

**University Of California, Berkeley**  
**Department of Mechanical Engineering**

**ME 171: Dynamics of Charged Particulate Systems: Modeling, Theory and Computation**  
**(3 units)**

**Undergraduate Elective**

*Syllabus*

**CATALOG DESCRIPTION**

Introduction to the dynamics of small-scale charged particle systems.

**COURSE DESCRIPTION EXPANDED**

Introduction to the dynamics of small-scale charged particle systems. Flowing, small-scale, particles (“particulates”) are ubiquitous in industrial processes and in the natural sciences. Applications include electrostatic copiers, inkjet printers, powder coating machines, etc, and a variety of small-scale manufacturing processes. Due to their small-scale size, external electromagnetic fields can be utilized to manipulate and control charged, particulates in industrial processes, in order to achieve results that are not possible by purely mechanical means alone. However, a unique feature of small-scale particulate flows is that they exhibit a strong sensitivity to inter-particle near-field forces, leading to agglomeration and cluster formation, which is frequently an unwanted occurrence. These clusters can lead to manufacturing inconsistencies/variability that can strongly affect the overall product quality, in particular if the manufactured devices have small dimensions. Also, recently, the mathematically-related topic of the dynamics of swarms of objects has gained the attention of a number of scientific communities, and models that are quite similar to the flow of charged particulates are now becoming widespread. Accordingly, this course also provides an introduction to that topic as well.

**COURSE PREREQUISITES:**

ME 104 or equivalent.

**TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL:**

Reader and notes. No textbook.

**COURSE OBJECTIVES :**

To endow students to with the ability to model dynamical systems comprised on charged particulates.

**DESIRED COURSE OUTCOMES:**

Coverage of the modeling and simulation of charged multibody systems.

**TOPICS COVERED**

- Dynamics of an individual charged particle
- Kinematics of a single particle
- Kinetics of a single particle
- Dynamics in the presence of an electromagnetic field
- Inter-particle near-field interaction
- Properties of a potential
- Dynamics of rigid clusters of charged particles:
- Decomposition of the electromagnetic contributions
- Numerical methods for the dynamics of a charged cluster
- Model problems/numerical examples
- Dynamics of flowing charged particles
- Multiple particulate flow in the presence of near-fields
- Contact and impact in the presence of near-fields
- “Friction” (Resistance to sliding)
- Numerical solution schemes
- Thermal effects and coupled systems
- Multiphysical numerical solution schemes
- Two-scale macro-EM-field/near-field decomposition
- Model problems
- An introduction to mechanistic modeling of swarms
- A basic construction of a swarm
- Numerical examples

#### **CLASS/LABORATORY SCHEDULE:**

3 hours of lecture per week.

#### **CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT:**

The modeling of charged particulates has wide applications in industry, for example on chemical vapor deposition, epitaxy.

#### **RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES:**

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (e) an ability to identify, formulate, and solve engineering problems
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

#### **ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES:**

8 Course Projects (50% - 6.25% each)  
Final Exam (50%)

**PERSON(S) WHO PREPARED THIS DESCRIPTION**

Professor Tarek Zohdi  
7 February 2011

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**ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM):** DYN CHRGD PAR SYS

**TIE CODE:** LECT

**GRADING:** Letter

**SEMESTER OFFERED:** Fall and Spring

**COURSES THAT WILL RESTRICT CREDIT:** None

**INSTRUCTORS:** Prof. Tarek Zohdi

**DURATION OF COURSE:** 14 Weeks

**EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK:** 9

**IS COURSE REPEATABLE FOR CREDIT?** No

**CROSSLIST:** None