Course Syllabus MAE 310 - **Heat Transfer Fundamentals** Fall 2009

1.1. Instructor's name, office address, telephone number, e-mail address, regularly scheduled class meeting times, and office hours for out-of-class consultation.

Sec: 001
Location: Br 2211
Days: TH
Time: 11:45 AM-1:00 PM

Instructor: M. A. Boles
Office: BR 3184
E-Mail Address: boles@ncsu.edu
Office Telephone: 919-515-5234
Office Hours: 12:00 AM-1:20 PM MW

1.2. Course prerequisites or restrictive statements.

Prerequisites: MA 341, C or better in MAE 301, **Corequisites:** MAE 308.

1.3. Designation of course as a General Education Requirement (GER). N/A

1.4. Student learning outcomes for the course.

Catalog Description: Analysis of steady state and transient one and multi-dimensional heat conduction employing both analytical methods and numerical techniques. Integration of principles and concepts of thermodynamics and fluid mechanics to the development of practical convective heat transfer relations relevant to mechanical engineers. Heat transfer by the mechanism of radiation heat transfer.

Course Web site: **www.mae.ncsu.edu/courses/mae310/boles/**

Course Objectives: The students will be asked to demonstrate their knowledge of the material covered in MAE 310 through their mastery of the following course objectives. Through the study of MAE 310 the student will be able to:

1. Determine surface temperature or heat rate by performing control surface energy balances;
2. Calculate heat rate using Fourier's law, Newton's law of cooling, and the Stefan-Boltzmann law;
3. Calculate interface temperatures, and or, heat rates for 1-D steady state heat transfer problems using the electrical resistance circuit analogy;
4. Determine the temperature distribution, heat rate, and performance of 1-D fins;
5. Determine 2D steady-state temperature distributions using finite difference techniques;
6. Determine 1D transient temperature distributions using separation of variables and finite difference techniques;
7. Determine 3D transient temperature distributions using the product solution technique;
8. Understand the concept of a velocity and thermal boundary layer, calculate boundary layer thickness, displacement thickness, momentum thickness, wall shear stress and convective heat transfer coefficient and determine whether the boundary layer is laminar or turbulent;
9. Calculate convective heat transfer rates for external forced convection of flat plates, cylinders, spheres and tube bundles;

10. Calculate convective heat transfer rates for internal laminar and turbulent flow for fully developed and developing flows;
11. Calculate convective heat transfer rates for buoyancy driven flows over flat plates, cylinders, spheres and in enclosures;
12. Determine the total and spectral blackbody emissive powers, surface radiation properties and radiation view factors;
13. Calculate surface temperature or heat rate of gray diffuse surface enclosures.

1.5. All required Textbook(s), title(s), date(s), price(s), Calculators, price(s)

Required Text: *Fundamentals of Heat and Mass Transfer*, 6th ed., by Incropera, DeWitt, Bergman & Lavine, 2007

Reference Text: Y. A. Çengel and M. A. Boles, Thermodynamics: an Engineering Approach (Packet including Property Table Booklet), 6th Ed, The McGraw Hill Companies, New York, 2008. $143.75 (new), $107.85 (used)

Only models of calculators approved by the instructor are permitted to be used in the classroom during tests and the final exam. *No other models of calculators or variations of the models listed below are permitted during tests and the final exam.* The following are the only calculators that will be permitted in the classroom during tests and the final exam and are the only ones allowed on the Fundamentals of Engineering Exam. Prices for these calculators range from $9.95 to $20.00.

Hewlett Packard – HP 33S
Casio – FX 115MS or FX 115MSPlus
Texas Instruments – TI 30X IIS
Texas Instruments – TI 36X SOLAR

1.6. Course organization and scope. List of topics and approximate time allocated to each major topic.

Topics covered*: (number of classes)*: Based on 3 classes per week for 14 week semesters, classes meet 3 days per week for 50 minute lectures (or 2 days per week for 75 minute lectures):

1. Basic concepts (4.5)
2. Steady-state heat conduction (9)
3. Transient heat conduction (6)
4. Convection heat transfer (11)
5. Thermal Radiation (7.5)
6. Review and tests (4)

