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**Math 180: Computational Geometry of Polyhedra**  
**Prepared by Jesus De Loera**  
**3 units**

**INSTRUCTOR:** Jesus De Loera (contact 530 754 70 29 or via email deloera@math.ucdavis.edu. for more information)

**COURSE DESCRIPTION:** This course is intended as an undergraduate level introduction to computational geometry through problems with polyhedra and their applications.

Convex polyhedra are familiar objects since our childhood. Indeed, cubes, pyramids, and triangles are common staples dating back in our experiences in kindergarten! But, unknown to most people polyhedra, in their high-dimensional version, are also widely used in applied mathematics (e.g. operations research, finances, computer networks, and more). Their beauty and simplicity appeal to all, but very few people know of the many easy-to-state difficult unsolved mathematical problems that hide behind their beauty.

A very important first goal of the lectures is to introduce an audience without prior background to some of these open research questions. The second goal is to show how computers can be used to do geometry. Methods from computational geometry are finding more and more applications in such diverse fields as optimization, bioinformatics, representation theory, algebraic geometry, number theory, and theoretical computer science.

**PREREQUISITES:** This course is suitable for both math majors and computer science majors. I will assume solid knowledge of linear algebra, enthusiasm for computation and computer software with ability equivalent to ECS 30, and maturity enough to write proofs.

**TEXTBOOK:** There will be some notes available for free to students, and I will put some further references on reserve at the library.

**GRADING:** Grades will be based on two midterms, homework and simple programming assignments using POLYMAKE. There will also be a final project.

**TENTATIVE SYLLABUS (week by week):**

- 0) Why compute with polyhedra? motivation
- 1) Introduction to polyhedral convexity
- 2) Faces of polyhedra (Convex hull algorithms)
- 3) Weyl-Minkowski and polarity
- 4) Duality of polyhedra and Farka's lemma
- 5) Graphs of polytopes
- 6) Slices, Projections and Shadows (Fourier-Motzkin algorithm, unfolding algorithms)
- 7) Schlegel Diagrams and nets
- 8) Volumes and Integration over polytopes
- 9) Lattice points inside polytopes. (Barvinok's algorithm)