FLUENT - Turbulent Flow Past a Sphere - Step 1

UNDER CONSTRUCTION

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Problem Specification
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Problem 1

Step 1: Create Geometry in GAMBIT

Strategy for Creating Geometry

To model this flow, we will need volume geometry approximating a sphere inside a wind tunnel. The sphere will be placed closer to the wind tunnel inlet so that we may view its wake structure. In order to use a hexahedral mesh, the interior of the wind tunnel will need to be subdivided into smaller components. This tutorial will guide you through building a coarse mesh for a rectangular volume.

Create a Working Directory

Create a folder called *sphere* on the desktop. We'll use this as the working folder in which files created during the session will be stored.

Start GAMBIT

Go to the Start menu and open *GAMBIT.* When the Startup window appears, type "C:\Documents and Settings\ (your username)\Desktop\sphere" for working directory. Under options, add "-id singlesphere".

Under **Main Menu**, select **Solver > FLUENT 5/6** since the mesh to be created is to be used in FLUENT 6.0.

Create Wind Tunnel and Sphere

We begin by creating a rectangular volume that will serve to represent the wind tunnel.

Operation Toolpad > Geometry Command Button 🔲 **> Volume Command Button** 🔲 **> Create Volume Real Brick** 🔲
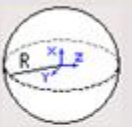
Set the dimensions as width 60, depth 20, and height 30, check that 'centered' is the default setting for direction, and label this volume *flow_domain*.
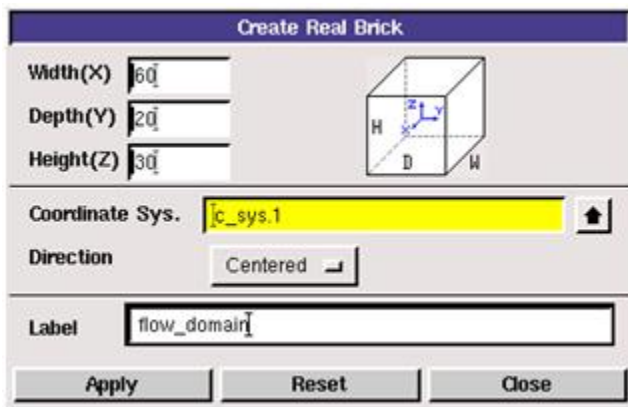
Click 'Apply' and the rectangle will be created with its center at the coordinate origin. Create a second brick with uniform dimensions 8x8x8, forming a cube, and label this volume *sphere_box*. Now right click on the **Create Volume** button and select **Create Real Sphere**. Create a spherical volume with radius 3 and label it *sphere*.

Operation Toolpad > Geometry Command Button [icon] > Volume Command Button [icon] > Move/Copy Volumes [icon]

We wish to physically move all three volumes so click the 'move' option and choose 'translational' for Operation. Select *flow_domain* and move it to global coordinates x = 30, y = z = 0.


The length of your rectangle should now be entirely on the positive x-axis. Select *sphere_box* and move it to global coordinates x = 12, y = z = 0. Select *sphere* and move it to global coordinates x = 12, y = z = 0 too. This will place your sphere at the center of *sphere_box*.
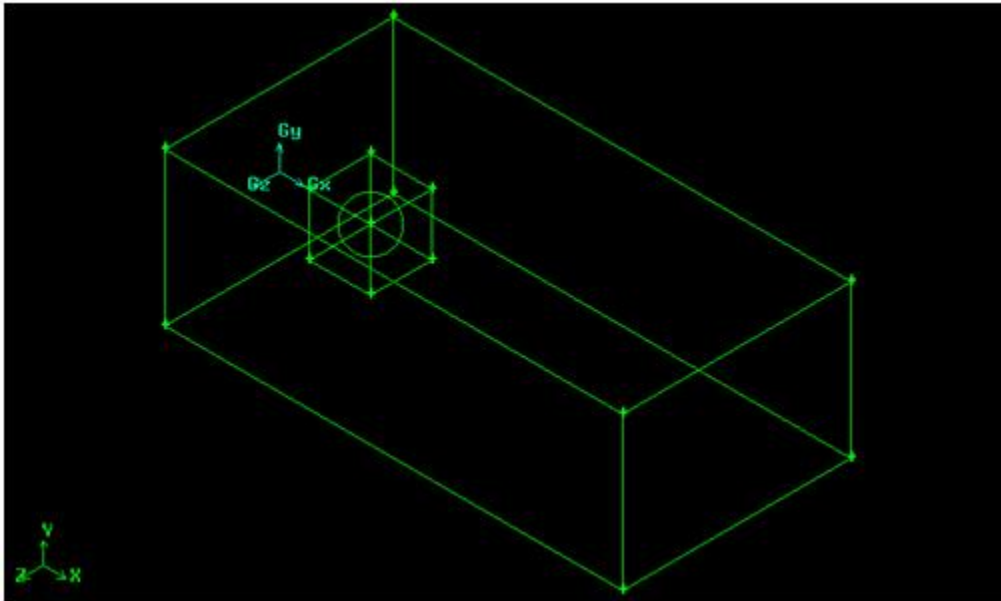
Now we want to isolate the volume contained by *sphere_box* from the rest of the flow domain's volume. We can achieve this by performing a volume split.

