.13026
shaft C rot: -1.24865 speed: -1.19036 accel: -1.13026
Torque: Tmotor=105.312 Tfreewheel=103.617 Tclutch=100 ratchet vane=5
Time: 4.17
shaft B rot: -0.00396127 speed: -1.1949 accel: -0.453877
shaft C rot: -1.2606 speed: -1.1949 accel: -0.453877
Torque: Tmotor=102.133 Tfreewheel=101.452 Tclutch=100 ratchet vane=5
Time: 4.18
shaft B rot: -0.0158877 speed: -1.19264 accel: 0.225087
shaft C rot: -1.27252 speed: -1.19264 accel: 0.225087
Torque: Tmotor=98.9421 Tfreewheel=99.2797 Tclutch=100 ratchet vane=5
Time: 4.19
shaft B rot: -0.0277239 speed: -1.18362 accel: 0.902772
shaft C rot: -1.28436 speed: -1.18362 accel: 0.902772
Torque: Tmotor=95.757 Tfreewheel=97.1111 Tclutch=100 ratchet vane=5
Time: 4.2
shaft B rot: -0.0394025 speed: -1.16786 accel: 1.57533
shaft C rot: -1.29604 speed: -1.16786 accel: 1.57533
Torque: Tmotor=92.596 Tfreewheel=94.959 Tclutch=100 ratchet vane=5
Time: 4.21
shaft B rot: -0.0508573 speed: -1.14547 accel: 2.23893
shaft C rot: -1.30749 speed: -1.14547 accel: 2.23893
Torque: Tmotor=89.477 Tfreewheel=92.8354 Tclutch=100 ratchet vane=5
Time: 4.22
shaft B rot: -0.062023 speed: -1.11658 accel: 2.88981
shaft C rot: -1.31866 speed: -1.11658 accel: 2.88981
Torque: Tmotor=86.4179 Tfreewheel=90.7526 Tclutch=100 ratchet vane=5
Time: 4.23
shaft B rot: -0.0728364 speed: -1.08133 accel: 3.52427
shaft C rot: -1.32947 speed: -1.08133 accel: 3.52427
Torque: Tmotor=83.4359 Tfreewheel=88.7223 Tclutch=100 ratchet vane=5
Time: 4.24
shaft B rot: -0.0832358 speed: -1.03995 accel: 4.13871
shaft C rot: -1.33987 speed: -1.03995 accel: 4.13871
Torque: Tmotor=80.5481 Tfreewheel=86.7561 Tclutch=100 ratchet vane=5
Time: 4.25
shaft B rot: -0.0931624 speed: -0.99265 accel: 4.72963

shaft C rot: -1.3498 speed: -0.99265 accel: 4.72963
Torque: Tmotor=77.7708 Tfreewheel=84.8652 Tclutch=100 ratchet vane=5
Time: 4.26
shaft B rot: -0.102559 speed: -0.939714 accel: 5.29367
shaft C rot: -1.3592 speed: -0.939714 accel: 5.29367
Torque: Tmotor=75.1197 Tfreewheel=83.0603 Tclutch=100 ratchet vane=5
Time: 4.27
shaft B rot: -0.111374 speed: -0.881437 accel: 5.82763
shaft C rot: -1.36801 speed: -0.881437 accel: 5.82763
Torque: Tmotor=72.6101 Tfreewheel=81.3516 Tclutch=100 ratchet vane=5
Time: 4.28
shaft B rot: -0.119555 speed: -0.818153 accel: 6.32849
shaft C rot: -1.37619 speed: -0.818153 accel: 6.32849
Torque: Tmotor=70.2561 Tfreewheel=79.7488 Tclutch=100 ratchet vane=5
Time: 4.29
shaft B rot: -0.127058 speed: -0.750219 accel: 6.79338
shaft C rot: -1.38369 speed: -0.750219 accel: 6.79338
Torque: Tmotor=68.0711 Tfreewheel=78.2612 Tclutch=100 ratchet vane=5
Time: 4.3
shaft B rot: -0.133838 speed: -0.678022 accel: 7.21966
shaft C rot: -1.39047 speed: -0.678022 accel: 7.21966
Torque: Tmotor=66.0676 Tfreewheel=76.8971 Tclutch=100 ratchet vane=5
Time: 4.31
shaft B rot: -0.139858 speed: -0.601973 accel: 7.60493
shaft C rot: -1.39649 speed: -0.601973 accel: 7.60493
Torque: Tmotor=64.2568 Tfreewheel=75.6642 Tclutch=100 ratchet vane=5
Time: 4.32
shaft B rot: -0.145083 speed: -0.522503 accel: 7.94698
shaft C rot: -1.40172 speed: -0.522503 accel: 7.94698
Torque: Tmotor=62.6492 Tfreewheel=74.5697 Tclutch=100 ratchet vane=5
Time: 4.33
shaft B rot: -0.149483 speed: -0.440064 accel: 8.24388
shaft C rot: -1.40612 speed: -0.440064 accel: 8.24388
Torque: Tmotor=61.2538 Tfreewheel=73.6196 Tclutch=100 ratchet vane=5
Time: 4.34
shaft B rot: -0.153034 speed: -0.355125 accel: 8.49393
shaft C rot: -1.40967 speed: -0.355125 accel: 8.49393
Torque: Tmotor=60.0785 Tfreewheel=72.8194 Tclutch=100 ratchet vane=5
Time: 4.35
shaft B rot: -0.155716 speed: -0.268168 accel: 8.69572
shaft C rot: -1.41235 speed: -0.268168 accel: 8.69572
Torque: Tmotor=59.1301 Tfreewheel=72.1737 Tclutch=100 ratchet vane=5
Time: 4.36
shaft B rot: -0.157513 speed: -0.179687 accel: 8.8481

shaft C rot: -1.41415 speed: -0.179687 accel: 8.8481
Torque: Tmotor=58.4139 Tfreewheel=71.6861 Tclutch=100 ratchet vane=5
Time: 4.37
shaft B rot: -0.158415 speed: -0.0901846 accel: 8.9502
shaft C rot: -1.41505 speed: -0.0901846 accel: 8.9502
Torque: Tmotor=57.934 Tfreewheel=71.3594 Tclutch=100 ratchet vane=5
Time: 4.38
shaft B rot: -0.158417 speed: -0.000170157 accel: 9.00145
shaft C rot: -1.41505 speed: -0.000170157 accel: 9.00145
Torque: Tmotor=57.6932 Tfreewheel=71.1954 Tclutch=100 ratchet vane=5
Time: 4.39
shaft B rot: -0.157518 speed: 0.0898453 accel: 9.00154
shaft C rot: -1.41505 speed: -3.37187e-17 accel: 0.0170157
Torque: Tmotor=-13.5023 Tfreewheel=0 Tclutch=0.0544502 ratchet vane=5
Time: 4.4
shaft B rot: -0.155725 speed: 0.17935 accel: 8.95049
shaft C rot: -1.41505 speed: -1.23568e-29 accel: 3.37187e-15
Torque: Tmotor=-13.4257 Tfreewheel=0 Tclutch=1.079e-14 ratchet vane=5
Time: 4.41
shaft B rot: -0.153046 speed: 0.267836 accel: 8.84858
shaft C rot: -1.41505 speed: -3.95166e-43 accel: 1.23568e-27
Torque: Tmotor=-13.2729 Tfreewheel=0 Tclutch=3.95417e-27 ratchet vane=5
Time: 4.42
shaft B rot: -0.149498 speed: 0.3548 accel: 8.69639
shaft C rot: -1.41505 speed: -6.23695e-56 accel: 3.95166e-41
Torque: Tmotor=-13.0446 Tfreewheel=0 Tclutch=1.26453e-40 ratchet vane=5
Time: 4.43
shaft B rot: -0.145101 speed: 0.439748 accel: 8.49479
shaft C rot: -1.41505 speed: 4.34673e-68 accel: 6.23695e-54
Torque: Tmotor=-12.7422 Tfreewheel=0 Tclutch=1.99583e-53 ratchet vane=5
Time: 4.44
shaft B rot: -0.139879 speed: 0.522197 accel: 8.24491
shaft C rot: -1.41505 speed: 1.58545e-80 accel: -4.34673e-66
Torque: Tmotor=-12.3674 Tfreewheel=0 Tclutch=-1.39095e-65 ratchet vane=5
Time: 4.45
shaft B rot: -0.133862 speed: 0.601679 accel: 7.94819
shaft C rot: -1.41505 speed: 1.23315e-92 accel: -1.58545e-78
Torque: Tmotor=-11.9223 Tfreewheel=0 Tclutch=-5.07343e-78 ratchet vane=5
Time: 4.46
shaft B rot: -0.127085 speed: 0.677742 accel: 7.60631
shaft C rot: -1.41505 speed: -8.34901e-105 accel: -1.23315e-90
Torque: Tmotor=-11.4095 Tfreewheel=0 Tclutch=-3.94609e-90 ratchet vane=5
Time: 4.47
shaft B rot: -0.119585 speed: 0.749954 accel: 7.2212

