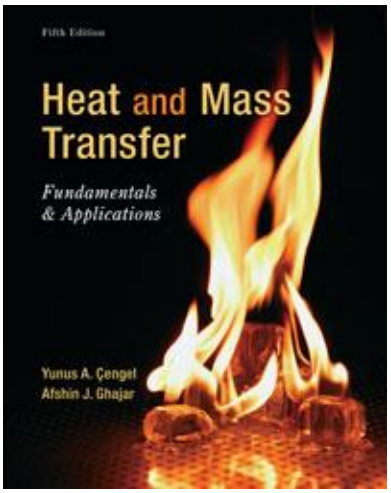
USC Viterbi School of Engineering

AME-331 Heat Transfer (Section 28735)

Term: Fall 2017 Units: 3.0

Course Syllabus (Rev 2)



Lecture: F 13:00-15:50
Location: VHE-210
Discussion (optional):

Mondays	**tbd**	**tbd**
Thursdays	**tbd**	**tbd**

Instructors: Dr. Leslie King
Office: VHE-418
Office Hours:

LK	M	6:00PM – 7:00PM
LK	F	12:00PM – 1:00PM

Contact Info:
LK lking@usc.edu (urgent : leslie.b.king@aero.org)

Teaching Assistant: Hugo Burbano
Office: VHE-202
Office Hours: Tue 5:00 – 7:00PM and Thu 8:00 – 10:00AM
Contact Info: burbano@usc.edu

Catalog Description General principles underlying heat transfer by conduction, convection, and radiation; steady and transient conditions; heat exchangers. Prerequisite: AME 310. Co-requisite: AME 309.

Instructors' Description This course is a one-semester introduction to heat transfer for mechanical and aerospace engineering students and others who need a solid understanding of the subject. For students intending to specialize in the thermosciences, advanced courses in convection, radiation, mass transfer, boiling/condensation, combustion, heat exchangers, and computational methods are encouraged. To emphasize the practical aspects of the subject, the lectures will contain "real world" applications of heat transfer in the engineering profession. Topics may include: utility boilers, industrial freezers, computer chip cooling, coffee makers, camp fires, thermal oxidizers, rotary kilns, temperature sensors, space shuttle tiles, and burn injuries.

Recommended Preparation The course material presented assumes the student has attained competency in physics, chemistry, calculus, ordinary differential equations, engineering thermodynamics, and fluid mechanics. The format will be lectures plus optional discussion sections. There is no lab.

Prerequisite(s): AME 310 **Co-Requisite (s):** AME 309 **Concurrent Enrollment:** none

Required Textbook

Heat and Mass Transfer – Fundamentals and Applications Fifth Edition; Yunus A. Cengel and Afshin J. Ghajar; McGraw-Hill, 2015. Chapters 1-9, 11-13. ISBN: 978-1-25-927990-4.
Students **MUST** purchase a hardcopy of the textbook. eBook version is optional as a supplement, but not in lieu of hard copy. eBook is **NOT** permitted for exams or quizzes. Paper printout from the eBook may be used as substitute for hardcover. (Publisher may require an extra fee for printing from eBook.)

Course Notes

Grading: Students earn points (1000 possible) by successfully completing the following assignments:

- Homework 240 (approximately 1 per week, graded)
- Quizzes 360 (6 per semester, 60 each)
- Design Project 100 (1)
- Final Exam 300 (1)
- EES Problems 36 extra credit (Cengel textbook, 1 per HW assignment)
- Poll Everywhere 30 extra credit (smartphone quizzes during lectures)

Final grades are based on absolute scores and calibrated against a normal distribution to ensure fairest treatment for each student. See course schedule for reading and homework assignments.

A (920+), A- (880+)	(mastered essentially all the material)
B+ (850+), B (820+), B- (780+)	(mastered the majority of the material)
C+ (750+), C (720+), C- (680+)	(understood a moderate amount of the material)
D+ (650+), D (600+)	(only grasped minimum content; consider re-taking course)
F (599 and below)	(failed to grasp the material; must re-take course)

Technological Proficiency and Hardware/Software Required

Because exams and quizzes are **open-book**, open-note but closed-smartphone, closed-laptop, students are expected to bring and use a **hand calculator** on quizzes and exams. Accessing computers/internet (including eBook version of textbook) is **not** allowed during any quiz or exam. Approximately 12 extra credit problems (~5 points each) will require use of a mathematical software application (e.g, EES, Matlab, Mathcad, or Excel) to obtain the final solution. Students are expected to provide their own software and submit printouts with their XC assignment(s). For Chapter 5, an Excel spreadsheet tool will be provided on Blackboard, but students may elect to perform the calculations with a different numerical application.