**Operation Toolpad > Geometry Command Button** **> Volume Command Button** **> Split Volumes**

A split operation takes one volume and uses another shape, which intersects the first in some way, to divide it into two distinct volumes. The volume we want to do the split on is *flow_domain*. The setting 'Volumes (Real)' means that Gambit will use a second volume as the tool to define the portion of *flow_domain* to be separated from the greater whole. Select *sphere_box* as the splitting tool. Check the options "Bidirectional" and "Connected." As the name suggests, "Connected" keeps the two resulting volumes linked. Each volume can be selected separately but they will use the same faces (i.e. the faces that compose the sides of *sphere_box*) to define their borders, meaning that mesh cell intervals must be consistent for two volumes that share a face. "Bidirectional" preserves the entire volume used as the splitting tool, regardless of how much of the splitting tool volume intersects the target volume.
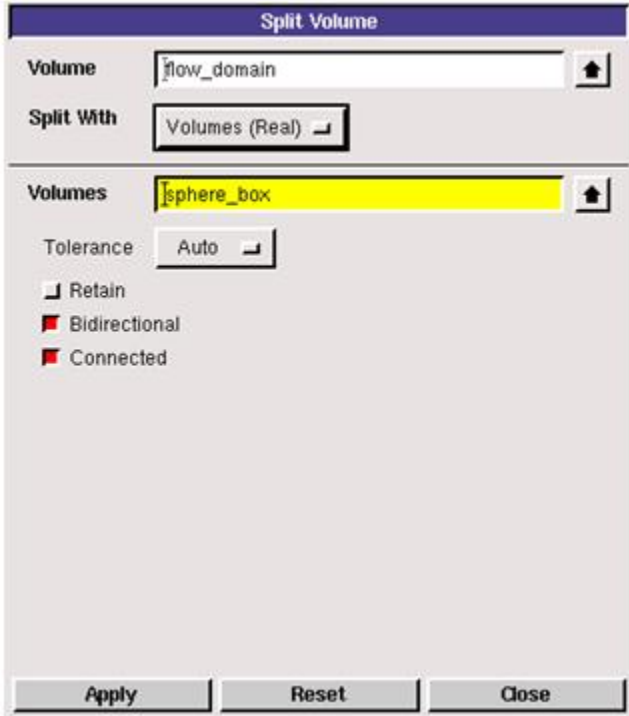
Now the entire region within *sphere_box* can be meshed but we want a mesh around the surface of the spherical volume, not a mesh that goes through the spherical volume. In fact, we don't want to do anything with the interior volume of the sphere so we must exclude it from the volume of *sphere_box*.

Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Boolean Operations**

Right click and select 'Subtract Real Volumes.' Similar to the split command, subtract uses one volume to remove a portion of another volume. The difference is that subtract doesn't create two volumes in place of one. Instead the removed portion is deleted. Select *sphere_box* as the volume we want to subtract from. Choose *sphere* as the volume we want to subtract with.
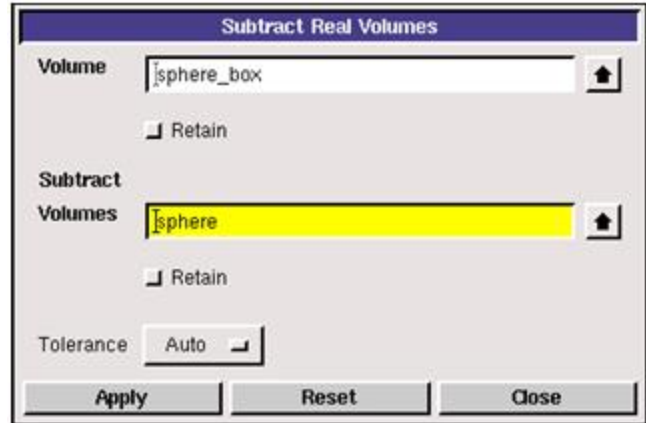

The geometry picture won't change but there will now only be two identified volumes: *flow_domain* and *sphere_box*.