shaft C rot: -1.41505 speed: -3.42647e-117 accel: 8.34901e-103
Torque: Tmotor=-10.8318 Tfreewheel=0 Tclutch=2.67168e-102 ratchet vane=5
Time: 4.48
shaft B rot: -0.111406 speed: 0.817904 accel: 6.79506
shaft C rot: -1.41505 speed: 8.79821e-130 accel: 3.42647e-115
Torque: Tmotor=-10.1926 Tfreewheel=0 Tclutch=1.09647e-114 ratchet vane=5
Time: 4.49
shaft B rot: -0.102594 speed: 0.881208 accel: 6.33031
shaft C rot: -1.41505 speed: 8.73549e-142 accel: -8.79821e-128
Torque: Tmotor=-9.49547 Tfreewheel=0 Tclutch=-2.81543e-127 ratchet vane=5
Time: 4.5
shaft B rot: -0.0931989 speed: 0.939504 accel: 5.82959
shaft C rot: -1.41505 speed: 2.01026e-155 accel: -8.73549e-140
Torque: Tmotor=-8.74439 Tfreewheel=0 Tclutch=-2.79536e-139 ratchet vane=5
Time: 4.51
shaft B rot: -0.0832743 speed: 0.992461 accel: 5.29575
shaft C rot: -1.41505 speed: -2.31438e-168 accel: -2.01026e-153
Torque: Tmotor=-7.94362 Tfreewheel=0 Tclutch=-6.43282e-153 ratchet vane=5
Time: 4.52
shaft B rot: -0.0728765 speed: 1.03978 accel: 4.73181
shaft C rot: -1.41505 speed: 1.19508e-180 accel: 2.31438e-166
Torque: Tmotor=-7.09771 Tfreewheel=0 Tclutch=7.40601e-166 ratchet vane=5
Time: 4.53
shaft B rot: -0.0620646 speed: 1.08119 accel: 4.14099
shaft C rot: -1.41505 speed: 1.62673e-194 accel: -1.19508e-178
Torque: Tmotor=-6.21148 Tfreewheel=0 Tclutch=-3.82424e-178 ratchet vane=5
Time: 4.54
shaft B rot: -0.0509 speed: 1.11646 accel: 3.52663
shaft C rot: -1.41505 speed: -4.50178e-207 accel: -1.62673e-192
Torque: Tmotor=-5.28995 Tfreewheel=0 Tclutch=-5.20555e-192 ratchet vane=5
Time: 4.55
shaft B rot: -0.0394463 speed: 1.14538 accel: 2.89224
shaft C rot: -1.41505 speed: -8.29936e-222 accel: 4.50178e-205
Torque: Tmotor=-4.33836 Tfreewheel=0 Tclutch=1.44057e-204 ratchet vane=5
Time: 4.56
shaft B rot: -0.0277683 speed: 1.16779 accel: 2.24141
shaft C rot: -1.41505 speed: -5.78648e-235 accel: 8.29936e-220
Torque: Tmotor=-3.36212 Tfreewheel=0 Tclutch=2.65579e-219 ratchet vane=5
Time: 4.57
shaft B rot: -0.0159326 speed: 1.18357 accel: 1.57785
shaft C rot: -1.41505 speed: -5.2935e-247 accel: 5.78648e-233
Torque: Tmotor=-2.36678 Tfreewheel=0 Tclutch=1.85167e-232 ratchet vane=5
Time: 4.58
shaft B rot: -0.0040064 speed: 1.19262 accel: 0.905324

shaft C rot: -1.41505 speed: 2.10869e-260 accel: 5.2935e-245
Torque: Tmotor=-1.35799 Tfreewheel=0 Tclutch=1.69392e-244 ratchet vane=5
Time: 4.59
shaft B rot: 0.0079426 speed: 1.1949 accel: 0.227652
shaft C rot: -1.41505 speed: 9.76249e-273 accel: -2.10869e-258
Torque: Tmotor=-0.341477 Tfreewheel=0 Tclutch=-6.74779e-258 ratchet vane=5
Time: 4.6
shaft B rot: 0.0198465 speed: 1.19039 accel: -0.451315
shaft C rot: -1.41505 speed: 2.37078e-285 accel: -9.76249e-271
Torque: Tmotor=0.676972 Tfreewheel=0 Tclutch=-3.124e-270 ratchet vane=5
Time: 4.61
shaft B rot: 0.0316376 speed: 1.17911 accel: -1.12772
shaft C rot: -1.41505 speed: 1.16695e-297 accel: -2.37078e-283
Torque: Tmotor=1.69157 Tfreewheel=0 Tclutch=-7.5865e-283 ratchet vane=5
Time: 4.62
shaft B rot: 0.0432489 speed: 1.16113 accel: -1.79771
shaft C rot: -1.41505 speed: 1.10632e-309 accel: -1.16695e-295
Torque: Tmotor=2.69656 Tfreewheel=0 Tclutch=-3.73425e-295 ratchet vane=5
Time: 4.63
shaft B rot: 0.0546145 speed: 1.13656 accel: -2.45749
shaft C rot: -1.41505 speed: 6.66989e-322 accel: -1.10632e-307
Torque: Tmotor=3.68623 Tfreewheel=0 Tclutch=-3.54024e-307 ratchet vane=5
Time: 4.64
shaft B rot: 0.0656697 speed: 1.10552 accel: -3.1033
shaft C rot: -1.41505 speed: 0 accel: -6.66989e-320
Torque: Tmotor=4.65496 Tfreewheel=0 Tclutch=-2.13436e-319 ratchet vane=5
Time: 4.65
shaft B rot: 0.0763518 speed: 1.06821 accel: -3.73148
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=5.59723 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.66
shaft B rot: 0.0866001 speed: 1.02483 accel: -4.33846
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=6.50769 Tfreewheel=0 Tclutch=0 ratchet vane=5
Time: 4.67
shaft B rot: 0.0963563 speed: 0.975617 accel: -4.92079
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=7.38118 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.68
shaft B rot: 0.105565 speed: 0.920866 accel: -5.47515
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=8.21273 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.69
shaft B rot: 0.114174 speed: 0.860882 accel: -5.99841

shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=8.99761 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.7
shaft B rot: 0.122134 speed: 0.796006 accel: -6.48758
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=9.73137 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.71
shaft B rot: 0.1294 speed: 0.726607 accel: -6.93989
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=10.4098 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.72
shaft B rot: 0.135931 speed: 0.65308 accel: -7.35276
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=11.0291 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.73
shaft B rot: 0.141689 speed: 0.575841 accel: -7.72385
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=11.5858 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.74
shaft B rot: 0.146642 speed: 0.49533 accel: -8.05106
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=12.0766 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.75
shaft B rot: 0.150762 speed: 0.412005 accel: -8.33251
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=12.4988 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.76
shaft B rot: 0.154026 speed: 0.326339 accel: -8.56662
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=12.8499 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.77
shaft B rot: 0.156414 speed: 0.238819 accel: -8.75205
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.1281 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.78
shaft B rot: 0.157913 speed: 0.149941 accel: -8.88776
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.3316 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.79
shaft B rot: 0.158516 speed: 0.0602115 accel: -8.97296
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.4594 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.8
shaft B rot: 0.158217 speed: -0.0298602 accel: -9.00717

shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.5108 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.81
shaft B rot: 0.157019 speed: -0.119762 accel: -8.9902
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.4853 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.82
shaft B rot: 0.154929 speed: -0.208984 accel: -8.92215
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.3832 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.83
shaft B rot: 0.151959 speed: -0.297018 accel: -8.8034
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=13.2051 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.84
shaft B rot: 0.148126 speed: -0.383364 accel: -8.63463
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=12.9519 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.85
shaft B rot: 0.14345 speed: -0.467532 accel: -8.41679
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=12.6252 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.86
shaft B rot: 0.13796 speed: -0.549043 accel: -8.15113
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=12.2267 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.87
shaft B rot: 0.131686 speed: -0.627435 accel: -7.83916
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=11.7587 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.88
shaft B rot: 0.124663 speed: -0.702261 accel: -7.48264
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=11.224 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.89
shaft B rot: 0.116932 speed: -0.773097 accel: -7.0836
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=10.6254 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.9
shaft B rot: 0.108537 speed: -0.83954 accel: -6.64431
shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=9.96646 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.91
shaft B rot: 0.0995244 speed: -0.901213 accel: -6.16726

shaft C rot: -1.41505 speed: 0 accel: 0
Torque: Tmotor=9.2509 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 4.92
 shaft B rot: 0.0899468 speed: -0.957765 accel: -5.65518
 shaft C rot: -1.41802 speed: -0.296409 accel: -29.6409
 Torque: Tmotor=203.334 Tfreewheel=194.851 Tclutch=100 ratchet vane=6
Time: 4.93
 shaft B rot: 0.079858 speed: -1.00887 accel: -5.11096
 shaft C rot: -1.42811 speed: -1.00887 accel: -71.2466
 Torque: Tmotor=335.655 Tfreewheel=327.989 Tclutch=100 ratchet vane=6
Time: 4.94
 shaft B rot: 0.0693155 speed: -1.05425 accel: -4.53769
 shaft C rot: -1.43865 speed: -1.05425 accel: -4.53769
 Torque: Tmotor=121.327 Tfreewheel=114.521 Tclutch=100 ratchet vane=6
Time: 4.95
 shaft B rot: 0.0583792 speed: -1.09364 accel: -3.93865
 shaft C rot: -1.44959 speed: -1.09364 accel: -3.93865
 Torque: Tmotor=118.512 Tfreewheel=112.604 Tclutch=100 ratchet vane=6
Time: 4.96
 shaft B rot: 0.0471111 speed: -1.12681 accel: -3.31722
 shaft C rot: -1.46085 speed: -1.12681 accel: -3.31722
 Torque: Tmotor=115.591 Tfreewheel=110.615 Tclutch=100 ratchet vane=6
Time: 4.97
 shaft B rot: 0.0355753 speed: -1.15358 accel: -2.67694
 shaft C rot: -1.47239 speed: -1.15358 accel: -2.67694
 Torque: Tmotor=112.582 Tfreewheel=108.566 Tclutch=100 ratchet vane=6
Time: 4.98
 shaft B rot: 0.0238373 speed: -1.17379 accel: -2.02146
 shaft C rot: -1.48413 speed: -1.17379 accel: -2.02146
 Torque: Tmotor=109.501 Tfreewheel=106.469 Tclutch=100 ratchet vane=6
Time: 4.99
 shaft B rot: 0.0119639 speed: -1.18734 accel: -1.35448
 shaft C rot: -1.496 speed: -1.18734 accel: -1.35448
 Torque: Tmotor=106.366 Tfreewheel=104.334 Tclutch=100 ratchet vane=6
Time: 5
 shaft B rot: 2.25731e-05 speed: -1.19414 accel: -0.679815
 shaft C rot: -1.50794 speed: -1.19414 accel: -0.679815
 Torque: Tmotor=103.195 Tfreewheel=102.175 Tclutch=100 ratchet vane=6
Time: 5.01
 shaft B rot: -0.0119189 speed: -1.19415 accel: -0.00128266
 shaft C rot: -1.51988 speed: -1.19415 accel: -0.00128266
 Torque: Tmotor=100.006 Tfreewheel=100.004 Tclutch=100 ratchet vane=6
Time: 5.02
 shaft B rot: -0.0237927 speed: -1.18738 accel: 0.677257