1.7. Projected schedule of reading assignments.

Assignment Schedule

Period	Date	Topic	Readings
1	Aug. 20	Introduction, conservation of energy	1.1, 1.3
2	25	Fourier's law, Newton's law of cooling	1.2
3	27	Examples, radiation HT, derivation of Heat Cond. Equ.	1.2, 2.3
4	Sept. 1	1D SS heat cond., thermal resistance, contact resistance	3.1
5	3	1D SS heat cond. – radial systems, critical insulation	3.3-3.5
6	8	Heating elements, finned surfaces	3.6
7	10	Fin selection, fin arrays, contact resistance, review	3.6
8	15	2D SS heat conduction, shape factors, FD method	4.2, 4.4
9	17	**Quiz #1** (covering actual material in lectures 1 – 7)	
10	22	2D SS heat conduction, FD method, computer project	4.4
11	24	Transient heat conduction - lumped	5.1, 5.2, 5.4
12	29	Transient analytic solutions - plane wall, polar coord.	5.5 – 5.6
13	Oct. 1	Semi-infinite solids, product solution	5.7 – 5.8
14	6	1D transient heat conduction – explicit FD method	5.9
	8	**<<*Holiday*>>**	
15	13	Convection, flow regimes, Reynolds number	6.1 – 6.3, 6.6
16	15	**Quiz #2** (covering actual material in lectures 8 – 14)	
17	20	Boundary layer flow	7.1 – 7.3
18	22	Flow over cylinders, spheres	7.4 – 7.5
19	27	Flow over tube bundles, Internal flow	7.6, 8.1
20	29	Internal flow	8.2 – 8.3
21	Nov. 3	Empirical correlations for internal flow	8.4 – 8.6
22	5	Natural convection – vertical flat plate, correlations	9.1, 9.3, 9.4, 9.6
23	10	Natural convection – enclosures, review	9.7 – 9.8
24	12	Thermal radiation	12.1, 12.3
25	17	Blackbody radiation, definition of view factors	12.3, 13.1
26	19	**Quiz #3** (covering actual material in lectures 15 – 23)	
27	24	Determination of view factors	13.1
	26	**<< *Thanksgiving Holiday* >>**	
28	Dec. 1	B.B. & diffuse-gray surface radiation exchange	13.2 – 13.3
29	3	Diffuse-gray surface radiation exchange, radiation shields	13.2 – 13.3
	Dec. 17	**Final Exam (8:00 – 11:00 AM)**	

To get course notes, practice problems and miscellaneous course material go to **MAE 310 web page**:
`http://www.mae.ncsu.edu/courses/mae310/boles/`

1.8. Projected schedule of any homework due dates, quizzes and tests.

All homework will be assigned on Thursday of the current week of class and will be due on Thursday of the next week. All homework papers are to be stapled in the upper left-hand corner and placed on the instructor's desk before the start of class. Tests and final exam are scheduled according to the projected schedule of reading assignments given above in Section 1.7. Unless given further notice, the exam time for this section is that listed in the Semester Examination Schedule published by the Department of Registration and Records.

There will be **three** 75 minute quizzes and a **final examination**. All exams will be **<u>opened-book</u>**.

Three to six homework problems will be assigned once a week and will be taken up at the **<u>beginning</u>** of class, graded and returned. Grading will be based on the combination of format and the correct result.
All homework must be neatly prepared, using only one side of clean, unused **engineering paper**. Your name, date and problem number must be on each homework problem. If a home problem takes more than one page, the pages must be numbered in the upper right-hand corner and then stapled together in the upper left-hand corner. **<u>Each new problem must start on a new page</u>**. The following procedure is required.

- State the problem (Given: & Find:) and draw the appropriate sketches.
- State clearly the **<u>assumptions</u>** you make and the basic equations you use. Be sure to show all unit conversions in your solution.
- If you present a graph as part of a solution, label the axes, the curve; include the units and choose a scale that can be easily interpreted.
- Block your final answer or conclusion so that it stands out.

This solution methodology is demonstrated in the sample problem included with this syllabus.

1.9. Course grades are determined as follows:

<u>Course Grade</u>:	Homework	10%	90 and above	A
	75 min Tests (3)	60%*	80 and < 90	B
	(*lowest score 10%, others 25%)		70 and < 80	C
	Final Exam	30%	60 and < 70	D
			Below 60	F

Due to current budget limitations the distribution of percentages assigned to the grading components may be changed within the first three weeks of class.

Plus/minus grades will be used for those border line cases where there is excellent attendance, excellent homework grades, and improvement in test and exam grades.

1.10. Instructor's policies on incomplete grades and late assignments.

An incomplete grade will be assigned only for incomplete work due to an excused absence. Incomplete work due to an excused absence, if any, must be arranged within two weeks of due date at the option of the instructor, but prior to two weeks before the scheduled exam time.

Arrangements for missed quizzes will be made on an individual basis provided you have an excused absence as defined by University attendance regulation (**www.ncsu.edu/policies/academic_affairs/courses_undergrad/REG02.20.3.php**). Missed homework cannot be made up once the solution is posted. For the case of missed homework with an excused absence, that homework grade will not be included in the calculation of homework average.

1.11. Instructor's policies on attendance:

Students are expected to attend all classes, and attendance may be recorded from time to time and may be used to determine grades for border line cases. **NCSU policy on attendance, including what constitutes an 'Excused Absence,' is at this link** (**www.ncsu.edu/policies/academic_affairs/courses_undergrad/REG02.20.3.php**).