Subdivide Sphere Surface

Although we have sufficient geometry to represent a sphere in a wind tunnel, additional geometry operations are required to compensate for the sphere's 3-dimensional curves and enable the use of a hexahedral volume mesh. The reasons for this will be explained further in Step 2. We'll first deal with the sphere.
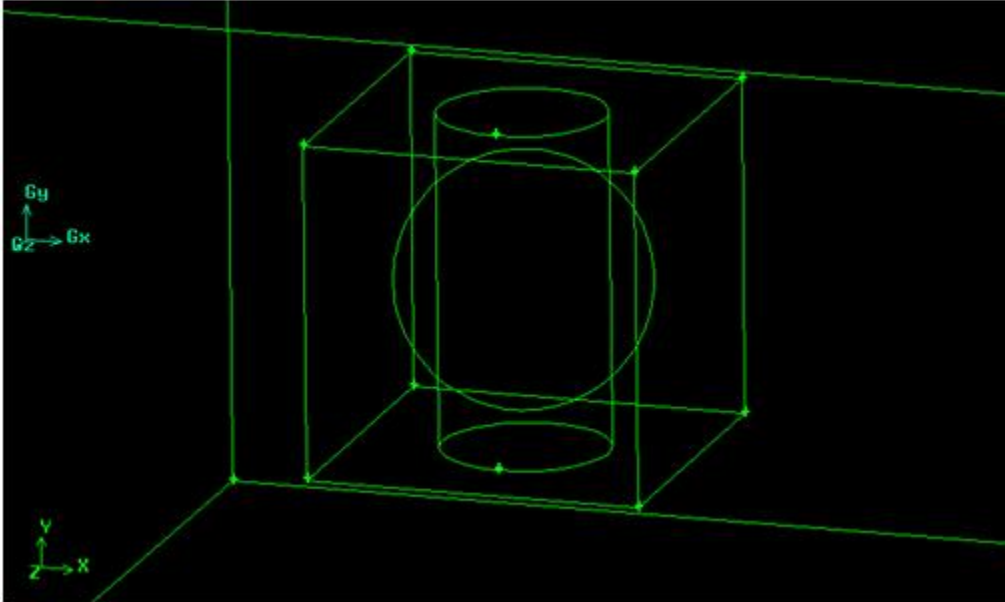
Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Create Volume Real Cylinder**

Right click on the "Create Volume" button and select "Cylinder." Create a cylindrical volume with height 8 and radius 2, orient it along the centered y-axis, and label it *cylinder*. The cylinder height must be the same as the length of *sphere_box* and the cylinder radius must be smaller than the sphere radius. Note: you cannot choose a cylinder radius of 1 because the resulting volume will be too small for our intended meshing. move it to x = 12, y = z = 0.
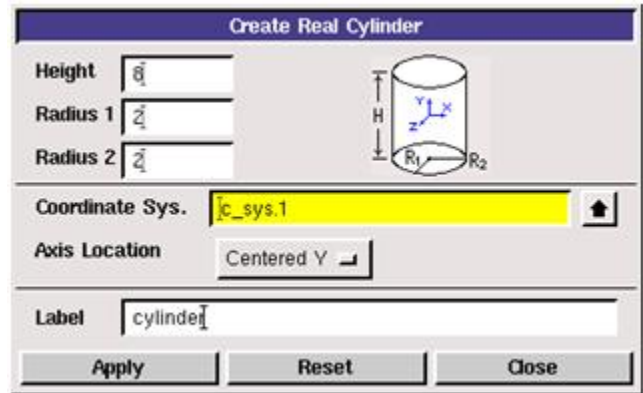
Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Move/Copy Volumes**

Go to the Move command window and move *cylinder* to global coordinates x = 12, y = z = 0 so that it is centered at the same point as the sphere.

The cylinder will serve as the tool for another volume split, allowing us to separately isolate the upper and lower y-axis 'poles' of the sphere.

Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Split Volumes**

Go to the Split command window and select *sphere_box* as the volume to be split and select *cylinder* as the splitting tool. This time only select the "Connected" option. Remember that "Bidirectional" preserves the original splitting tool and that, by this point, only the region outside of the sphere counts as *sphere_box*'s internal volume. Most of the cylinder is within the region defined as our sphere, our solid sphere, where we have no need or use for it.
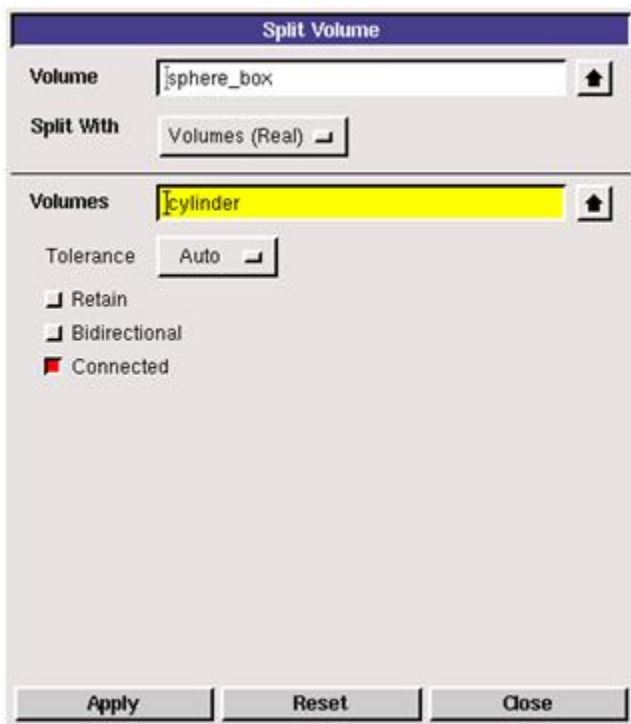
These settings will yield three volumes: one small cylinder for each y-axis pole and the remains of *sphere_box*. The unnecessary portion of the original *cylinder* that was inside the sphere is deleted.

Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Modify Volume Color/Label**

Right click and select "Modify Label." There now four defined volumes. Notice that the *cylinder* label is still used by one of the two cylindrical caps we just created. Select the other small cylinder, which bears a default Gambit-provided number tag, and label it *cap*. This will prove helpful later during meshing, when we will need to be able to easily select these cylindrical pieces from a large list of volumes.
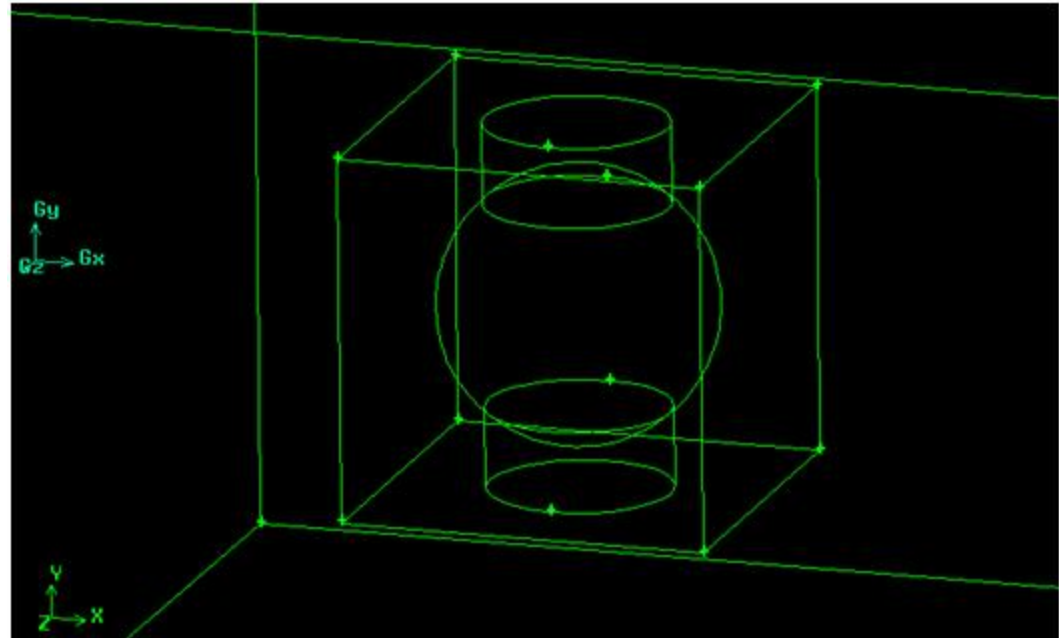
Our ultimate goal is to ensure that none of the volumes composing the sphere contain a radius = 3, circular element of the sphere. Next we need to construct a new face to further divide *sphere_box*.