shaft C rot: -1.53176 speed: -1.18738 accel: 0.677257
Torque: Tmotor=96.8169 Tfreewheel=97.8328 Tclutch=100 ratchet vane=6
Time: 5.03
shaft B rot: -0.0355313 speed: -1.17386 accel: 1.35195
shaft C rot: -1.5435 speed: -1.17386 accel: 1.35195
Torque: Tmotor=93.6458 Tfreewheel=95.6738 Tclutch=100 ratchet vane=6
Time: 5.04
shaft B rot: -0.047068 speed: -1.15367 accel: 2.01896
shaft C rot: -1.55503 speed: -1.15367 accel: 2.01896
Torque: Tmotor=90.5109 Tfreewheel=93.5393 Tclutch=100 ratchet vane=6
Time: 5.05
shaft B rot: -0.0583372 speed: -1.12692 accel: 2.67449
shaft C rot: -1.5663 speed: -1.12692 accel: 2.67449
Torque: Tmotor=87.4299 Tfreewheel=91.4416 Tclutch=100 ratchet vane=6
Time: 5.06
shaft B rot: -0.0692749 speed: -1.09377 accel: 3.31484
shaft C rot: -1.57724 speed: -1.09377 accel: 3.31484
Torque: Tmotor=84.4203 Tfreewheel=89.3925 Tclutch=100 ratchet vane=6
Time: 5.07
shaft B rot: -0.079819 speed: -1.05441 accel: 3.93634
shaft C rot: -1.58778 speed: -1.05441 accel: 3.93634
Torque: Tmotor=81.4992 Tfreewheel=87.4037 Tclutch=100 ratchet vane=6
Time: 5.08
shaft B rot: -0.0899096 speed: -1.00906 accel: 4.53548
shaft C rot: -1.59787 speed: -1.00906 accel: 4.53548
Torque: Tmotor=78.6833 Tfreewheel=85.4865 Tclutch=100 ratchet vane=6
Time: 5.09
shaft B rot: -0.0994893 speed: -0.957968 accel: 5.10884
shaft C rot: -1.60745 speed: -0.957968 accel: 5.10884
Torque: Tmotor=75.9884 Tfreewheel=83.6517 Tclutch=100 ratchet vane=6
Time: 5.1
shaft B rot: -0.108504 speed: -0.901436 accel: 5.65318
shaft C rot: -1.61647 speed: -0.901436 accel: 5.65318
Torque: Tmotor=73.4301 Tfreewheel=81.9098 Tclutch=100 ratchet vane=6
Time: 5.11
shaft B rot: -0.116901 speed: -0.839782 accel: 6.16539
shaft C rot: -1.62487 speed: -0.839782 accel: 6.16539
Torque: Tmotor=71.0226 Tfreewheel=80.2707 Tclutch=100 ratchet vane=6
Time: 5.12
shaft B rot: -0.124635 speed: -0.773357 accel: 6.64258
shaft C rot: -1.6326 speed: -0.773357 accel: 6.64258
Torque: Tmotor=68.7799 Tfreewheel=78.7438 Tclutch=100 ratchet vane=6
Time: 5.13
shaft B rot: -0.13166 speed: -0.702537 accel: 7.08201

shaft C rot: -1.63962 speed: -0.702537 accel: 7.08201
Torque: Tmotor=66.7145 Tfreewheel=77.3376 Tclutch=100 ratchet vane=6
Time: 5.14
shaft B rot: -0.137938 speed: -0.627724 accel: 7.48121
shaft C rot: -1.6459 speed: -0.627724 accel: 7.48121
Torque: Tmotor=64.8383 Tfreewheel=76.0601 Tclutch=100 ratchet vane=6
Time: 5.15
shaft B rot: -0.143431 speed: -0.549346 accel: 7.83789
shaft C rot: -1.6514 speed: -0.549346 accel: 7.83789
Torque: Tmotor=63.1619 Tfreewheel=74.9187 Tclutch=100 ratchet vane=6
Time: 5.16
shaft B rot: -0.14811 speed: -0.467845 accel: 8.15004
shaft C rot: -1.65607 speed: -0.467845 accel: 8.15004
Torque: Tmotor=61.6948 Tfreewheel=73.9199 Tclutch=100 ratchet vane=6
Time: 5.17
shaft B rot: -0.151946 speed: -0.383686 accel: 8.41588
shaft C rot: -1.65991 speed: -0.383686 accel: 8.41588
Torque: Tmotor=60.4454 Tfreewheel=73.0692 Tclutch=100 ratchet vane=6
Time: 5.18
shaft B rot: -0.15492 speed: -0.297347 accel: 8.6339
shaft C rot: -1.66288 speed: -0.297347 accel: 8.6339
Torque: Tmotor=59.4207 Tfreewheel=72.3715 Tclutch=100 ratchet vane=6
Time: 5.19
shaft B rot: -0.157013 speed: -0.209319 accel: 8.80286
shaft C rot: -1.66498 speed: -0.209319 accel: 8.80286
Torque: Tmotor=58.6266 Tfreewheel=71.8309 Tclutch=100 ratchet vane=6
Time: 5.2
shaft B rot: -0.158214 speed: -0.120101 accel: 8.9218
shaft C rot: -1.66618 speed: -0.120101 accel: 8.9218
Torque: Tmotor=58.0676 Tfreewheel=71.4503 Tclutch=100 ratchet vane=6
Time: 5.21
shaft B rot: -0.158516 speed: -0.0302004 accel: 8.99004
shaft C rot: -1.66648 speed: -0.0302004 accel: 8.99004
Torque: Tmotor=57.7468 Tfreewheel=71.2319 Tclutch=100 ratchet vane=6
Time: 5.22
shaft B rot: -0.157917 speed: 0.0598716 accel: 9.0072
shaft C rot: -1.66648 speed: -5.68674e-13 accel: 3.02004
Torque: Tmotor=-13.5108 Tfreewheel=0 Tclutch=9.66412 ratchet vane=6
Time: 5.23
shaft B rot: -0.156421 speed: 0.149603 accel: 8.97318
shaft C rot: -1.66648 speed: -2.88483e-25 accel: 5.68674e-11
Torque: Tmotor=-13.4598 Tfreewheel=0 Tclutch=1.81976e-10 ratchet vane=6
Time: 5.24
shaft B rot: -0.154036 speed: 0.238485 accel: 8.88817

shaft C rot: -1.66648 speed: 5.45044e-38 accel: 2.88483e-23
Torque: Tmotor=-13.3323 Tfreewheel=0 Tclutch=9.23146e-23 ratchet vane=6
Time: 5.25
shaft B rot: -0.150776 speed: 0.326012 accel: 8.75266
shaft C rot: -1.66648 speed: 3.83375e-50 accel: -5.45044e-36
Torque: Tmotor=-13.129 Tfreewheel=0 Tclutch=-1.74414e-35 ratchet vane=6
Time: 5.26
shaft B rot: -0.14666 speed: 0.411686 accel: 8.56741
shaft C rot: -1.66648 speed: -2.61081e-62 accel: -3.83375e-48
Torque: Tmotor=-12.8511 Tfreewheel=0 Tclutch=-1.2268e-47 ratchet vane=6
Time: 5.27
shaft B rot: -0.141709 speed: 0.495021 accel: 8.33349
shaft C rot: -1.66648 speed: -1.89564e-74 accel: 2.61081e-60
Torque: Tmotor=-12.5002 Tfreewheel=0 Tclutch=8.35458e-60 ratchet vane=6
Time: 5.28
shaft B rot: -0.135954 speed: 0.575543 accel: 8.05221
shaft C rot: -1.66648 speed: -1.18682e-86 accel: 1.89564e-72
Torque: Tmotor=-12.0783 Tfreewheel=0 Tclutch=6.06604e-72 ratchet vane=6
Time: 5.29
shaft B rot: -0.129426 speed: 0.652795 accel: 7.72517
shaft C rot: -1.66648 speed: -5.11665e-99 accel: 1.18682e-84
Torque: Tmotor=-11.5878 Tfreewheel=0 Tclutch=3.79783e-84 ratchet vane=6
Time: 5.3
shaft B rot: -0.122163 speed: 0.726337 accel: 7.35424
shaft C rot: -1.66648 speed: 3.01954e-111 accel: 5.11665e-97
Torque: Tmotor=-11.0314 Tfreewheel=0 Tclutch=1.63733e-96 ratchet vane=6
Time: 5.31
shaft B rot: -0.114205 speed: 0.795752 accel: 6.94152
shaft C rot: -1.66648 speed: 1.35171e-123 accel: -3.01954e-109
Torque: Tmotor=-10.4123 Tfreewheel=0 Tclutch=-9.66253e-109 ratchet vane=6
Time: 5.32
shaft B rot: -0.105599 speed: 0.860646 accel: 6.48936
shaft C rot: -1.66648 speed: -1.00348e-135 accel: -1.35171e-121
Torque: Tmotor=-9.73404 Tfreewheel=0 Tclutch=-4.32547e-121 ratchet vane=6
Time: 5.33
shaft B rot: -0.0963921 speed: 0.920649 accel: 6.00032
shaft C rot: -1.66648 speed: 2.07888e-148 accel: 1.00348e-133
Torque: Tmotor=-9.00048 Tfreewheel=0 Tclutch=3.21114e-133 ratchet vane=6
Time: 5.34
shaft B rot: -0.0866379 speed: 0.975421 accel: 5.47719
shaft C rot: -1.66648 speed: -1.23815e-160 accel: -2.07888e-146
Torque: Tmotor=-8.21579 Tfreewheel=0 Tclutch=-6.65243e-146 ratchet vane=6
Time: 5.35
shaft B rot: -0.0763914 speed: 1.02465 accel: 4.92294

