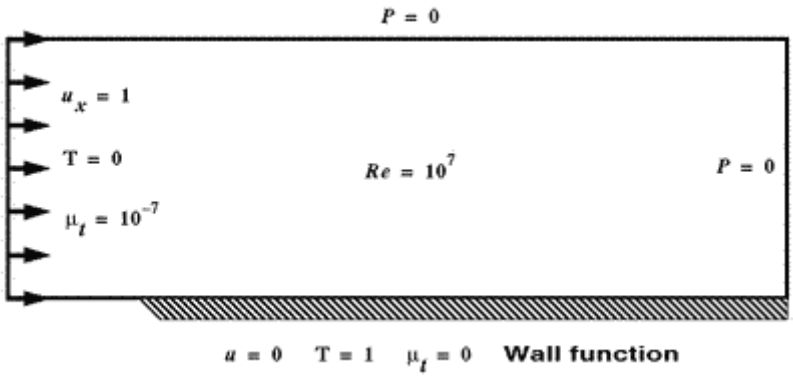
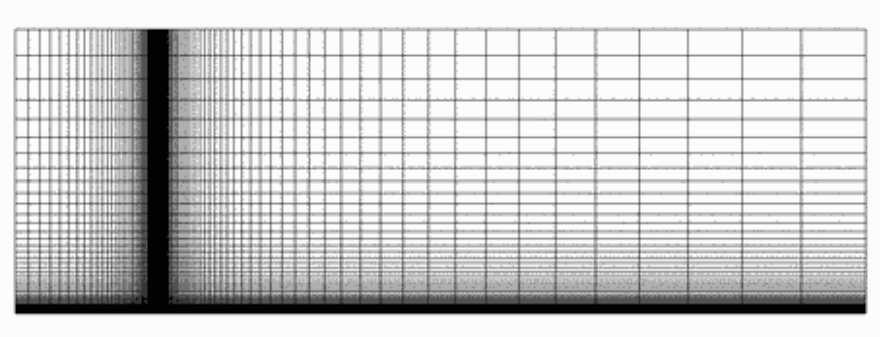
Brick/Tet Element Comparison

The effect of mesh topology on the accuracy and performance of *AcuSolve* is tested for a turbulent flat plate problem. The Reynolds number based on plate length is 10^7. The Spalart-Allmaras turbulence model is used with wall functions. The problem statement is given below:



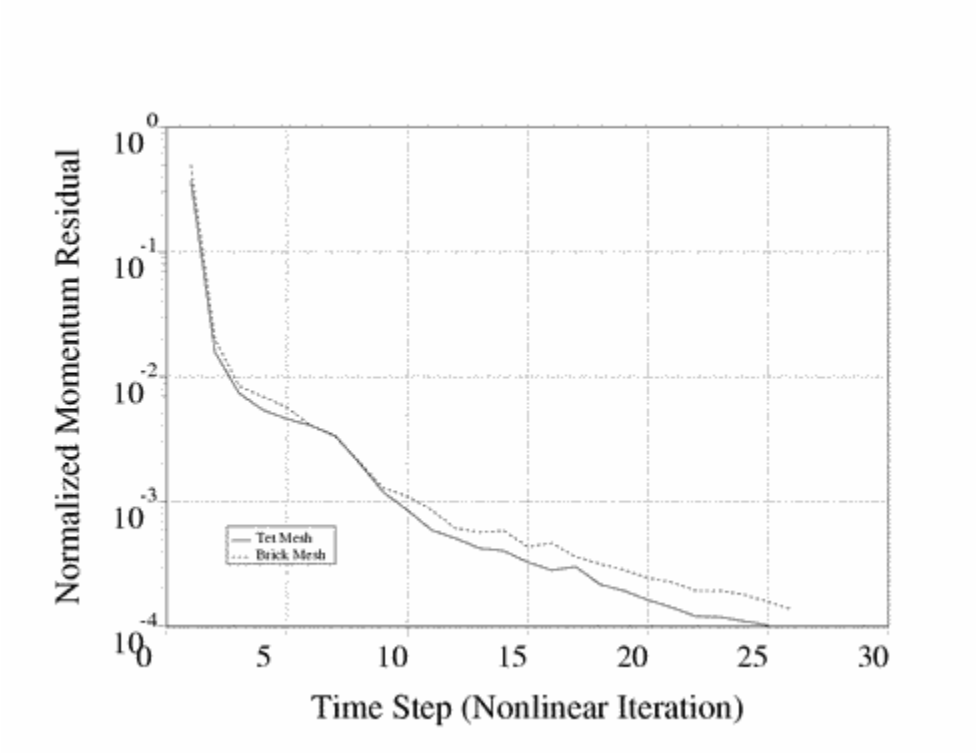
Two meshes are tested:

1. One layer of structured brick elements with 8064 elements and 16512 nodes. The height of the first layer of elements is 0.001, which yields a y+ of about 35 at the exit. This mesh is shown in the figure below. The maximum aspect ratio is 917.