Operation Toolpad > Geometry Command Button **> Edge Command Button** **> Create Edge**

The simplest option is to create a diagonal face that is aligned parallel to the cylindrical caps. First create a pair of edges using *sphere_box* vertices. Hold down 'Shift' and left-click on two, diagonally-opposite vertices on the positive y-axis side of *sphere_box*. Label the new edge *Line1*.
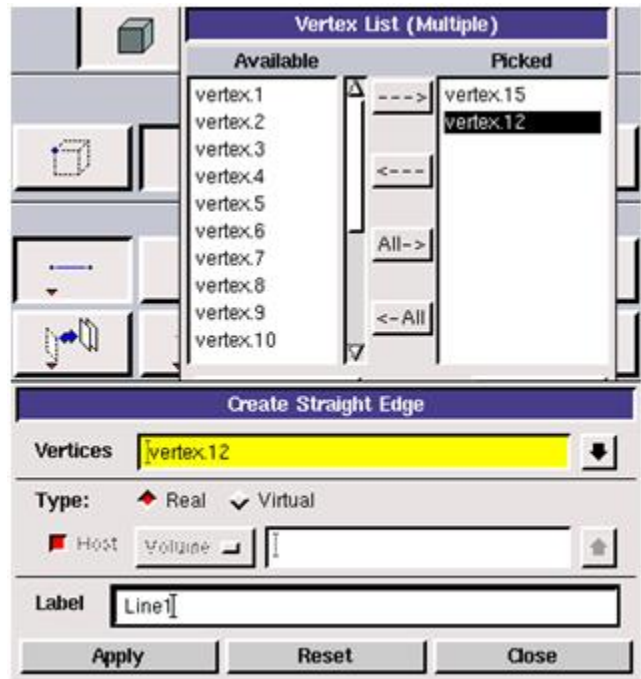
Repeat the process for the negative y-axis side of *sphere_box* and label this edge *Line2*.

Operation Toolpad > Geometry Command Button **> Face Command Button** **> Form Face**