shaft C rot: -1.66648 speed: 8.2664e-173 accel: 1.23815e-158
Torque: Tmotor=-7.38441 Tfreewheel=0 Tclutch=3.96207e-158 ratchet vane=6
Time: 5.36
shaft B rot: -0.0657108 speed: 1.06806 accel: 4.34071
shaft C rot: -1.66648 speed: -4.22309e-186 accel: -8.2664e-171
Torque: Tmotor=-6.51107 Tfreewheel=0 Tclutch=-2.64525e-170 ratchet vane=6
Time: 5.37
shaft B rot: -0.0546569 speed: 1.1054 accel: 3.73382
shaft C rot: -1.66648 speed: -3.10193e-198 accel: 4.22309e-184
Torque: Tmotor=-5.60073 Tfreewheel=0 Tclutch=1.35139e-183 ratchet vane=6
Time: 5.38
shaft B rot: -0.0432923 speed: 1.13645 accel: 3.10571
shaft C rot: -1.66648 speed: 9.70225e-211 accel: 3.10193e-196
Torque: Tmotor=-4.65857 Tfreewheel=0 Tclutch=9.92618e-196 ratchet vane=6
Time: 5.39
shaft B rot: -0.0316818 speed: 1.16105 accel: 2.45996
shaft C rot: -1.66648 speed: 6.19683e-223 accel: -9.70225e-209
Torque: Tmotor=-3.68993 Tfreewheel=0 Tclutch=-3.10472e-208 ratchet vane=6
Time: 5.4
shaft B rot: -0.0198913 speed: 1.17905 accel: 1.80022
shaft C rot: -1.66648 speed: 3.70715e-235 accel: -6.19683e-221
Torque: Tmotor=-2.70034 Tfreewheel=0 Tclutch=-1.98298e-220 ratchet vane=6
Time: 5.41
shaft B rot: -0.00798769 speed: 1.19036 accel: 1.13026
shaft C rot: -1.66648 speed: -2.48473e-247 accel: -3.70715e-233
Torque: Tmotor=-1.69539 Tfreewheel=0 Tclutch=-1.18629e-232 ratchet vane=6
Time: 5.42
shaft B rot: 0.00396127 speed: 1.1949 accel: 0.453877
shaft C rot: -1.66648 speed: -1.3138e-259 accel: 2.48473e-245
Torque: Tmotor=-0.680815 Tfreewheel=0 Tclutch=7.95114e-245 ratchet vane=6
Time: 5.43
shaft B rot: 0.0158877 speed: 1.19264 accel: -0.225087
shaft C rot: -1.66648 speed: -8.08727e-273 accel: 1.3138e-257
Torque: Tmotor=0.337631 Tfreewheel=0 Tclutch=4.20416e-257 ratchet vane=6
Time: 5.44
shaft B rot: 0.0277239 speed: 1.18362 accel: -0.902772
shaft C rot: -1.66648 speed: -5.71352e-286 accel: 8.08727e-271
Torque: Tmotor=1.35416 Tfreewheel=0 Tclutch=2.58793e-270 ratchet vane=6
Time: 5.45
shaft B rot: 0.0394025 speed: 1.16786 accel: -1.57533
shaft C rot: -1.66648 speed: 1.55015e-298 accel: 5.71352e-284
Torque: Tmotor=2.36299 Tfreewheel=0 Tclutch=1.82832e-283 ratchet vane=6
Time: 5.46
shaft B rot: 0.0508573 speed: 1.14547 accel: -2.23893

shaft C rot: -1.66648 speed: -9.18824e-312 accel: -1.55015e-296
Torque: Tmotor=3.3584 Tfreewheel=0 Tclutch=-4.96048e-296 ratchet vane=6
Time: 5.47
shaft B rot: 0.062023 speed: 1.11658 accel: -2.88981
shaft C rot: -1.66648 speed: 4.94066e-324 accel: 9.18824e-310
Torque: Tmotor=4.33472 Tfreewheel=0 Tclutch=2.94024e-309 ratchet vane=6
Time: 5.48
shaft B rot: 0.0728364 speed: 1.08133 accel: -3.52427
shaft C rot: -1.66648 speed: 0 accel: -4.94066e-322
Torque: Tmotor=5.28641 Tfreewheel=0 Tclutch=-1.4822e-321 ratchet vane=6
Time: 5.49
shaft B rot: 0.0832358 speed: 1.03995 accel: -4.13871
shaft C rot: -1.66648 speed: 0 accel: 0
Torque: Tmotor=6.20806 Tfreewheel=0 Tclutch=0 ratchet vane=6
Time: 5.5
shaft B rot: 0.0931624 speed: 0.99265 accel: -4.72963
shaft C rot: -1.66648 speed: 0 accel: 0
Torque: Tmotor=7.09444 Tfreewheel=0 Tclutch=0 ratchet vane=7
Time: 5.51
shaft B rot: 0.102559 speed: 0.939714 accel: -5.29367
shaft C rot: -1.66648 speed: 0 accel: 0
Torque: Tmotor=7.94051 Tfreewheel=0 Tclutch=0 ratchet vane=7

demo_CH_solver:

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Chrono version: 9.0.1

TEST: generic system with two constraints

Solver Info

Type: 0

Iterative? 1

Direct? 0

Access as iterative solver: 0x7fff701511d0

Access as direct solver: 0

Matrix M (6x6)

1 1 10

2 2 10

3 3 10

4 4 20

5 5 20

6 6 20

Matrix Cq (2x6)

1 1 1
1 2 2
1 3 -1
1 4 1
1 5 -2
2 2 1
2 5 -2
**** Using ChSolverPSOR *****

METRICS: max residual: 0.0162576 max LCP error: 0

vars q_a and q_b -----
2.02024
1.08091
-1.92024
0.960121
1.03934
0
multipliers l_1 and l_2 -----

19.2024
-29.5958

constraint residuals c_1 and c_2 ---
-0.0162576
0.00223336

TEST: 1D vertical pendulum

Solver Info
Type: 12
Iterative? 1
Direct? 0
Access as iterative solver: 0x7fff70151570
Access as direct solver: 0
MINRES iterations: 19 error: 5.23548e-15
||Ax-b|| = 1.36478e-14

VARIABLES:

0
7.71952e-16
1.5439e-15
2.4078e-15

3.21965e-15
3.89272e-15
4.51722e-15
4.85723e-15
5.17641e-15
5.35683e-15
5.3707e-15

CONSTRAINTS:

9.8
8.82
7.84
6.86
5.88
4.9
3.92
2.94
1.96
0.98

TEST: generic system with stiffness blocks

Solver Info

Type: 12
Iterative? 1
Direct? 0
Access as iterative solver: 0x7fff70150df0
Access as direct solver: 0
MINRES iterations: 100 error: 1.09287e-09
 $\|Ax-b\| = 9.19227e-09$

TEST: generic system with two constraints

Solver Info

Type: 8
Iterative? 0
Direct? 1
Access as iterative solver: 0
Access as direct solver: 0x7fff70150fb0
Matrix M (6x6)
1 1 10
2 2 10
3 3 10

```
4 4 20
5 5 20
6 6 20
Matrix Cq (2x6)
1 1 1
1 2 2
1 3 -1
1 4 1
1 5 -2
2 2 1
2 5 -2
**** Using ChSolverSparseQR ****
```

METRICS: max residual: 1.77636e-15 max LCP error: 0

vars q_a and q_b -----

```
2.02632
1.08421
-1.92632
0.963158
1.04211
0
```

multipliers l_1 and l_2 -----

```
19.2632
-29.6842
```

constraint residuals c_1 and c_2 ---

```
1.77636e-15
-2.22045e-16
```

Co-simulation (COSIM) Demos:

*COSIM demos cannot be run without MathWorks Simulink

demo COSIM data exchange:

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Chrono version: 9.0.1
CHRONO demo about cosimulation

NOTE! This requires that you also run a copy of Simulink.

*** Waiting Simulink to start... ***

(load 'data/cosimulation/test_cosimulation.mdl' in Simulink and press Start...)

demo_COSIM_hydraulics:

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Chrono version: 9.0.1

CHRONO SimHydraulics cosimulation

NOTE! This requires a copy of Simulink with SimHydraulics.

*** Waiting Simulink to start... ***

(load 'data/cosimulation/test_cosim_hydraulics.mdl' in Simulink and press Start...)

demo_COSIM_socket:

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Chrono version: 9.0.1

CHRONO demo about sockets

Local host information:

srun: error: gpu05: task 0: Segmentation fault (core dumped)

Finite Element Analysis (FEA) Demos:

demo_FEA_basic:

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Chrono version: 9.0.1

Example: the FEM technology for finite elements

TEST: LINEAR tetrahedral element FEM

MINRES iterations: 42 error: 1.39641e-13

$\|Ax-b\| = 2.34418e-07$

Resulting node positions:
4.64025e-13 2.08325e-14 4.56821e-13

-4.25453e-13 8.73492e-16 1

4.69815e-13 1.00428 4.92455e-13

1 4.23651e-15 -4.25453e-13

Resulting constraint reactions:

4110.71 9183.33 4110.71

1.1463e-06 -408.333 -4110.71

-4110.71 -408.333 1.1463e-06

TEST: QUADRATIC tetrahedral element FEM

MINRES iterations: 134 error: 8.73017e-13

$\|Ax-b\| = 4.84255e-06$

7.3348e-14 -1.0215e-14 5.09909e-14

0.001 1.11792e-14 -8.05101e-14

-0.00013969 0.000834446 -0.00013969

-9.67605e-14 -4.53885e-14 0.001

node3 displ: -0.00013969 -0.000165554 -0.00013969

TEST: LINEAR hexahedral element FEM

MINRES iterations: 39 error: 8.53746e-13

$\|Ax-b\| = 5.09962e-10$

-4.38207e-13 3.84412e-14 -4.40301e-13

-4.38452e-13 3.46577e-14 0.01

0.01 -3.84211e-14 0.01

0.01 -3.46728e-14 -4.39904e-13

node5 displ: -0.000399911 -0.0177827 -0.000399911

node6 displ: -0.000399911 -0.0177827 0.000399911

node7 displ: 0.000399911 -0.0177827 0.000399911

node8 displ: 0.000399911 -0.0177827 -0.000399911

TEST: QUADRATIC hexahedral element FEM

MINRES iterations: 62 error: 8.08734e-13

$\|Ax-b\| = 1.00943e-07$

node5 displ: -9.16572e-05 -0.0199548 -9.16572e-05

node6 displ: -9.16572e-05 -0.0199548 9.16572e-05

node7 displ: 9.16572e-05 -0.0199548 9.16572e-05

node8 displ: 9.16572e-05 -0.0199548 -9.16572e-05

Element volume 1e-05

demo_FEA_dynamics:

Copyright (c) 2017 projectchrono.org
Chrono version: 9.0.1

TEST: tetrahedron FEM dynamics, implicit integration

```
t =0.001 mnode3 pos.y()=1.00991
t =0.002 mnode3 pos.y()=1.00974
t =0.003 mnode3 pos.y()=1.00951
t =0.004 mnode3 pos.y()=1.00923
t =0.005 mnode3 pos.y()=1.00891
t =0.006 mnode3 pos.y()=1.00856
t =0.007 mnode3 pos.y()=1.0082
t =0.008 mnode3 pos.y()=1.00782
t =0.009 mnode3 pos.y()=1.00743
t =0.01 mnode3 pos.y()=1.00704
t =0.011 mnode3 pos.y()=1.00666
t =0.012 mnode3 pos.y()=1.00627
t =0.013 mnode3 pos.y()=1.00589
t =0.014 mnode3 pos.y()=1.00552
t =0.015 mnode3 pos.y()=1.00516
t =0.016 mnode3 pos.y()=1.00482
t =0.017 mnode3 pos.y()=1.00448
t =0.018 mnode3 pos.y()=1.00416
t =0.019 mnode3 pos.y()=1.00385
t =0.02 mnode3 pos.y()=1.00355
t =0.021 mnode3 pos.y()=1.00327
t =0.022 mnode3 pos.y()=1.003
t =0.023 mnode3 pos.y()=1.00275
t =0.024 mnode3 pos.y()=1.0025
t =0.025 mnode3 pos.y()=1.00227
t =0.026 mnode3 pos.y()=1.00206
t =0.027 mnode3 pos.y()=1.00185
t =0.028 mnode3 pos.y()=1.00166
t =0.029 mnode3 pos.y()=1.00148
t =0.03 mnode3 pos.y()=1.00131
t =0.031 mnode3 pos.y()=1.00115
t =0.032 mnode3 pos.y()=1.001
t =0.033 mnode3 pos.y()=1.00086
t =0.034 mnode3 pos.y()=1.00073
t =0.035 mnode3 pos.y()=1.00061
```

t =0.036 mnode3 pos.y()=1.00049
t =0.037 mnode3 pos.y()=1.00038
t =0.038 mnode3 pos.y()=1.00028
t =0.039 mnode3 pos.y()=1.00019
t =0.04 mnode3 pos.y()=1.0001
t =0.041 mnode3 pos.y()=1.00002
t =0.042 mnode3 pos.y()=0.999941
t =0.043 mnode3 pos.y()=0.99987
t =0.044 mnode3 pos.y()=0.999804
t =0.045 mnode3 pos.y()=0.999742
t =0.046 mnode3 pos.y()=0.999685
t =0.047 mnode3 pos.y()=0.999631
t =0.048 mnode3 pos.y()=0.999582
t =0.049 mnode3 pos.y()=0.999536
t =0.05 mnode3 pos.y()=0.999493
t =0.051 mnode3 pos.y()=0.999453
t =0.052 mnode3 pos.y()=0.999416
t =0.053 mnode3 pos.y()=0.999382
t =0.054 mnode3 pos.y()=0.99935
t =0.055 mnode3 pos.y()=0.999321
t =0.056 mnode3 pos.y()=0.999293
t =0.057 mnode3 pos.y()=0.999268
t =0.058 mnode3 pos.y()=0.999244
t =0.059 mnode3 pos.y()=0.999223
t =0.06 mnode3 pos.y()=0.999202
t =0.061 mnode3 pos.y()=0.999184
t =0.062 mnode3 pos.y()=0.999166
t =0.063 mnode3 pos.y()=0.99915
t =0.064 mnode3 pos.y()=0.999135
t =0.065 mnode3 pos.y()=0.999122
t =0.066 mnode3 pos.y()=0.999109
t =0.067 mnode3 pos.y()=0.999097
t =0.068 mnode3 pos.y()=0.999086
t =0.069 mnode3 pos.y()=0.999076
t =0.07 mnode3 pos.y()=0.999067
t =0.071 mnode3 pos.y()=0.999058
t =0.072 mnode3 pos.y()=0.99905
t =0.073 mnode3 pos.y()=0.999043
t =0.074 mnode3 pos.y()=0.999036
t =0.075 mnode3 pos.y()=0.99903
t =0.076 mnode3 pos.y()=0.999024
t =0.077 mnode3 pos.y()=0.999018
t =0.078 mnode3 pos.y()=0.999013
t =0.079 mnode3 pos.y()=0.999009

```
t =0.08 mnode3 pos.y()=0.999004  
t =0.081 mnode3 pos.y()=0.999  
t =0.082 mnode3 pos.y()=0.998997  
t =0.083 mnode3 pos.y()=0.998993  
t =0.084 mnode3 pos.y()=0.99899  
t =0.085 mnode3 pos.y()=0.998987  
t =0.086 mnode3 pos.y()=0.998985  
t =0.087 mnode3 pos.y()=0.998982  
t =0.088 mnode3 pos.y()=0.99898  
t =0.089 mnode3 pos.y()=0.998978  
t =0.09 mnode3 pos.y()=0.998976  
t =0.091 mnode3 pos.y()=0.998974  
t =0.092 mnode3 pos.y()=0.998973  
t =0.093 mnode3 pos.y()=0.998971  
t =0.094 mnode3 pos.y()=0.99897  
t =0.095 mnode3 pos.y()=0.998968  
t =0.096 mnode3 pos.y()=0.998967  
t =0.097 mnode3 pos.y()=0.998966  
t =0.098 mnode3 pos.y()=0.998965  
t =0.099 mnode3 pos.y()=0.998964  
t =0.1 mnode3 pos.y()=0.998963
```

demo_FEA_loads_statics:

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Chrono version: 9.0.1

TEST: load applied to a beam

```
MINRES iterations: 9 error: 5.58627e-12  
||Ax-b|| = 1.17363e-09  
constraintA reaction force F= 0 -588.395 0  
constraintA reaction torque T= 0 0 -588.595  
nodeC position = 2.5 10 3  
stiff_load K jacobian=100 -0 -0  
-0 400 -0  
-0 -0 -0  
nodeD position = 2.5 10 3  
custom_load K jacobian=100 0 0  
0 400 0  
0 0 0  
nodeE position = 2 10.04 3  
nodeF position = 2 11.24 3  
custom_multi_load K jacobian= 60 -0 -0 -0 -0 -0
```

-0 60 -0 -0 -10 -0
-0 -0 -0 -0 -0 -0
-0 -0 -0 -0 -0 -0
-0 -10 -0 -0 10 -0
-0 -0 -0 -0 -0 -0

Graphics Processing Unit (GPU) Demos:

demo_GPU_ballCosim:

```
Reading parameters: ../data/gpu/ballCosim.json
--- Parsing JSON ---
params.sphere_radius 1.000000
params.sphere_density 1.000000
params.box_X 300.000000
params.box_Y 300.000000
params.box_Z 200.000000
params.time_end 2.000000
params.grav_X 0.000000
params.grav_Y 0.000000
params.grav_Z -980.000000
params.normalStiffS2S 100000000.000000
params.normalStiffS2W 100000000.000000
params.normalStiffS2M 100000000.000000
params.normalDampS2S 10000.000000
params.normalDampS2W 10000.000000
params.normalDampS2M 10000.000000
params.tangentStiffS2S 100000000.000000
params.tangentStiffS2W 100000000.000000
params.tangentStiffS2M 100000000.000000
params.tangentDampS2S 2000.000000
params.tangentDampS2W 2000.000000
params.tangentDampS2M 2000.000000
params.static_friction_coeffS2S 0.500000
params.static_friction_coeffS2W 0.500000
params.static_friction_coeffS2M 0.500000
params.cohesion_ratio 0.000000
params.adhesion_ratio_s2w 0.000000
params.adhesion_ratio_s2m 0.000000
params.verbose 0
params.psi_T 32
params.psi_L 16
params.run_mode frictionless
params.output_dir ballCosim
params.write_mode csv
params.step_size 0.000050
```

Now run_mode == FRICTIONLESS, this run is particle settling phase.

After it is done, you will have a settled bed of granular material.

A checkpoint file will be generated in the output directory to store this state.

Next, edit the JSON file, change 'run_mode' from 0 (FRICTIONLESS) to 1 (ONE_STEP), then run this demo again to proceed with the ball drop part of this demo.

622476 particles sampled!

Output frame 1

Output frame 402

Output frame 802

Output frame 1202

Output frame 1602

Output frame 2002

Output frame 2402

Output frame 2802

Output frame 3202

Output frame 3602

Output frame 4002

Output frame 4402

Output frame 4802

Output frame 5201

Output frame 5602

Output frame 6002

Output frame 6402

Output frame 6802

Output frame 7202

Output frame 7602

Output frame 8002

Output frame 8401

Output frame 8802

Output frame 9202

Output frame 9602

Output frame 10002

Output frame 10401

Output frame 10802

Output frame 11202

Output frame 11601

Output frame 12002

Output frame 12402

Output frame 12802

Output frame 13202

Output frame 13602

Output frame 14002

Output frame 14402

Output frame 14802
Output frame 15202
Output frame 15601
Output frame 16002
Output frame 16402
Output frame 16801
Output frame 17202
Output frame 17602
Output frame 18001
Output frame 18402
Output frame 18802
Output frame 19202
Output frame 19602
Output frame 20002
Output frame 20402
Output frame 20801
Output frame 21201
Output frame 21602
Output frame 22002
Output frame 22402
Output frame 22802
Output frame 23201
Output frame 23601
Output frame 24002
Output frame 24402
Output frame 24802
Output frame 25202
Output frame 25602
Output frame 26001
Output frame 26402
Output frame 26802
Output frame 27202
Output frame 27602
Output frame 28002
Output frame 28401
Output frame 28802
Output frame 29202
Output frame 29602
Output frame 30002
Output frame 30402
Output frame 30802
Output frame 31201
Output frame 31602
Output frame 32002

```
Output frame 32402
Output frame 32802
Output frame 33202
Output frame 33601
Output frame 34002
Output frame 34402
Output frame 34802
Output frame 35202
Output frame 35602
Output frame 36001
Output frame 36402
Output frame 36802
Output frame 37202
Output frame 37602
Output frame 38002
Output frame 38402
Output frame 38802
Output frame 39202
Output frame 39602
Writing checkpoint data to file "DEMO_OUTPUT/GPU/ballCosim/checkpoint.dat"
```

demo_GPU_fixedTerrain:

```
Reading parameters: ./data/gpu/fixedTerrain.json
--- Parsing JSON ---
params.sphere_radius 0.750000
params.sphere_density 1.000000
params.box_X 400.000000
params.box_Y 400.000000
params.box_Z 100.000000
params.time_integrator centered_difference
params.time_end 1.000000
params.grav_X 0.000000
params.grav_Y 0.000000
params.grav_Z -980.000000
params.normalStiffS2S 100000000.000000
params.normalStiffS2W 100000000.000000
params.normalDampS2S 100.000000
params.normalDampS2W 100.000000
params.tangentStiffS2S 100000000.000000
params.tangentStiffS2W 100000000.000000
params.tangentDampS2S 100.000000
params.tangentDampS2W 100.000000
params.friction_mode multi_step
params.static_friction_coeffS2S 0.500000
```

```
params.static_friction_coeffS2W 0.500000
params.rolling_mode schwartz
params.rolling_friction_coeffS2S 0.500000
params.rolling_friction_coeffS2W 0.500000
params.cohesion_ratio 5.000000
params.adhesion_ratio_s2w 0.000000
params.verbose 0
params.psi_T 32
params.psi_L 16
params.output_dir fixedTerrain
params.write_mode csv
params.step_size 0.000100
```

Adding 498944 spheres.