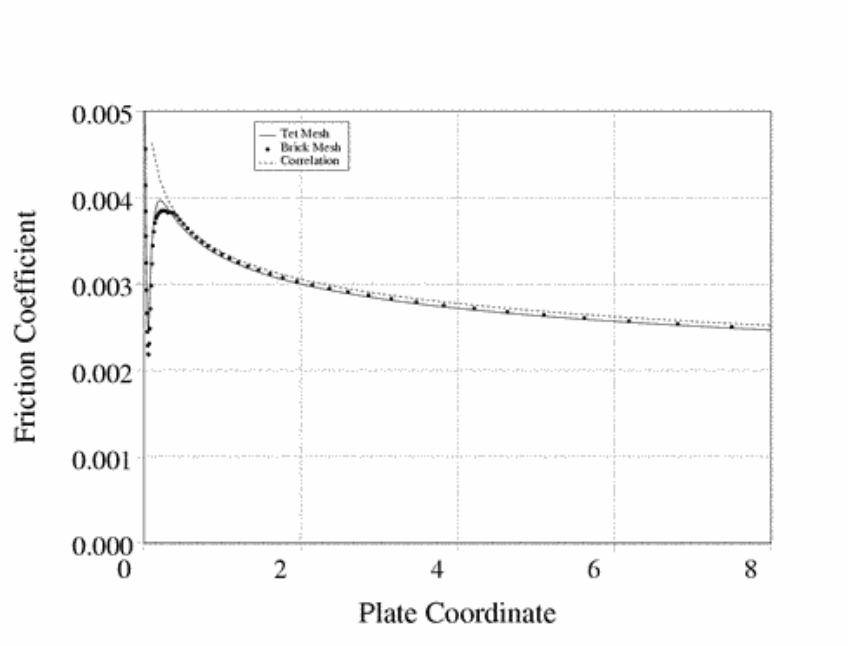


2. Structured tetrahedral mesh with same nodal distribution as above. Each brick is subdivided into 6 tet elements, yielding 48384 elements.

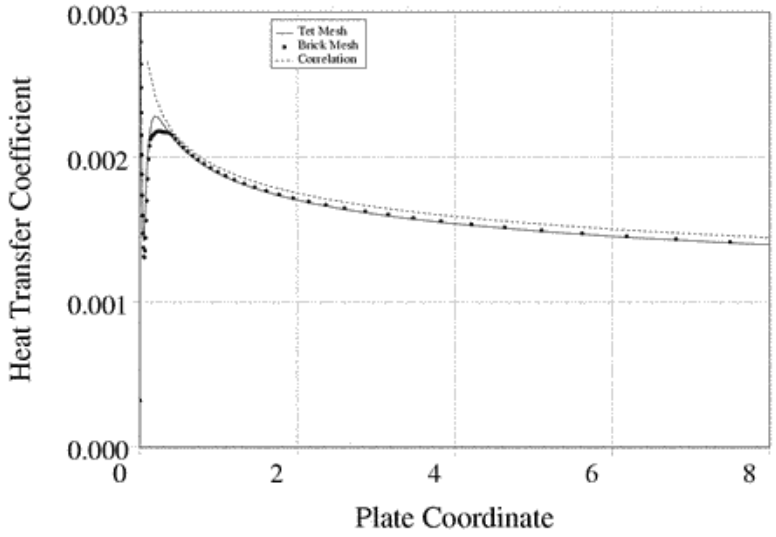
The tet mesh requires 25 time steps while the brick mesh requires 26 time steps to reach convergence. Shown below are the convergence histories for the momentum residual. Other convergence measures, such as the residuals and solution increments of continuity, turbulence and temperature are similar to the plot below.



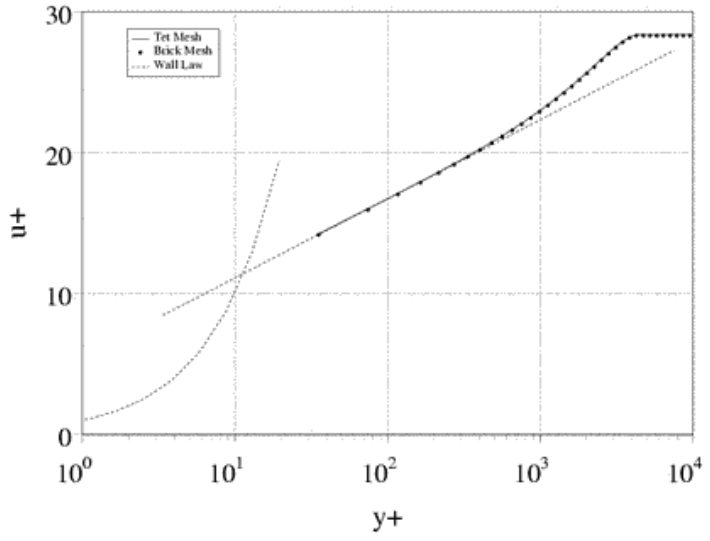
The coefficient of friction as a function of plate coordinate is shown below along with an accepted experimental correlation curve (see Schlichting, "Boundary-Layer Theory"). The difference between the tet and brick curves is less than 0.5% nearly everywhere. The brick results are about 1.5% less than the correlation curves, which is within experimental error.



The coefficient of heat as a function of plate coordinate is shown below along with a correlation curve derived from the Reynolds analogy (see White, "Viscous Fluid Flow"). Again, the agreement between the two meshes and the correlation is excellent, especially considering the difficulty of heat transfer measurements.



The velocity profiles in wall units at x=7.5 are plotted below along with the standard viscous sublayer and log law profiles. Note that the first point in the mesh is located just above the transition region. The difference between the tet and brick mesh results is insignificant.



The solutions of these two meshes are summarized in the table below:

Tet to Brick Ratio	
Total Drag	1.00
Total heat flux	1.00
Nonlinear iterations	0.96
Average flow linear iterations	0.82
Total CPU	0.79
Total Memory	0.85
Size of LHS Matrix	0.61

In summary, an *AcuSolve* thermal/flow solution on a tet mesh typically has the same accuracy as the solution on an equivalent brick mesh. However, the computer resources (CPU time and memory) are significantly less with the tet mesh. The difference in resource requirements is even greater for complex 3D problems.