Potential Senior Research Topics for 2008-2009 with Prof. Bruce Piper

1. **Aesthetic Surface Modeling:** The creation of surfaces for aesthetic appeal is needed in animation and design. The mathematical models of "aesthetic appeal" can be as varied as the people observing the surface.

   (a) **Projects:** Students will choose or create one or more mathematical criteria for the aesthetic quality of a surface and investigate it using visual displays. Appropriate algorithms for creating surfaces will be studied and the images of surfaces will be compared and contrasted both visually and with respect to the mathematically defined aesthetic criteria.

   (b) **Background Skills:** Students will be asked to visualize surfaces in three dimensions as well as reason algebraically and analytically. It is recommended that students have taken "Fundamentals of Geometry" or the equivalent but some students with "Advanced Calculus" may be qualified. Students should have some programming experience, preferably with using Maple for the display of surfaces.

2. **Embedded Persistent Calculus Courses Assessments:** To accurately assess the performance of students in a Calculus course over time, it is necessary to develop questions that meet a wide variety of criteria. Some of these criteria include the relation of the questions to the instruction of the particular course and the extent to which the questions factor into the course grade. But the questions must also reflect the knowledge needed for the course and vary appropriately from year to year to provide reliable comparative statistics.

   (a) **Projects:** Students will develop sets of questions for the assessment of one aspect of a Calculus course. The questions will go beyond just a single exam in that they will explicitly include the relation between the questions on an exam and the questions that students are shown how to do in class and are asked to do to prepare for the exam. The thesis will discuss the relations of the question groupings, how they reflect the material and how they can be made to vary consistently so as to maintain statistical reliability when used on a yearly basis.

   (b) **Background Skills:** Students should have an interest in pursuing teaching at some level. Familiarity with a broad range of Calculus student attitudes and psychology may be helpful. It is preferred that students have taken Calculus at RPI, but this is not required.

3. **Convex Hulls of Surfaces:** The convex hull of a collection of points (intersection of all convex sets containing the points) has been extensively studied in the Computational Geometry literature and has many nice properties. But when the points are replaced by surfaces, the problem becomes considerable more complex. Even with the case of n spheres of varying radius, the complexity of the boundary of the convex hull can be n^2 whereas for points it is always $O(n)$.

   (a) **Projects:** Students may investigate the nature of convex hulls of surfaces for a variety of different cases involving surfaces. Pictures will be drawn demonstrating the different cases and conclusions will be derived about the properties of the shapes of the boundaries of the convex hulls and/or the complexity of the shapes or the algorithms to compute them.

   (b) **Background Skills:** Students will be asked to visualize and analyze complicated geometric structures in three dimension. Some programming ability that includes graphics and data structures will be needed but the programming ability may or may not be from formal courses. Courses in "Data Structures and Algorithms" or "Computer Graphics" might be helpful but are not required.