Rendering frame 1 of 50

Rendering frame 2 of 50

Rendering frame 3 of 50

Rendering frame 4 of 50

Rendering frame 5 of 50

Rendering frame 6 of 50

Rendering frame 7 of 50

Rendering frame 8 of 50

Rendering frame 9 of 50

Rendering frame 10 of 50

Rendering frame 11 of 50

Rendering frame 12 of 50

Rendering frame 13 of 50

Rendering frame 14 of 50

Rendering frame 15 of 50

Rendering frame 16 of 50

Rendering frame 17 of 50

Rendering frame 18 of 50

Rendering frame 19 of 50

Rendering frame 20 of 50

Rendering frame 21 of 50

Rendering frame 22 of 50

Rendering frame 23 of 50

Rendering frame 24 of 50

Rendering frame 25 of 50

Rendering frame 26 of 50

Rendering frame 27 of 50

Rendering frame 28 of 50

Rendering frame 29 of 50

Rendering frame 30 of 50

```
Rendering frame 31 of 50
Rendering frame 32 of 50
Rendering frame 33 of 50
Rendering frame 34 of 50
Rendering frame 35 of 50
Rendering frame 36 of 50
Rendering frame 37 of 50
Rendering frame 38 of 50
Rendering frame 39 of 50
Rendering frame 40 of 50
Rendering frame 41 of 50
Rendering frame 42 of 50
Rendering frame 43 of 50
Rendering frame 44 of 50
Rendering frame 45 of 50
Rendering frame 46 of 50
Rendering frame 47 of 50
Rendering frame 48 of 50
Rendering frame 49 of 50
Rendering frame 50 of 50
```

demo_GPU_mixer:

```
Reading parameters: ./data/gpu/mixer.json
--- Parsing JSON ---
params.sphere_radius 0.500000
params.sphere_density 2.800000
params.box_X 100.000000
params.time_end 3.000000
params.normalStiffS2S 100000000.000000
params.normalStiffS2W 100000000.000000
params.normalStiffS2M 100000000.000000
params.normalDampS2S 10000.000000
params.normalDampS2W 10000.000000
params.normalDampS2M 10000.000000
params.tangentStiffS2S 100000000.000000
params.tangentStiffS2W 100000000.000000
params.tangentStiffS2M 100000000.000000
params.tangentDampS2S 10000.000000
params.tangentDampS2W 10000.000000
params.tangentDampS2M 10000.000000
params.static_friction_coeffS2S 0.500000
params.static_friction_coeffS2W 0.500000
params.static_friction_coeffS2M 0.500000
params.cohesion_ratio 0.000000
```

```
params.adhesion_ratio_s2w 0.000000
params.adhesion_ratio_s2m 0.000000
params.psi_T 32
params.psi_L 16
params.output_dir mixer
params.write_mode csv
params.step_size 0.000010
-----
Box Dims: 100 100 66.6667
Fill radius 49
Fill bottom 0
Fill top 33.3333
Use user defined contact force model, maximum effective stiffness is 1.000000e+08
UU mass is 1.466077
SU gravity is 0.000000, 0.000000, -0.301309
SU radius is 10737418
CFL timestep is about 0.000121
Length unit is 0.000000465661288
Initialize spheres.
18000 Sds as 30, 30, 20
Resizing vector SD_numSpheresTouching, old size 0, new size 18000, byte delta 70.3125 KiB
Resizing vector SD_SphereCompositeOffsets, old size 0, new size 18000, byte delta 70.3125
KiB
Resizing vector SD_SphereCompositeOffsets_ScratchPad, old size 0, new size 18000, byte
delta 70.3125 KiB
max pos is 2147483670, 2147483670, 1431655720
adding plane!
adding plane!
adding plane!
adding plane!
adding plane!
adding plane!
adding cylinder!
236880 balls added!
Resizing vector sphere_owner_SDs, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_local_pos_X, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_local_pos_Y, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_local_pos_Z, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_fixed, old size 0, new size 236880, byte delta 231.328 KiB
Resizing vector pos_X_dt, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector pos_Y_dt, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector pos_Z_dt, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_acc_X, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_acc_Y, old size 0, new size 236880, byte delta 925.312 KiB
```

Resizing vector sphere_acc_Z, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_stats_buffer, old size 0, new size 236881, byte delta 925.316 KiB
Resizing vector sphere_stats_buffer_int, old size 0, new size 236881, byte delta 925.316 KiB
Resizing vector spheres_in_SD_composite, old size 0, new size 473760, byte delta 1.80725 MiB
Resizing vector sphere_Omega_X, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_Omega_Y, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_Omega_Z, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_ang_acc_X, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_ang_acc_Y, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector sphere_ang_acc_Z, old size 0, new size 236880, byte delta 925.312 KiB
Resizing vector contact_partners_map, old size 0, new size 2842560, byte delta 10.8435 MiB
Resizing vector contact_active_map, old size 0, new size 2842560, byte delta 2.71088 MiB
Resizing vector contact_history_map, old size 0, new size 2842560, byte delta 32.5305 MiB
Resizing vector contact_duration, old size 0, new size 2842560, byte delta 10.8435 MiB
Doing initial broadphase!
max possible composite offset with 256 limit is 4608000
Initial broadphase finished!
z grav term with timestep 2.642845 is -2.104534
running at approximate timestep 0.000010
Resizing vector SD_numTrianglesTouching, old size 0, new size 18000, byte delta 70.3125 KiB
Resizing vector SD_TrianglesCompositeOffsets, old size 0, new size 18000, byte delta 70.3125 KiB
Resizing vector Triangle_NumSDsTouching, old size 0, new size 2892, byte delta 11.2969 KiB
Resizing vector Triangle_SDsCompositeOffsets, old size 0, new size 2892, byte delta 11.2969 KiB
Resizing vector SD_trianglesInEachSD_composite, old size 0, new size 0, byte delta 0 B
Output at frame 1
torque: 0, 0, 0
Output at frame 501
torque: 0, 0, 0
Output at frame 1002
torque: 0, 0, 0
Output at frame 1502
torque: 0, 0, 0
Output at frame 2002
torque: 0, 0, 0
Output at frame 2501
torque: 0, 0, 0
Output at frame 3001
torque: 0, 0, 0
Output at frame 3501
torque: 0, 0, 0
Output at frame 4002

torque: 0, 0, 0
Output at frame 4502
torque: 0, 0, 0
Output at frame 5002
torque: 0, 0, 0
Output at frame 5502
torque: 0, 0, 0
Output at frame 6002
torque: 0, 0, 0
Output at frame 6502
torque: 0, 0, 0
Output at frame 7002
torque: 0, 0, 0
Output at frame 7502
torque: 0, 0, 0
Output at frame 8002
torque: 0, 0, 0
Output at frame 8502
torque: 0, 0, 0
Output at frame 9002
torque: 0, 0, 0
Output at frame 9502
torque: 0, 0, 0
Output at frame 10002
torque: 0, 0, 0
Output at frame 10502
torque: 0, 0, 0
Output at frame 11002
torque: 0, 0, 0
Output at frame 11503
torque: 0, 0, 0
Output at frame 12003
torque: 0, 0, 0
Output at frame 12503
torque: 0, 0, 0
Output at frame 13003
torque: 0, 0, 0
Output at frame 13503
torque: -347346, 1.39548e+06, -2.76815e+07
Output at frame 14003
torque: -6.14662e+06, -6.99563e+06, -1.48146e+09
Output at frame 14503
torque: 8.68959e+07, 1.56345e+08, -3.63981e+09
Output at frame 15003

torque: -1.13139e+07, 4.05778e+07, -4.17774e+09
Output at frame 15503
torque: -3.33558e+06, -1.5301e+08, -4.92365e+09
Output at frame 16003
torque: -2.48488e+07, 1.30903e+08, -5.64128e+09
Output at frame 16503
torque: -2.48667e+08, -2.29635e+07, -6.83625e+09
Output at frame 17003
torque: -1.26017e+08, 1.12857e+08, -6.85996e+09
Output at frame 17503
torque: 2.80192e+08, -1.4528e+08, -8.52123e+09
Output at frame 18003
torque: 3.76221e+07, -3.81321e+08, -1.04959e+10
Output at frame 18503
torque: 313536, 2.3984e+07, -1.0663e+10
Output at frame 19004
torque: -4.73354e+08, 5.09297e+08, -1.38269e+10
Output at frame 19504
torque: 2.06729e+08, 3.30986e+08, -1.5712e+10
Output at frame 20004
torque: -1.89854e+07, 3.27841e+08, -1.72627e+10
Output at frame 20504
torque: 1.80788e+08, 2.535e+07, -1.66134e+10
Output at frame 21004
torque: 2.3282e+08, -3.93922e+08, -1.69112e+10
Output at frame 21504
torque: 9.70261e+07, -3.00311e+08, -1.64118e+10
Output at frame 22004
torque: 6.88445e+07, -3.63797e+08, -1.64264e+10
Output at frame 22504
torque: 1.25249e+08, -2.95761e+08, -1.68064e+10
Output at frame 23004
torque: -4.24883e+08, 923950, -1.59614e+10
Output at frame 23504
torque: -2.19412e+08, 4.56387e+08, -1.4817e+10
Output at frame 24004
torque: -7.20937e+08, 2.7937e+08, -1.51762e+10
Output at frame 24504
torque: 8.47516e+07, -4.38866e+07, -1.48423e+10
Output at frame 25004
torque: -2.26984e+08, -2.49548e+08, -1.46634e+10
Output at frame 25504
torque: 3.56531e+07, 6.11569e+07, -1.74176e+10
Output at frame 26003