Homework Submission Policy

See Class Schedule (posted on Blackboard) for assigned problems and due dates. (HW is due most Thursdays)

HW is LATE if not received by instructor at the end of class (no grace period provided).

- 25% penalty if 1 to 24 hours late
- 50% penalty if 25 to 48 hours late
- 75% penalty if 49 or more hours late

Solutions are posted on Blackboard after 2nd day

Regular HW must be submitted as hardcopy, in class or electronically (as PDF) if student cannot attend class. Never leave hard copy in instructor office! It may get lost and it will always be marked 3 days late.

Late HW may be submitted electronically via email (with email datestamp).

Late credit will be given for homework submitted up to the last day of class (Friday, December 1, 2017)

Additional Policies

- Design Projects (2 PowerPoint slides per design team) are due at 11:59 PM on Thursday, November 30 (approximately 13 hours before the 1:00PM Friday lecture). No exceptions.
- Students should inform the instructor in advance if they are unable able to sit for a quiz or exam due to illness or unavoidable schedule conflict. Permission to sit for a make-up exam is solely at the discretion of the instructor. Students must take the final exam on the assigned date – no exceptions.

Learning Objectives

Students should be able to demonstrate their understanding of each concept, law, or method enumerated below on one (or more) of the following assignment/exam types: HW, Quiz, MT, Final, or Project:

1. Week #1
   a. 1st & 2nd Law
   b. Temperature as Driving Force for Heat Transfer
   c. Heat Flux
   d. Properties of Solids (e.g., ρ, c_p, k)
   e. Fourier's Law
   f. Newton's Law of Cooling
   g. Properties of fluids and flows (e.g., V, μ, ρ, h)
   h. Stefan Boltzmann Law
   i. Radiative Properties of Surfaces (e.g., ε, F_{12})
2. Week #2
   a. 1-D Energy Equation for Conduction
   b. Conduction in Plane Wall
   c. Heat Generation
   d. Heat Storage
   e. Differential Formulation of First Law (x,y,z)
   f. Boundary Conditions for Differential Equations.
3. Week #3
   a. Poisson Eq., Laplace Eq., Diffusion Eq.
   b. Cylindrical, Spherical Coordinate Systems
   c. Six Types of Boundary Conditions
   d. Formulating/Solving Conduction Problems
   e. Mathematics of Heat Generation
4. Week #4
   a. Heat Generation Problem Solutions
   b. Mathematicas of Variable Thermal Conductivity
   c. Electric Circuit Analogy
   d. Thermal Resistance Network
   e. Sum of Resistances
   f. Overall Heat Transfer Coeff
   g. Thermal Contact Resistance
5. Week #5
   a. 1-D Conduction/Convection Systems
   b. Fin Equation
   c. Fin Efficiency, Effectiveness
   d. Shape Factor for 2D Conduction
   e. 2D Conductdion (Separation of Variables)
6. Week #6
   a. Lumped capacitance - Biot No.
   b. Distributed capacitance - Fourier No.
   c. Heisler charts
7. Week #7
   a. Transient Q, Semi-Infinite Solids
   b. Self-similarity method
   c. Error function, Complementary Error function
   d. Finite Difference Method for 1D Geometries
   e. Finite Difference Method for 2D Geometries
   f. Finite Diff Method for 1st 2nd Derivatives
   g. Source Terms, Transients, Boundary Conditions
8. Week #8
   a. Mass, Momentum, Energy Conservation
   b. Fluid Properties
   c. Boundary Layer Thickness
   d. Blasius vs Cubic Solution for Velocity Profile in BL
   e. Thermal BL
9. Week #9
   a. Prandtl Number and Thermal BL
   b. Reynolds-Colburn Analogy
   c. External BL (Drag, Wake)
   d. Film Temperature
   e. Heat transfer coefficient
   f. Stanton, Nusselt Numbers
   g. Cylinders, spheres (McAdams, Churchill, etc.)
   h. Drag coefficient
10. Week #10
    a. Laminar Tube Flow - Velocity Profile
    b. Laminar Tube Flow - Entry Length, Graetz Number
    c. Fully Developed Laminar Tube Flow
    d. Friction Factor, Nusselt Number
    e. Bulk and Bulk-Mean Temperatures
    f. Hydraulic Diameter
    g. Boundary Conditions - Constant T, Constant q"
    h. Log Mean Temperature Difference
    i. Turbulent Q (Dittus-Boelter, Petukhov)
    j. Moody Chart for friction factor
11. Week #11
    a. Natural Convection, Buoyancy Forces
    b. Volume Coefficient of Expansion
    c. Momentum Equation
12. Week #12
    a. Grashof Number, Rayleigh Number
    b. Other geometries (inclined plate, cylinders)
    c. Thermal, Momemtum BL
    d. Overall Heat Transfer Coefficient
    e. LMTD Method for Heat Exchangers
    f. Fouling
13. Week #13
    a. Parallel, Counterflow, Crossflow, Mixed, Unmixed
    b. Effectiveness-NTU method for Heat Exchangers
    c. Cmin, Cmax, NTU
    d. Radiation Fundamentals, Planck's Law
    e. Wien's Displacement Law
    f. Gray bodies, Emissivity, Absorptivity
14. Week #14
    a. Intensity, Steradians
    b. Radiant Exchange Equation
    c. View Factor derivation
    d. View Factor algebra
    e. Radiosity, Irradiation
    f. Thermal Radiation Resistance Networks
15. Week #15
    a. Radiation Shields
    b. Thermocouple Error
    c. Solar Radiation

