# University Of California, Berkeley
# Department of Mechanical Engineering

## ME 151A– Conductive and Radiative Transport (3 units)

**Undergraduate Course**

***Syllabus***

### CATALOG DESCRIPTION

Fundamentals of conductive heat transfer. Analytical and numerical methods for heat conduction in rigid media. Fundamentals of radiative transfer. Radiative properties of solids, liquids and gas media. Radiative transport modeling in enclosures and participating media.

### COURSE PREREQUISITES

Undergraduate courses in engineering thermodynamics, fluid dynamics and heat transfer (ME40, ME106 and ME109 or equivalent). Each student must have access to a PC, Macintosh or workstation machine with scientific programming capabilities for use in homework and projects.

### TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

**Example:** D.W. Hahn, M.N. Ozisik, *Heat Conduction*, 3rd Edition, Wiley, 2012
J.R. Howell, R. Siegel and M.P. Menguc, *Thermal Radiation Heat Transfer*, 6th ed., CRC Press, 2015.

### COURSE OBJECTIVES

The course will provide students with knowledge of the physics of conductive transport in solids, the analysis of steady and transient heat conduction by both analytical and numerical methods and the treatment of phase change problems. Furthermore, the course will provide students with knowledge of radiative properties, the mechanisms of radiative transfer and will present theory and methods of solution of radiative transfer problems in participating and nonparticipating media

### DESIRED COURSE OUTCOMES

Students will gain knowledge of the mechanisms of conductive transfer and will develop the ability to quantify steady and transient temperature in important engineering problems often encountered (e.g. manufacturing, materials processing, bio-thermal treatment and electronics cooling) by applying analytical methods and by constructing numerical algorithms. Students will also gain knowledge of the fundamental radiative properties and the mechanisms of radiative transport in enclosures, absorbing, emitting and scattering media as well as the interaction of thermal radiation with other modes of heat transfer.

### TOPICS COVERED

See CLASS/LABORATORY SCHEDULE below.

## CLASS/LABORATORY SCHEDULE

Two 1.5 hour lectures, and up to 6 hours work on a homework problem set or a project assignment per week.

## CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

This course will provide students with knowledge of the physics and methods of solution of conductive and radiative transport that can model processes in important applications in materials processing and manufacturing, bio-thermal treatment, electronics cooling, energy conversion and storage applications, solar energy applications. Projects will introduce students to conductive and radiative transport modeling and the development of computational methods that can be used for heat transfer equipment performance modeling and design.

## ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

The course grade will be based on homework assignments (5%), quizzes (10%), two midterm projects (25% each) and a final project (35%). Undergraduate and graduate students graded as separate groups. Graduate students will be assigned additional, more challenging project tasks.

## GRADUATE ROOMSHARE INFORMATION

This course will be roomshared with ME 250A. Graduate students will be assigned additional, more challenging project tasks (about 20% additional work). Undergraduate and graduate students graded as separate groups.

## SAMPLE OF WEEKLY AGENDA

| Week | Topic |
|---|---|
| 1 | Equation of heat conduction for isotropic and anisotropic materials |
| 2 | Steady heat conduction - separation of variables, nonhomogeneous problems, sources and sinks |
| 3 | Unsteady heat conduction - separation of variables in the rectangular, cylindrical and spherical coordinate systems |
| 4 | Unsteady heat conduction – Duhamel’s superposition theorem, instantaneous sources and sinks, moving sources of heat, the method of images, Green’s functions |
| 5 | Laplace Transform, problems periodic in time |
| 6 | Numerical methods of solution – finite differences methods for steady conduction, explicit and implicit Schemes for transient heat conduction, stability analysis. |
| 7 | Phase change problems - melting and freezing - exact solutions, approximate solutions - numerical solutions - the enthalpy formulation |
| 8 | Radiative properties of surfaces and simple transfer. |
| 9 | Configuration factors – radiative exchange between surfaces |
| 10 | Radiative transfer equation in absorbing, emitting and scattering media |
| 11 | Microscopic basis of gas radiation |
| 12 | Radiative properties of particles |
| 13 | Approximate solutions – gas radiation in enclosures – mean beam lengths |
| 14 | Combined modes of transfer |

**PERSON(S) WHO PREPARED THIS DESCRIPTION**
Costas P. Grigoropoulos 02/26/2018

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**ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM):** COND & RAD TRANSP
**TIE CODE:** LECT
**GRADING:** Letter
**SEMESTER OFFERED:** Fall and/or Spring
**COURSES THAT WILL RESTRICT CREDIT:** ME 151, ME 250A
**INSTRUCTORS:** Costas P. Grigoropoulos
**DURATION OF COURSE:** 14 Weeks
**EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK:** 6 hours
**IS COURSE REPEATABLE FOR CREDIT?** No
**CROSSLIST:** Crosslisted as ME150A for undergraduates and ME250A for graduate students