**EE599: Computational Differential Geometry for Engineers**

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**Schedule:** 12:30-1:50P  
**Location:** OHE 100C

**Course Overview:** The course will deal with the basic material of differential geometry of curves and surfaces and its application for solving engineering problems. In this course, the students will be familiar with the concepts of differential and Riemannian geometry such as vectors, tensors, manifolds, differential forms, topological and geometric invariants, vector fields and integration on manifolds. We will also discuss computational methods such as finite element methods and level set methods on manifolds. Some applications in Computer Vision, Signal and Image Processing and Machine Learning will be discussed.

**Prerequisite:** The course is self-contained; however students should have a good background in calculus and familiarity with Matlab or C++.

**Texts:** There is no required text. Tutorial articles/online resources for each of the major topics studied will be provided. Supplemental course notes will be posted each week.

Following texts are recommended:


**Grading:**

1. *Home Works 30%* Weekly home works will be given for students to sharpen their understanding of concepts introduced in class.

2. *Mid-Term Exam: 30%* A take home midterm exam will be given during the 8th week. The exams will test student comprehension of concepts and techniques
presented up to week 7.

3. Class Project: 40% Students will work in teams of 2 people. I will help students choose a project or students can select their own projects.

**Course Outline (Tentative)**

Week 1: Introduction, Theory of Curves tangents, arc-length, curvature, torsion, fundamental theorem of curves.

Week 2: Partial differential equations, heat and Laplace equation, Numerical methods for their solutions


Week 4: Mesh generation, marching cubes algorithm, surface parameterization, harmonic maps, conformal maps.

Week 5: Local theory of surfaces gauss map, Gaussian, mean and principle curvature.

Week 6: Some results on surfaces, curvature and geodesics.

Week 7: Conjugate gradient method, numerical methods for solving PDEs on surfaces.

Week 8: (take home midterm) Laplacian on manifolds and its properties. Numerical spectral geometry, GPS surface representation.

Week 9: Smooth manifold, definition, properties, examples, theorems. Differentiation on manifolds, integration.

Week 10: Riemannian metric, geodesics, tensors, covariant and contravariant tensors. Groups, Lie groups.

Week 11: Lie groups, SO3, Grassmannian, statistical manifold.
Week 12: Level Set Methods, geodesic active contours, geodesic curvature flow.

Week 13: Manifold learning methods, linear approaches, principle component analysis, multidimensional scaling, non-linear approaches, local linear embedding, ISOMAP.

Week 14: Shape analysis.

Week 15: Project presentations

**Statement on Academic Conduct and Support Systems**

**Academic Conduct**

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards [https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/](https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [http://policy.usc.edu/scientific-misconduct/](http://policy.usc.edu/scientific-misconduct/).

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity [http://equity.usc.edu/](http://equity.usc.edu/) or to the Department of Public Safety [http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us](http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us). This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men [http://www.usc.edu/student-affairs/cwm/](http://www.usc.edu/student-affairs/cwm/) provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.
Support Systems

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information http://emergency.usc.edu/ will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.