Galaxy / CSG

Greg consulted with Dr. Alexander Pletzer at NIWA for New Zealand eScience Infrastructure to build the foundational Galaxy toolset for constructive solid geometry. The tools can be used for creating and assembling 3-dimensional shapes and solving equations on them. Greg implemented a Galaxy CSG Viewer Visualization plugin for viewing the shapes within the Galaxy interface in the browser.

The intent is for these tools to provide a foundational platform for others to enhance with additional tools to provide more complex analyses, or perhaps for educational instruction in a classroom setting. The current toolset consists of the following tools.

- [Create 3D shape](#) - Creates a selected primitive shape where shapes are Box, Cone, Cylinder and Sphere.
- [Compose 3D shapes](#) - Creates a shape composed of any number of selected shapes where the composition is based on a mathematical expression consisting of +, - and * operations. The + results in a union of shapes, the - operator removes a shape and the * operator results in an intersection of shapes.
- [Scale shape](#) - Magnifies the dimensions of a shape along some specified axes.
- [Translate shape](#) - Applies translation operations to a shape by adding a displacement to each coordinate.
- [Rotate shape](#) - Applies a rotation to a shape by a given angle about an arbitrary axis.
- [Refine shape](#) - Refines the discrete, triangulated surface representation of a shape using a maximum edge length criterion, breaking triangles into smaller ones where necessary.
- [Coarsen shape](#) - Coarsens the discrete, triangulated surface representation of a shape using a minimum cell area criterion, merging triangles into larger ones where necessary.
- [Add texture](#) - Adds a texture to a shape by projecting an image onto the surface of the shape.

- [Add surface field](#) - Adds a surface field to a selected shape based on a given mathematical expression consisting of variables x, y, z (shape point coordinates) and t (time).
- [Color surface field](#) - Colors a shape's surface field using a selected color map.
- [Solve Laplace equation](#) - Solve the Laplace equation given prescribed Dirichlet boundary conditions applied as a surface field. The resulting field corresponds to the electric field in an electrostatic problem.

Figure 13 displays the interface for the Create 3D Shape tool which allows you to create 4 primitive shapes; boxes, cones, cylinders and spheres. Here we're creating a cylinder.

Figure 13: Using the Galaxy / CSG Create 3D Shape tool to create a cylinder

We can view and manipulate the cylinder using the Galaxy CSG Viewer plug-in...

...which renders the 3D image in the Galaxy tool panel.

Here we can create a cone...

Create shape (Galaxy Version 1.0.0)   ▾ Options

Create or clone?

| Create a shape | ▾ |

Create a new shape or clone a shape in your history.

Select shape

| Cone | ▾ |

Radius

| 0.25 |

Floating point number

X coordinate of origin

| −0.06 |

Floating point number

Y coordinate of origin

| 0.0 |

Floating point number

Z coordinate of origin

| 0.0 |

Floating point number

Length in the X direction

| 0.14 |

Floating point number

Length in the Y direction

| 0.0 |

Floating point number

Length in the Z direction

| 0.0 |

Floating point number

Number of slices
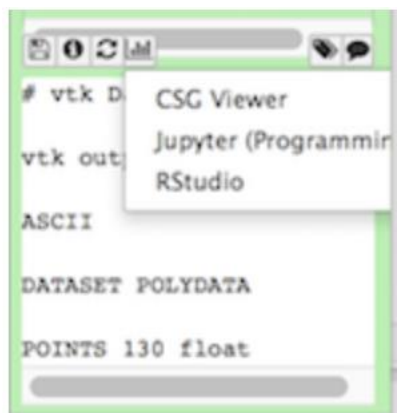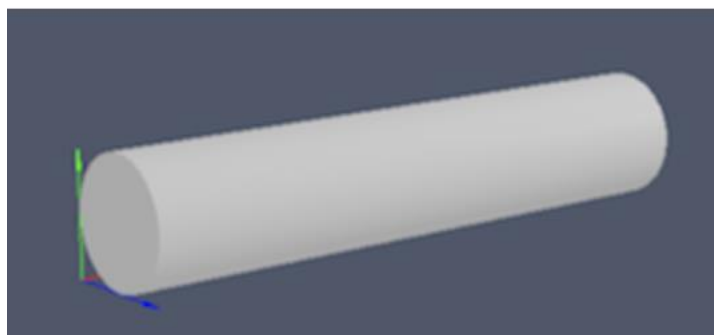
| 16 |

Controls the tessellation along the longitude direction

Output file type

| Vtk–ascii | ▾ |

✔ Execute

...and a box.