torque: -2.86601e+08, 7.03499e+07, -1.99168e+10
Output at frame 26502
torque: -2.18471e+08, -5.4426e+07, -2.65701e+10
Output at frame 27002
torque: 2.99439e+06, 2.71038e+08, -2.93517e+10
Output at frame 27501
torque: 3.40667e+08, 1.66689e+08, -2.2198e+10
Output at frame 28000
torque: 5.49442e+07, 4.75959e+07, -1.27031e+10
Output at frame 28500
torque: -5.18729e+07, 9.90973e+07, -5.74399e+09
Output at frame 28999
torque: -1.11762e+08, 6.04418e+07, -2.72523e+09
Output at frame 29498
torque: -4.49669e+07, 5.69392e+07, -2.31346e+09
Output at frame 29998
torque: 4.19344e+07, 1.36872e+08, -2.13161e+09
Output at frame 30497
torque: 609824, 3.12214e+07, -2.86443e+09
Output at frame 30996
torque: -1.4774e+06, 4.66204e+07, -3.98639e+09
Output at frame 31496
torque: 3.0991e+07, 3.03945e+06, -5.80316e+09
Output at frame 31995
torque: -3.71874e+07, -8.18269e+07, -7.56843e+09
Output at frame 32494
torque: -2.67872e+07, 5.00846e+07, -8.54598e+09
Output at frame 32993
torque: 2.10283e+07, -2.22478e+08, -9.64399e+09
Output at frame 33493
torque: 2.49472e+08, -5.8969e+07, -1.12727e+10
Output at frame 33992
torque: 1.07159e+07, -2.06225e+08, -1.14259e+10
Output at frame 34491
torque: 2.64059e+08, 6.11315e+07, -1.14859e+10
Output at frame 34991
torque: 2.87849e+08, 3.37912e+07, -1.30433e+10
Output at frame 35490
torque: -1.48669e+08, 3.10475e+08, -1.18883e+10
Output at frame 35989
torque: -3.70492e+08, 1.14552e+08, -1.06741e+10
Output at frame 36489
torque: -3.43016e+08, 2.02495e+08, -8.72215e+09
Output at frame 36988

torque: -1.46915e+08, -8.21141e+07, -7.19856e+09
Output at frame 37487
torque: 4.0489e+07, -1.21905e+08, -6.32977e+09
Output at frame 37987
torque: -3.48917e+07, -3.02028e+08, -6.57439e+09
Output at frame 38486
torque: 1.9756e+08, -1.63246e+08, -6.42103e+09
Output at frame 38985
torque: 1.40309e+08, 2.91984e+07, -6.42721e+09
Output at frame 39485
torque: 1.77015e+08, -6.45161e+07, -6.25463e+09
Output at frame 39984
torque: 1.46707e+07, -9.04482e+06, -6.3147e+09
Output at frame 40483
torque: 6.80896e+07, 8.72452e+07, -7.63722e+09
Output at frame 40983
torque: -8.52883e+07, 2.89755e+08, -7.846e+09
Output at frame 41482
torque: -1.46177e+08, 2.26361e+08, -8.08068e+09
Output at frame 41981
torque: -8.02381e+07, -7.11521e+06, -8.35929e+09
Output at frame 42481
torque: -1.22921e+08, 1.57732e+08, -8.61509e+09
Output at frame 42980
torque: -5.86629e+07, 1.45353e+08, -7.84055e+09
Output at frame 43479
torque: -1.51781e+08, -1.67318e+08, -7.34626e+09
Output at frame 43979
torque: 8.39621e+07, -6.89994e+07, -6.87907e+09
Output at frame 44478
torque: 9.66844e+07, -6.84836e+07, -6.51311e+09
Output at frame 44977
torque: 1.80874e+08, -4.76767e+07, -6.98494e+09
Output at frame 45477
torque: -9.94396e+07, -7.95619e+07, -6.72709e+09
Output at frame 45976
torque: -1.65899e+08, -1.53856e+08, -6.57834e+09
Output at frame 46475
torque: -1.20774e+07, -8.89054e+07, -6.72277e+09
Output at frame 46974
torque: 2.89374e+06, -1.91383e+08, -6.63887e+09
Output at frame 47474
torque: -3.49301e+07, -1.79629e+08, -5.73184e+09
Output at frame 47973

torque: -7.65163e+07, -1.40945e+08, -6.81361e+09
Output at frame 48472
torque: -3.08053e+08, 1.62308e+08, -7.42294e+09
Output at frame 48972
torque: -8.93362e+07, 1.58687e+08, -7.4817e+09
Output at frame 49471
torque: -5.57489e+07, 1.57307e+08, -7.27882e+09
Output at frame 49970
torque: 5.09761e+07, 9.96991e+07, -7.48209e+09
Output at frame 50470
torque: -1.3813e+08, -1.75538e+08, -7.76439e+09
Output at frame 50969
torque: -2.32379e+08, -9.94438e+06, -7.75698e+09
Output at frame 51468
torque: -2.30932e+07, 7.92606e+06, -7.40808e+09
Output at frame 51968
torque: 1.09233e+08, 1.11629e+08, -7.4793e+09
Output at frame 52467
torque: 2.64921e+08, -5.54792e+07, -7.83821e+09
Output at frame 52966
torque: 9.01542e+07, -1.59091e+08, -7.40381e+09
Output at frame 53466
torque: 1.29833e+08, -7.53116e+07, -6.62577e+09
Output at frame 53965
torque: 1.48816e+08, -2.56893e+08, -6.95988e+09
Output at frame 54464
torque: 3.00614e+08, 5.85184e+07, -7.14249e+09
Output at frame 54964
torque: -1.39696e+08, 5.3982e+07, -6.6695e+09
Output at frame 55463
torque: -1.33569e+08, -3.86032e+07, -7.42742e+09
Output at frame 55962
torque: -1.146e+08, 2.12303e+08, -7.12518e+09
Output at frame 56462
torque: -1.52866e+08, -2.67798e+07, -7.14827e+09
Output at frame 56961
torque: 2.13572e+07, 7.132e+07, -7.28309e+09
Output at frame 57460
torque: 2.74146e+08, -2.27109e+08, -7.51968e+09
Output at frame 57960
torque: 5.50601e+07, -1.22501e+08, -7.90701e+09
Output at frame 58459
torque: 9.69558e+07, -1.68244e+08, -7.6126e+09
Output at frame 58958

torque: 7.38582e+07, 2.84316e+07, -7.24491e+09
Output at frame 59458
torque: 4.18449e+07, -5.21618e+07, -7.10035e+09
Output at frame 59957
torque: -7.09208e+07, -6.8322e+07, -7.01504e+09
Output at frame 60456
torque: -3.87486e+07, 1.96222e+08, -7.53774e+09
Output at frame 60956
torque: -6.69475e+07, -142411, -7.23798e+09
Output at frame 61455
torque: -6.03441e+07, -2.29057e+07, -7.6555e+09
Output at frame 61954
torque: 5.06127e+07, 1.31399e+07, -7.66867e+09
Output at frame 62453
torque: -1.5547e+07, 9.1394e+06, -7.62018e+09
Output at frame 62953
torque: -2.34969e+08, 6.05466e+06, -7.62199e+09
Output at frame 63452
torque: -2.32466e+08, -1.52898e+07, -7.42646e+09
Output at frame 63951
torque: 1.07627e+08, -1.55176e+08, -7.52402e+09
Output at frame 64451
torque: 3.21849e+08, -1.1213e+08, -7.67121e+09
Output at frame 64950
torque: 1.19922e+08, -8.56644e+07, -7.4303e+09
Output at frame 65449
torque: 2.48871e+08, -1.94801e+07, -7.17515e+09
Output at frame 65949
torque: 2.59343e+08, 1.42285e+07, -7.67835e+09
Output at frame 66448
torque: -2.73852e+07, 1.90114e+08, -7.08794e+09
Output at frame 66947
torque: 2.11699e+07, 1.06028e+07, -8.04168e+09
Output at frame 67447
torque: -206850, -4.10485e+06, -7.30435e+09
Output at frame 67946
torque: -2.02245e+07, 3.43507e+07, -7.72205e+09
Output at frame 68445
torque: -2.16267e+08, 1.78424e+08, -7.60016e+09
Output at frame 68945
torque: -3.39921e+06, -2.26063e+08, -7.58111e+09
Output at frame 69444
torque: 1.08067e+08, -1.49256e+08, -7.01314e+09
Output at frame 69943

torque: 1.43974e+08, 1.68698e+08, -7.2057e+09
Output at frame 70443
torque: 2.34629e+08, -1.85164e+08, -6.91782e+09
Output at frame 70942
torque: 1.59105e+08, -1.78336e+08, -7.48627e+09
Output at frame 71441
torque: 1.26671e+07, -9.86062e+07, -7.22472e+09
Output at frame 71941
torque: -8.70867e+07, -7.94692e+07, -7.11394e+09
Output at frame 72440
torque: 1.48952e+08, 7.40738e+07, -6.88605e+09
Output at frame 72939
torque: 3.94519e+07, 1.46801e+08, -7.06782e+09
Output at frame 73439
torque: -1.1072e+07, -1.82334e+06, -6.70231e+09
Output at frame 73938
torque: 1.79795e+08, 1.76021e+08, -7.10984e+09
Output at frame 74437
torque: 9.32273e+07, 2.24621e+08, -6.80011e+09
Output at frame 74937
torque: 5.84533e+07, 5.9022e+07, -7.09362e+09
Output at frame 75436
torque: 6.45256e+07, 6.43602e+07, -7.29882e+09
Output at frame 75935
torque: 3.96377e+07, -1.53088e+08, -6.88253e+09
Output at frame 76434
torque: 8.10442e+07, -5.60264e+07, -6.86686e+09
Output at frame 76934
torque: -1.79634e+07, -2.09976e+08, -7.12996e+09
Output at frame 77433
torque: -4.43513e+07, -7.63221e+07, -7.45001e+09
Output at frame 77932
torque: -2.02953e+08, 1.0964e+08, -7.30978e+09
Output at frame 78432
torque: 1.06297e+08, 3.09248e+07, -6.80297e+09
Output at frame 78931
torque: 1.86791e+08, 1.64335e+08, -6.95586e+09
Output at frame 79430
torque: 1.09808e+08, -8.56459e+07, -7.56792e+09
Output at frame 79930
torque: 2.31047e+07, 1.94685e+07, -7.41115e+09
Output at frame 80429
torque: 6.92332e+07, -5.48604e+07, -7.06226e+09
Output at frame 80928