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. 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.

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 or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety of the 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/ provides 24/7 confidential support, and the sexual assault resource center webpage http://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.

Week No.	Lecture No.	Day/Date	Cengel Reading	SUBJECT	Student Work Product	Cengel Homework Due Last Items Each Row (Red Text) are Extra Credit
1	1	Fri 8/25	1-1 to 1-11	Introduction, Mechanisms of Heat Transfer	<none>	
2	2	Fri 9/1	2-1 to 2-4	Conduction, Differential Eqs, Boundary/Initial Conditions	Homework #1	1-2, 1-6, 1-12, 1-13, 1-26, 1-116
3	3	Fri 9/8	2-5 to 2-7	1-D Conduction, Heat Generation, Variable k	Homework #2 and **Quiz #1**	1-53, 1-61, 1-66, 1-84, 1-95, 1-96, 1-82
4	4	Fri 9/15	3-1 to 3-5	Plane Walls, Contact Resistance, Resistance Networks	Homework #3	2-4, 2-11, 2-21, 2-31, 2-35, 2-48, 2-50, 2-102
5	5	Fri 9/22	3-6; 3-8	Finned Surfaces, Shape Factors	Homework #4 and **Quiz #2**	2-66, 2-86, 2-87, 2-90, 2-105, 2-106, 2-113, 2-154
6	6	Fri 9/29	4-1 to 4-3	Lumped Capacitance, Heisler Charts, Semi-Infinite Solids	Homework #5	3-7, 3-16, 3-24, 3-28, 3-71, 3-119, 3-122, 3-123
7	7	Fri 10/6	4-4; 5-1 to 5-4	Transient Superposition, Finite Difference Method	Homework #6 and **Quiz #3**	3-140, 4-2, 4-24, 4-50, 4-90, 4-115, 4-116, 5-8, 4-61
8	8	Fri 10/13	6-1 to 6-11	Convection Fundamentals, Conservation Equations	<none>	
9	9	Fri 10/20	7-1 to 7-4	External Forced Convection, Flat Plates, Cylinders, Spheres	Homework #7 and **Quiz #4**	5-28, 5-59, 5-68, 6-3, 6-5, 6-6, 6-32, 5-67
10	10	Fri 10/27	8-1 to 8-5	Internal Forced Convection, Fully Developed Flow, Laminar Flow	Homework #8	6-17, 6-30, 6-35, 6-56, 6-59, 6-91, 6-96, 6-101
11	11	Fri 11/3	8-6; 9-1 to 9-3	Turbulent Flow in Tubes, Natural Convection	Homework #9 and **Quiz #5**	7-4, 7-14, 7-17, 7-38, 7-44, 7-69, 7-85, 7-98
12	12	Fri 11/10	11-1 to 11-5	Heat Exchangers, Log Mean Temp Diff, Effectiveness-NTU	Homework #10	8-4, 8-13, 8-41, 8-89, 9-13, 9-36, 9-39, 9-47, 8-81
13	13	Fri 11/17	12-1 to 12-5; 13-1 to 13-2	Blackbody Radiation, Intensity, Emissivity, View Factor	Homework #11 and **Quiz #6**	11-6, 11-9, 11-50, 11-54, 11-65, 11-97, 11-108, 11-132
14	14	Fri 11/24		**THANKSGIVING BREAK**		
15	15	Fri 12/1	13-3 to 13-5 Design Projects	Gray Surfaces, Radiosity, Radiation Networks, Radiation Shields	Homework #12 and **Design Project Presentations**	12-8, 12-18, 12-22, 12-43, 12-52, 13-2, 13-34, 13-39 13-88, 13-89
	optional	*Tue12/5*		*Optional Review Session (location tbd)*		
28735	(13:00 -15:50 Section)	Wed 12/13 11AM-1PM	Location: VHE-210	**FINAL EXAM (Chapters 2-9, 11-13)**		