Create shape (Galaxy Version 1.0.0)   ▾ Options

Create or clone?

Create a shape   ▾

Create a new shape or clone a shape in your history.

Select shape

Box   ▾

X coordinate of origin

−0.06

Floating point number

Y coordinate of origin

−0.015

Floating point number

Z coordinate of origin

−0.15

Floating point number

Length in the X direction

0.03

Floating point number

Length in the Y direction

0.03

Floating point number

Length in the Z direction

0.30

Floating point number

Output file type

Vtk−ascii   ▾

✔ Execute

The Create 3D shape tool allows you to create a shape by cloning another shape. Options include rotating or translating the cloned shape. Here we clone the box we just created, rotating it 90 degrees around the X axis.

Create shape (Galaxy Version 1.0.0)   ▾ Options

Create or clone?

Clone a shape in your history   ▾
Create a new shape or clone a shape in your history.

  Shape to clone

    [icons]   ▾
        3: Create shape : box
  Select shape for cloning.

  Rotate cloned shape?

  Yes   ▾

    X coordinate of rotation axis

    1

    Floating point number

    Y coordinate of rotation axis

    0.0

    Floating point number

    Z coordinate of rotation axis

    0.0

    Floating point number

    Degree of rotation

    90.0

    Floating point number

  Translate cloned shape?

  No   ▾

✔ Execute

This is the Compose shapes tool. This tool creates a shape composed of any number of selected shapes where the composition is based on a mathematical expression consisting of +, - and * operations. The + operator results in a union of shapes, the - operator removes a shape and the * operator results in an intersection of shapes. Here we are composing the four primitive shapes we just created, adding the cone to the cylinder and subtracting both boxes.

Compose shapes (Galaxy Version 1.0.0)   ▾ Options

Composition expression

| head + shaft – notch1 – notch2 |

Example: A + B – C * D

Expression variable and shape

1: Expression variable and shape   🗑

Expression variable

| head |

The selected shape will be associated with this variable in the expression.

Shape

| 🗋 | 🗐 | 🗁 | ▾

| 2: Create shape : cone |

2: Expression variable and shape   🗑

Expression variable

| shaft |

The selected shape will be associated with this variable in the expression.

Shape

| 🗋 | 🗐 | 🗁 | ▾

| 1: Create shape : cylinder |

3: Expression variable and shape   🗑

Expression variable

| notch1 |

The selected shape will be associated with this variable in the expression.

Shape

| 🗋 | 🗐 | 🗁 | ▾

| 3: Create shape : box |

4: Expression variable and shape   🗑

Expression variable

| notch2 |

The selected shape will be associated with this variable in the expression.

Shape

| 🗋 | 🗐 | 🗁 | ▾

| 4: Create shape: Cloned data 3 |

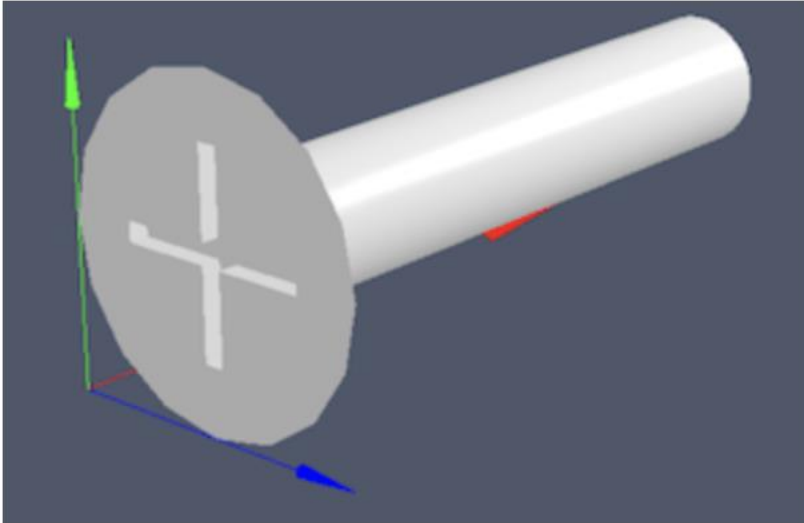➕ Insert Expression variable and shape

Output file type

| Vtk–ascii | ▾

✔ Execute

Our composed shapes produce a bolt.

This is the Add texture to shape tool. It allows you to select an image dataset from your history and project it onto the shape's surface.

Our bolt is shiny after adding the texture.