Change to the Face Command options and open the Form Face window. This enables you to create a face from a wireframe pattern of edges. Again old down 'Shift' and left-click on *Line1* and *Line2* and the two vertical edges that link *Line1* and *Line2*. Label the new face *slice*.
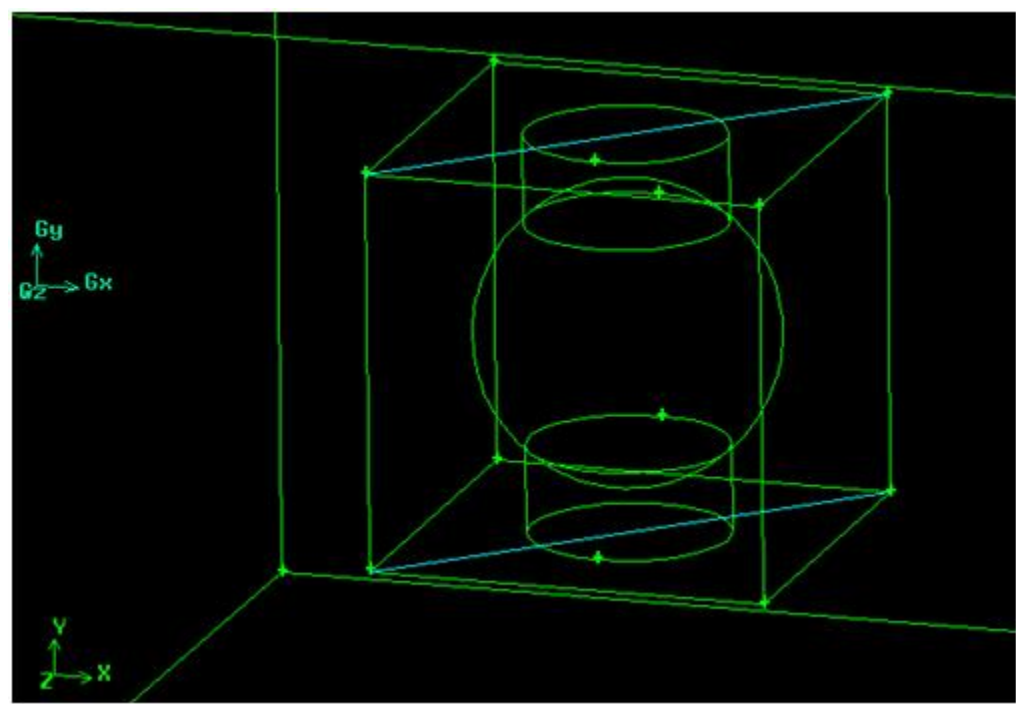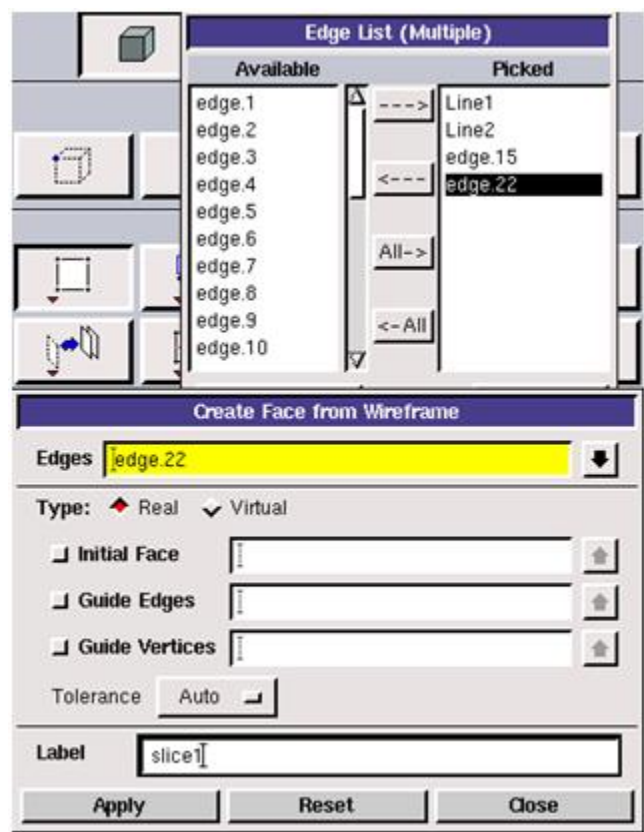
Now we have a new tool for another volume split.

Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Split Volumes**

This time we will use a face to split a volume, effectively cutting the volume in half. Select *sphere_box* as the volume to be split. For "Split With", choose "Faces (Real)" and select *slice1* as the splitting tool. As before, when performing the split with the cylinder, click only the "Connected" option since we only need *slice1* for one operation.
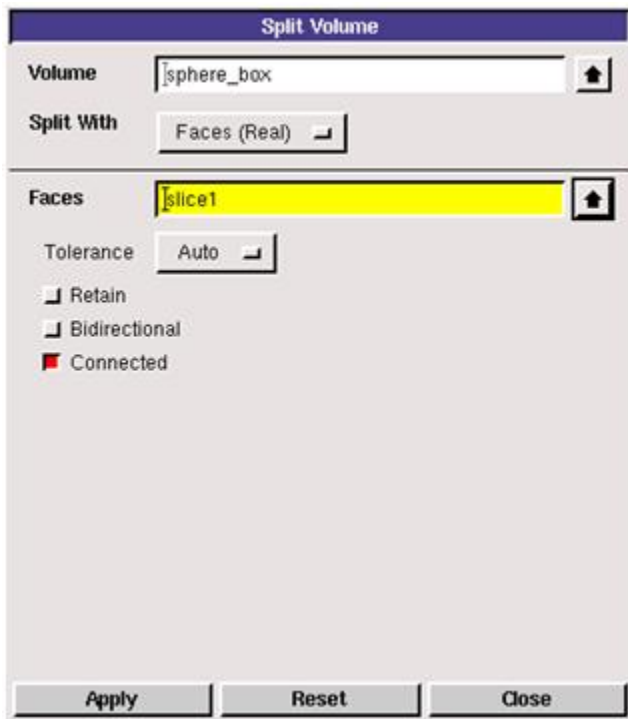
You now have two diagonal halves instead of the single box. The *sphere_box* label is still used by one of the halves; go to the Modify Volume Label window.

Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Modify Volume Color/Label**

Select the only generic volume name in the list and label it *diag_box* so it can be easily recognized later. Your sphere should now be composed of four distinct volumes.
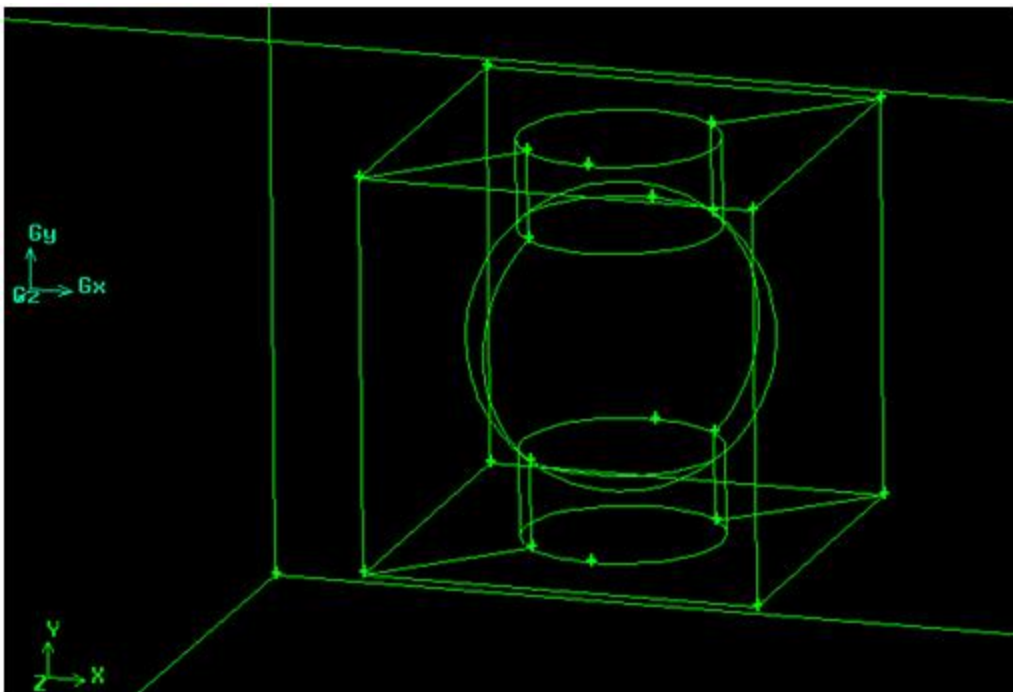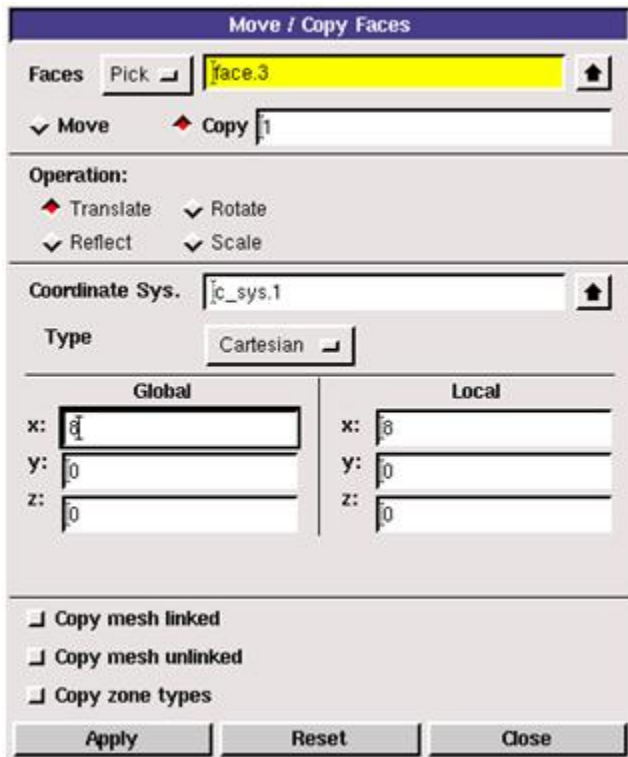

Subdivide Flow Domain

The exterior edges of the whole sphere box also present a problem for our goal of applying a hexahedral mesh. To compensate, the flow domain must be divided into rectangular segments that line up evenly with the sides of the sphere box.

Operation Toolpad > Geometry Command Button **> Face Command Button** **> Move/Copy Faces**

We will create some new faces by making copies of existing faces. Go to the Move/Copy Faces command window. The six faces that compose the exterior of volume *flow_domain* have the right dimensions to aid us. Each of those six faces needs to be copied and moved inward so that all six copy faces border the sphere box.