Work that is late due to an excused absence will either be 'excused' from your grade, or it may be turned in late. It is the students' responsibility to contact the instructor to discuss the most appropriate action.

In the event that a test is scheduled for a day in which the WAKE COUNTY PUBLIC SCHOOLS or the University are closed due to inclement weather, that test will be held at the next regularly scheduled class period when the University is officially open.

1.12. Instructor's Academic Integrity statement, which consists of:

1.12.1. The faculty acknowledges the existence of the University policy on academic integrity found in the Code of Student Conduct Policy (POL11.35.1) and expects students to adhere to it.

1.12.2. The utilization implication of the Honor Pledge[1]; and,

An Honor Pledge is expected to be signed and dated on each test, final exam, and any additional special assignments. The Honor pledge will be as follows: "**I have neither given nor received unauthorized aid on this test, exam or special assignment. I have not discussed the contents of this test or exam prior to taking it.**"

1.12.3. The expectations of faculty concerning honesty in the completion of test and assignments.

It is the expectation of faculty that students neither give nor receive unauthorized aid on any test, exam, or special assignment. The faculty recognizes the value of discussions by students regarding weekly homework assignments in student groups, with teaching assistants, and the faculty. However, homework assignments submitted for grading must be the product of the student submitting the work. Possession of copies of a solution manual by students is prohibited. In fact the solution manual for this course specifically states at the bottom of each original page that if you are a student using the solution manual, you are using it without permission.

1.13. Statement for students with disabilities:

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities at **http://www2.ncsu.edu/ncsu/provost/info/hat/current/appendix/appen_k.html**.

1.14. Statement on laboratory safety:

There are no laboratory assignments for this course; therefore, no special safety training or equipment is needed.

1.15. Statement on extra expenses:

There are no charges or fees beyond the purchase of your calculator and textbook packet which should include the textbook and property table booklet.

1.16. Statement on transportation:

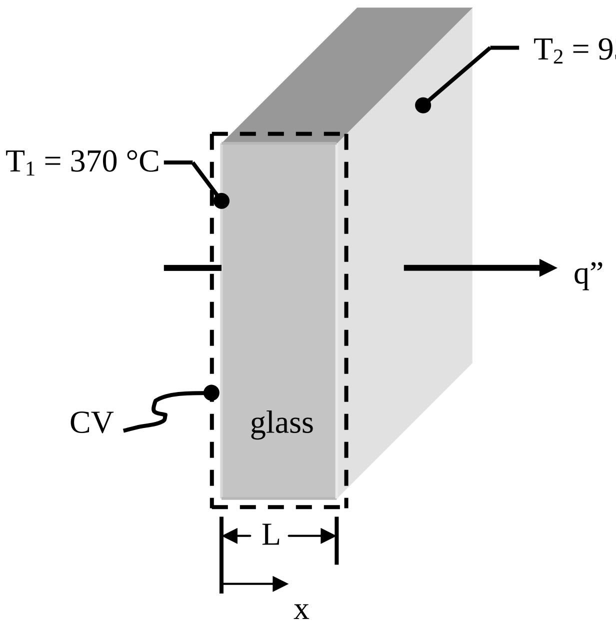
No transportation is required for this course.

1.17. Statement on personal communication devices:

All personal communication devices and computers must be turned off upon entering the classroom. Substantial penalties are applied to the final grade of those students who allow their device to be activated and, thus, disrupt the class. For the class as a whole, the first disruption is free. The second disruption results in a 5-point reduction in the final average of the person that possesses that device; the third results in a 10-point reduction in the final average of the person that possesses that device; etc.

Please Print name **NAME**	**COURSE NUMBER** **DATE**	**PROBLEM NUMBER**	1/1

GIVEN: A solid wall constructed out of special glass with the following thermophysical and geometric properties



k = 0.78 W/m-K
ρ = 2700 kg/m^3
C_p = 0.84 kJ/kg-K
L =15 cm

FIND: The heat flux through the wall at steady state conditions

SOLUTION:

BASIC EQUATION:

$$q_x = \frac{kA}{L}\cdot\left(T_1 - T_2\right)$$

or

$$q_x^{'} = q_x / A = \frac{k}{L}\cdot\left(T_1 - T_2\right)$$

$$q_x^{'} = 0.78\frac{\text{W}}{\text{m}-\text{K}}\cdot\frac{1}{15\ \ \text{cm}}\cdot\frac{100\ \ \text{cm}}{\text{m}}\cdot\left(370-93\right)°\text{C}$$

$$\boxed{q_x^{'} = 1440\frac{\text{W}}{\text{m}^2}}$$