torque: -4.90006e+07, 1.19206e+08, -6.2528e+09
Output at frame 81428
torque: 8.68236e+07, 1.38451e+08, -6.57278e+09
Output at frame 81927
torque: -1.57489e+07, -1.94908e+07, -7.23105e+09
Output at frame 82426
torque: -1.44976e+08, -8.7326e+07, -7.01412e+09
Output at frame 82926
torque: -5.3996e+07, -2.74478e+08, -6.9589e+09
Output at frame 83425
torque: -1.64945e+08, 6.36449e+06, -7.2554e+09
Output at frame 83924
torque: -3.08446e+07, 7.41514e+07, -7.11457e+09
Output at frame 84424
torque: 1.97253e+08, 7.66383e+07, -7.7672e+09
Output at frame 84923
torque: 1.66879e+08, -1.28899e+08, -7.23246e+09
Output at frame 85422
torque: 3.28403e+08, -1.87924e+07, -7.3505e+09
Output at frame 85922
torque: 8.43629e+07, -1.43202e+08, -7.33956e+09
Output at frame 86421
torque: 1.19542e+08, -1.40404e+08, -7.34148e+09
Output at frame 86920
torque: 1.38555e+08, 4.24583e+07, -6.64973e+09
Output at frame 87420
torque: -2.03347e+08, -1.02052e+08, -6.87653e+09
Output at frame 87919
torque: -1.46696e+08, -2.14809e+07, -7.06779e+09
Output at frame 88418
torque: -1.7281e+08, -6.64898e+07, -7.23364e+09
Output at frame 88918
torque: -2.34977e+08, 1.05192e+08, -7.66865e+09
Output at frame 89417
torque: -4.3535e+07, 3.55775e+06, -7.59702e+09
Output at frame 89916
torque: -2.41157e+07, -2.42744e+08, -6.7186e+09
Output at frame 90415
torque: -5.33433e+07, -1.49872e+07, -6.7877e+09
Output at frame 90915
torque: 9.38763e+07, 1.93316e+07, -7.26468e+09
Output at frame 91414
torque: 1.21891e+08, -2.71938e+07, -7.34329e+09
Output at frame 91913

```
torque: 1.1807e+08, -3.2539e+08, -7.1405e+09
Output at frame 92413
torque: 2.40273e+07, -9.94695e+07, -7.23462e+09
Output at frame 92912
torque: 2.82935e+08, 4.16819e+07, -7.67791e+09
Output at frame 93411
torque: 9.73991e+07, -7.29668e+07, -7.86619e+09
Output at frame 93911
torque: 1.94133e+08, -2.47489e+08, -7.54291e+09
Output at frame 94410
torque: 1.87456e+07, 1.21955e+08, -7.51831e+09
Output at frame 94909
torque: -2.62185e+08, 9.05507e+07, -7.45033e+09
Output at frame 95409
torque: -3.6611e+08, 2.03831e+08, -7.60717e+09
Output at frame 95908
torque: -1.86316e+08, 2.13867e+08, -6.85971e+09
Output at frame 96407
torque: -1.56962e+08, 7.39181e+06, -6.99899e+09
Output at frame 96907
torque: -8.58516e+06, -8.06624e+07, -7.72716e+09
Output at frame 97406
torque: 1.02452e+08, -2.6909e+06, -6.93679e+09
Output at frame 97905
torque: 2.25956e+08, 2.63791e+08, -6.80326e+09
Output at frame 98405
torque: 7.39952e+07, 1.13801e+08, -7.52308e+09
Output at frame 98904
torque: -2.57889e+08, 5.00141e+07, -7.37263e+09
Output at frame 99403
torque: -1.96638e+06, 6.92347e+07, -7.22282e+09
Output at frame 99903
torque: 2.72599e+08, -1.08392e+08, -7.37439e+09
Output at frame 100402
torque: 2.86306e+08, 4.9595e+07, -7.24728e+09
```

*Interrupted execution at this point because it was taking a very long time

demo_GPU_movingBoundary:

```
Reading parameters: ../data/gpu/movingBoundary.json
--- Parsing JSON ---
params.sphere_radius 1.000000
params.sphere_density 2.500000
params.box_X 200.000000
```

```
params.box_Y 200.000000
params.box_Z 100.000000
params.time_end 18.000000
params.grav_X 0.000000
params.grav_Y 0.000000
params.grav_Z -980.000000
params.normalStiffS2S 10000000.000000
params.normalStiffS2W 10000000.000000
params.normalDampS2S 1000.000000
params.normalDampS2W 1000.000000
params.tangentStiffS2S 2000000.000000
params.tangentStiffS2W 1000000.000000
params.tangentDampS2S 50.000000
params.tangentDampS2W 50.000000
params.static_friction_coeffS2S 0.500000
params.static_friction_coeffS2W 0.500000
params.cohesion_ratio 0.000000
params.adhesion_ratio_s2w 0.000000
params.psi_T 32
params.psi_L 16
params.output_dir movingBoundary
params.write_mode csv
params.step_size 0.000100
```

```
frame step is 0.02
rendering frame 1 of 900
rendering frame 2 of 900
rendering frame 3 of 900
rendering frame 4 of 900
rendering frame 5 of 900
rendering frame 6 of 900
rendering frame 7 of 900
rendering frame 8 of 900
rendering frame 9 of 900
rendering frame 10 of 900
rendering frame 11 of 900
rendering frame 12 of 900
rendering frame 13 of 900
rendering frame 14 of 900
rendering frame 15 of 900
rendering frame 16 of 900
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rendering frame 18 of 900
rendering frame 19 of 900
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rendering frame 20 of 900
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demo_GPU_repose:

```
Reading parameters: ../data/gpu/repose.json
--- Parsing JSON ---
params.sphere_radius 0.100000
params.sphere_density 2.800000
params.box_X 40.000000
params.box_Y 40.000000
params.box_Z 40.000000
params.time_end 10.000000
params.grav_X 0.000000
params.grav_Y 0.000000
params.grav_Z -980.000000
params.normalStiffS2S 100000000.000000
params.normalStiffS2W 100000000.000000
params.normalStiffS2M 100000000.000000
params.normalDampS2S 1000000.000000
params.normalDampS2W 1000000.000000
params.normalDampS2M 1000000.000000
params.tangentStiffS2S 100000000.000000
params.tangentStiffS2W 100000000.000000
params.tangentStiffS2M 100000000.000000
params.tangentDampS2S 1000000.000000
params.tangentDampS2W 1000000.000000
params.tangentDampS2M 1000000.000000
params.static_friction_coeffS2S 0.750000
params.static_friction_coeffS2W 0.750000
params.static_friction_coeffS2M 0.750000
params.rolling_friction_coeffS2S 0.000000
params.rolling_friction_coeffS2W 0.000000
params.rolling_friction_coeffS2M 0.000000
params.cohesion_ratio 0.000000
params.adhesion_ratio_s2w 0.000000
params.psi_T 32
params.psi_L 16
params.output_dir repose
params.write_mode csv
params.step_size 0.000002
```

Added 60674 granular material points

Added 45030 fixed (ground) points

In total, added 105704

Output frame 1

Total kinetic energy: 343.434
Numer of particles still in funnel: 60674
Output frame 2
Total kinetic energy: 1373.73
Numer of particles still in funnel: 60674
Output frame 3
Total kinetic energy: 3090.81
Numer of particles still in funnel: 60674
Output frame 4
Total kinetic energy: 5494.81
Numer of particles still in funnel: 60674
Output frame 5
Total kinetic energy: 8585.84
Numer of particles still in funnel: 60674
Output frame 6
Total kinetic energy: 12363.8
Numer of particles still in funnel: 60674
Output frame 7
Total kinetic energy: 16828.7
Numer of particles still in funnel: 60674
Output frame 8
Total kinetic energy: 21979.7
Numer of particles still in funnel: 60674
Output frame 9
Total kinetic energy: 27817.3
Numer of particles still in funnel: 60674
Output frame 10
Total kinetic energy: 34341.6
Numer of particles still in funnel: 60674
Output frame 11
Total kinetic energy: 41552.6
Numer of particles still in funnel: 60674
Output frame 12
Total kinetic energy: 49450.3
Numer of particles still in funnel: 60674
Output frame 13
Total kinetic energy: 58034.7
Numer of particles still in funnel: 60674
Output frame 14
Total kinetic energy: 67305.8
Numer of particles still in funnel: 60674
Output frame 15
Total kinetic energy: 77265.9
Numer of particles still in funnel: 60674

Output frame 16
Total kinetic energy: 87914.3
Numer of particles still in funnel: 60674
Output frame 17
Total kinetic energy: 99249.8
Numer of particles still in funnel: 60674
Output frame 18
Total kinetic energy: 111273
Numer of particles still in funnel: 60674
Output frame 19
Total kinetic energy: 123982
Numer of particles still in funnel: 60674
Output frame 20
Total kinetic energy: 137380
Numer of particles still in funnel: 60674
Output frame 21
Total kinetic energy: 151464
Numer of particles still in funnel: 60674
Output frame 22
Total kinetic energy: 166235
Numer of particles still in funnel: 60674
Output frame 23
Total kinetic energy: 181694
Numer of particles still in funnel: 60674
Output frame 24
Total kinetic energy: 197839
Numer of particles still in funnel: 60674
Output frame 25
Total kinetic energy: 214672
Numer of particles still in funnel: 60674
Output frame 26
Total kinetic energy: 232192
Numer of particles still in funnel: 60674
Output frame 27
Total kinetic energy: 250400
Numer of particles still in funnel: 60674
Output frame 28
Total kinetic energy: 269294
Numer of particles still in funnel: 60674
Output frame 29
Total kinetic energy: 288871
Numer of particles still in funnel: 60674
Output frame 30
Total kinetic energy: 309126

Numer of particles still in funnel: 60674
Output frame 31
Total kinetic energy: 330066
Numer of particles still in funnel: 60674
Output frame 32
Total kinetic energy: 351693
Numer of particles still in funnel: 60674
Output frame 33
Total kinetic energy: 374006
Numer of particles still in funnel: 60674
Output frame 34
Total kinetic energy: 397006
Numer of particles still in funnel: 60674
Output frame 35
Total kinetic energy: 420691
Numer of particles still in funnel: 60674
Output frame 36
Total kinetic energy: 445063
Numer of particles still in funnel: 60674
Output frame 37
Total kinetic energy: 470121
Numer of particles still in funnel: 60674
Output frame 38
Total kinetic energy: 495865
Numer of particles still in funnel: 60674

*Interrupted execution at this point because it was taking a very long time

Vehicle (VEH) Demos:

*Tried to run with RigidSlope10.json but the terrain specification file is not visible to any of the demos: (Ex. salloc -Qn 8 mpirun ./demo_VEH_Cosim_Curiosity --terrain_specfile/data/vehicle/terrain/RigidSlope10.json)

demo_VEH_Cosim_Curiosity:

ERROR: Missing terrain specification file!

demo_VEH_Cosim_TrackedVehicle:

ERROR: Missing terrain specification file!

demo_VEH_Cosim_Viper:

ERROR: Missing terrain specification file!

demo_VEH_Cosim_WheeledVehicle:

*Errored with exit code 1

demo_VEH_Cosim_WheelRig:

ERROR: Missing terrain specification file!

demo_VEH_Cosim_WheelRig_CustomTerrain:

*Errored with exit code 1

demo_VEH_Test_Accel:

demo_VEH_Test_FMTV_Ride:

demo_VEH_Test_ISO2631_Ride:

demo_VEH_Test_ISO2631_Shock:

demo_VEH_Test_TireFEA: