This is largely a survey course. There will be no regular homework. Students are required to attend the lectures and will be graded on attendance. The major part of the grade is based on an individual project and a presentation to be given at the end of the semester and during final exam week. With luck the project can be related to a student’s work or research. Note this should be much less work than a regular class, but I expect the student to put significant effort into the project.

There is no textbook for the course by a good survey is available free at http://resolver.caltech.edu/CaltechBOOK:2005.001

Topics:

- Motion of single particles and bubbles in fluids.
- Bubble growth and collapse, cavitation
- Multiphase Flow Patterns
- Interphasial Forces
- Multiphase Flow Modeling
  - Homogeneous Flows
  - Separated Flows
  - Drift Flux Models
- Kinematic Waves
- Traffic Flow
- Soil Liquefaction
- Fluidization and Fluidized Beds
- Granular Flows
Grading

Project: (See below)  60%
Attendance:  40%

Project Schedule:

Thursday Jan 31, Third Week of Class: (Student should decide on topic. (Students may change their mind later but should hand a page stating their topic on this date)

Thursday Feb 28, 7th Week of Class, Students should hand in a list of at least 15 references on their chosen topic.

March 10-17 Spring Break

Thursday April 4th, 12th Week, of Class, hand in a 1 page outline or summary of talk.

Student presentations will be made on the Last Week of Class, TTh April 23 and 25 and if necessary during the scheduled final exam period, Thursday May 2 2-4pm

At least one week before their presentation, students must make a one hour appointment with me to give me a practice run-through of their presentation. This is to help the students prepare the presentation. I will make suggestions and provide helpful hints to improve the final presentation. Students will not be graded on the run-through, only on the final presentation.

Report due by 2pm on May 2, the final exam date.

Projects for ME520: Multiphase Flows

The major course requirement for AME533 is an individual research project which is to be presented in the form of (1) a 15 page report (with at least 10 single spaced pages of text) and (2) a short (20min) presentation to the class; both students and I are permitted to answer questions during the presentation which will function as a kind of oral exam. In all cases the engineering relevance of the project must be clearly shown. The projects may fall into three categories:

(1) A survey or review of a general area concerning multiphase flows.

(2) A presentation of one particular piece of work in detail, such as a mathematical derivation. (A “piece of work" may consist of one or more papers.) In this case, the introduction should detail the relevance of the work and include a review of previous work.
(3) An original piece of research. Once again, the introduction should detail the relevance of the work and include a review of previous work.

I recommend that (2) and (3) be limited to those who have a current research or business interest in the subject. I also require that some of the presentation should include some work which is done explicitly for this class, and not be just a rehash of some previous project.

Grading will be based on the degree of understanding of the subject balanced with the difficulty of the task undertaken and the quality of the presentation. I prefer that you emphasize the basics of the problem rather than give a lot of disjointed problems.

PREVIOUSLY PRESENTED TITLES

The following are title of presentations that were previously given in this course or in a similar course given at Caltech. They are presented here to inspire ideas of your own. Only the more general topics should be considered as possible subject. I prefer some originality in the final choice. The final decision should be made in discussions with me and should be made within a month. My office phone is (213)740-0498; please call and make an appointment.

To get you started, I have the list of references used in all of the following. Each report must contain a similar reference list.

A Survey of Coagulation

Acoustic Cavitation and the Subharmonic mode

Spherical Instability During the Explosive Growth of a Liquid at the Superheat Limit

An Introduction to Two-phase Flow in Turbomachinery

Instrumentation in Two-phase Flow

The Rayleigh Taylor and Landau Instabilities

Flow of Dusty Gases

Analytical Methods in Two-phase Flows

The Effective Thermal Conductivity of Dilute Suspensions

The Sedimentation of Solid Spheres in a Quiescent Viscous Fluid

Some Aspects of Cavitation

Bubble Formation at an Orifice
Stability of Dusty Gases
The Viscosity of Suspension of Rigid Particles
The Dynamic Performance of Cavitating Pumps
Bubble Collapse and Microjets
Flow of Electrostatically Charges Suspensions
Cavitation Inception in Turbulent Shear Flows
Constitutive Relations for Fluid-solid mixtures
An Introduction to the Rayleigh-Taylor Instability
Ultrasonic Cavitation
Heat Transfer in the three Different Regimes of Pool Boiling
Aggregative and Particulate Fluidization
Performance Limitations in Heat Pipes
Stability of Fluidized Beds
The description of Particle Motions in Turbulent Flows
The Hydrodynamics of Hydrofoil Craft
Drag on Spherical Particles
The Viscosity of Concentrated Suspensions
Vapor Explosions: A survey of Models and Experimental Results
Departure from Nucleate Boiling in Pressurized Water Reactors
Radiation Attenuation Measurements for Two-phase Flow Measurements
Free Streamline theory Applied to a Cascade
The Spherical Droplet in a Gaseous Carrier: A Dimensional Analysis
Techniques for the Measurement of Cavitation Nucleation
Models of Heat Transfer in Fluidized Beds

Condensation Heat Transfer

A Model of the Maximum Flow Rate of a Two-phase Mixture

Secondary Atomization (Micro-Explosion) of the Fuel Droplet in Liquid Hydrocarbon-Fuel Combustion Systems

Spray Atomization

Flow Regime Transition in Horizontal Liquid-Gas Flow

Instabilities at a Two-phase Interface

Simultaneous Heat and Moisture Transfer in Porous Media

Drag on Small Particles and Drops in Stokes Flow

Two-phase Flow Instabilities in Heated Channels

Heat Transfer Phenomena during Quenching

Cavitation in Turbopumps

Microlayer in Nucleate Boiling

Two-phase Critical Flow

The Stress Tensor in Rapid Granular Flows

Transition and Film Boiling Phenomena

Acceleration of Burst Particles by an Exploding Vapor Field

Formation Mechanism of Ripples and Dunes on a Horizontal Errodable Bed

Sonoluminescence

Atomization of a Liquid Jet

A Survey of Current Cavitation Inception Study and Testing

A Theory of Bubble Coalescence
Gas to Particle Heat Transfer

Bubbles in Gas Fluidized Beds

The Effective Thermal Conductivity of Sheared Suspensions

Drop Size Distributions and Geometries of Atomizer Sprays

**Statement for Students with Disabilities**

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

**Statement on Academic Integrity**

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: [http://www.usc.edu/dept/publications/SCAMPUS/gov/](http://www.usc.edu/dept/publications/SCAMPUS/gov/). Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: [http://www.usc.edu/student-affairs/SJACS/](http://www.usc.edu/student-affairs/SJACS/).