To avoid the risk of potential confusion with Gambit's default identity tags, each of the six faces will be described by the coordinate plane they occupy and their position on the perpendicular coordinate axis. The yz-plane face that intersects the coordinate origin (located closest to the sphere) should be copied and moved to Global Coordinates x = 8, y = z = 0. The yz-plane face at the local maximum of the positive x-axis (furthest from the sphere) should be copied and moved to Global Coordinates x = -44, y = z = 0. The yx-plane face on the positive z-axis should be copied and moved to Global Coordinates x = y =0, z = -11. The yx-plane face on the negative z-axis should be copied and moved to Global Coordinates x = y = 0, z = 11. The xz-plane face on the positive y-axis should be copied and moved to Global Coordinates x = z = 0, y = -6. The xz-plane face on the negative y-axis should be copied and moved to Global Coordinates x = z = 0, y = 6.

Operation Toolpad > Geometry Command Button **> Volume Command Button** **> Split Volumes**

With the copied faces in position, it's time for one final volume split. Go to the Volume Split command window. Select *flow_domain* as the volume to be split and choose to split with real faces. Now left click on the text field where you select what faces you want to use to split (the text field will highlight yellow). Hold down 'Shift' and use the mouse to click on the six copied faces bordering the sphere box (the copied faces will have light-blue borders). You can only split one volume at a time, but Gambit does allow you to split that one volume with multiple elements. Therefore the entire flow domain can be segmented in one split command. Because of this, only the "Connected" option needs to be checked.
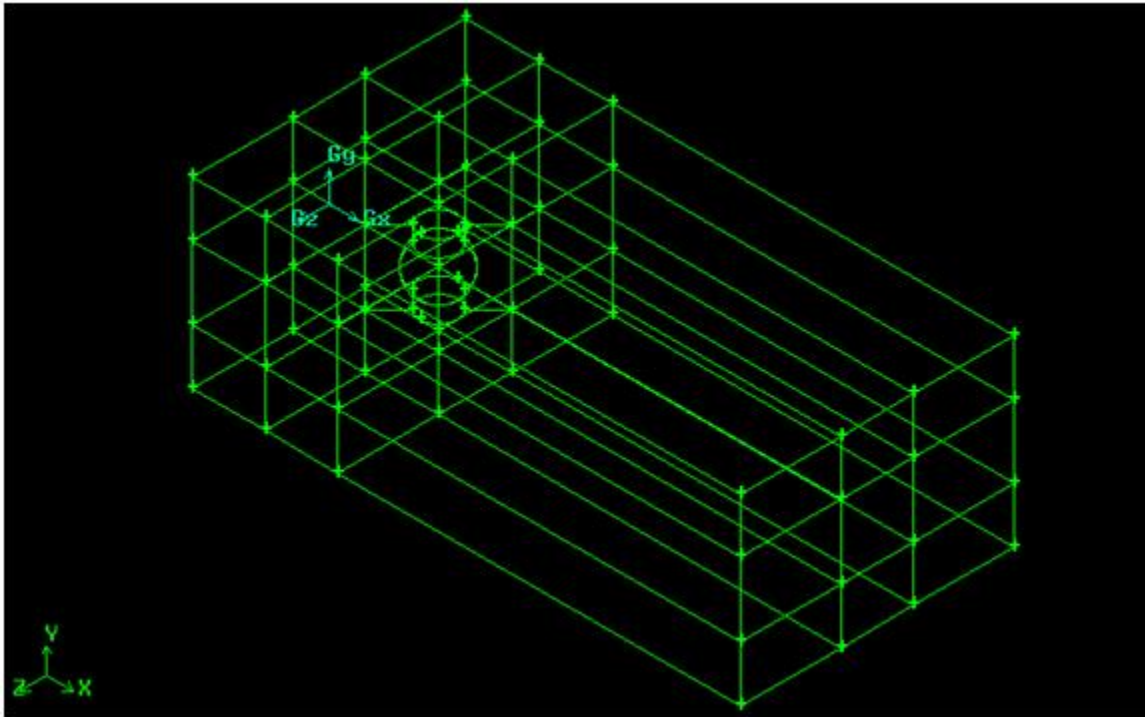
This should divide the flow domain into twenty-six, empty rectangular segments plus the box containing the sphere.

Go to 2. Mesh Geometry in GAMBIT

Go to all FLUENT Learning Modules