University of Massachusetts
Mechanical and Industrial Engineering 606
Spring 2005

Advanced Heat Transfer

TTh 9:30-10:45AM   Hasbrouk 228

This course is designed to be the core graduate course in heat and mass transfer. Concepts including conservation laws, conduction, laminar and turbulent convection, phase change and radiation will be developed and applied. The course is open to students from all areas of engineering although an undergraduate background in heat transfer will be assumed. The problems and examples will include theory and applications drawn from a wide range of engineering design and manufacturing problems.

Instructor

Professor Jonathan P. Rothstein
Gunness 16
577-0110
rothstein@ecs.umass.edu

Office hours: Mondays 3:00-5:00 PM
Fridays 10:00-11:00 AM

Web Page

http://www.ecs.umass.edu/mie/faculty/rothstein/courses.html

Course Text

Mills, A. F., *Heat Transfer*, Prentice Hall, 1999.

Grading

The course grade will be based on two midterm exams and a final exam with the following weight:

Homework	20%
Hour Exams (2)	40%
Final Exam	40%

Homework

A set of homework problems will be assigned roughly once a week during lectures. You should work through these problems carefully as they are essential for your learning of the material. The problems will be collected and graded.

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Course Syllabus

Date	**Topics to be Covered**	**Suggested Reading**
Week 1 (1/24/2005)	Introductory Material	Mills: Ch 1;
Week 2 (1/31/2005)	Conservation Equations	Mills: 5.7; White Ch. 1-2; K&C: Ch 2
Week 3 (2/7/2005)	Conduction	Mills: Ch 2&3; C&J: Ch 1
Week 4 (2/14/2005)	Laminar Boundary Layers	Mills: Ch. 4-5; K&C: Ch. 8&10
Week 5 (2/21/2005)	Laminar Boundary Layers (cont.)	
Week 6 (2/28/2005)	**Quiz #1** Laminar Internal Flows	Mills: Ch. 4-5; K&C: Ch 7&9
Week 7 (3/7/2005)	Natural Convection	Mills: Ch. 4&5; K&C: Ch 16
Week 8 (3/14/2005)	Spring Break – No Classes	
Week 9 (3/21/2005)	Turbulence	Mills: Ch. 5; K&C: Ch 5&11-14; White: Ch. 6
Week 10 (3/28/2005)	Turbulence (cont.)	
Week 11 (4/4/2005)	Condensation	Mills: Ch. 7
Week 12 (4/11/2005)	**Quiz #2** Boiling	
Week 13 (4/18/2005)	Radiation	S&H; Mills: Ch. 6
Week 14 (4/25/2005)	Radiation (cont.)	
Week 15 (5/9/2005)	Mass Transfer	K&C: Ch. 17-19; Mills “Mass Transfer”; Handouts
Week 16 (5/9/2005)	Mass Transfer (cont.)	
Week 17 (5/16/2005)	**Final Exam** (Date and time TBA)	

Reference Materials

The following texts are all available in the library. They are not currently being held on reserve, but if availability becomes an issue I can place them on reserve. Mills is a broad, but relatively deep advanced undergraduate text, however, you may need to use some of the more advanced texts to fill in some of the blanks.

Good Undergraduate Texts

Mills, A. F., *Heat and Mass Transfer*, Irwin, Chicago, Ill., 1995.

Incropera, F. P., and DeWitt, D. P., *Fundamentals of Heat and Mass transfer*, Wiley, New York, 1996.

Lienhard, J. H., *A Heat Transfer Textbook*, Prentice-Hall, Englewood Cliffs, N.J., 1981. (Available online – see course web site for link)

Fluid Dynamics Texts

White, F. M., *Viscous fluid flow*, McGraw-Hill, New York, 1991.

Vincenti, W. G., and Kruger, C. H., *Introduction to physical gas dynamics*, Wiley, New York,, 1965.

Conduction Texts

Arpaci, V. S., *Conduction heat transfer*, Addison-Wesley Pub. Co., Reading, Mass., 1966.

Carslaw, H. S., and Jaeger, J. C., *Conduction of heat in solids*, Clarendon Press; Oxford University Press, Oxford New York, 1986.

Convection Texts

Kays, W. M., and Crawford, M. E., *Convective heat and mass transfer*, McGraw-Hill, New York, 1993.

Bejan, A., *Convection heat transfer*, J. Wiley, New York, 1995.

Radiation Texts

Siegel, R., and Howell, J. R., *Thermal radiation heat transfer*, Hemisphere Pub. Corp., Washington, D.C., 1992.

References for physical properties of matter

The following are a series of books/tables which you can go to find various physical properties of matter. You should not need to use any of the references to solve the problems assigned in class, but they might be useful to you for future reference.

Y.S. Touloukian, ed., *Thermophysical properties of matter*, 14 vol., Purdue Univ., 1970-1978.

R.C. Reid, et al., *The properties of liquids and gases*, 4th ed., McGraw-Hill, 1987.

N.B. Vargaftik, *Handbook of physical properties of liquids and gases: pure substances and mixtures*, 3rd ed., 1996.

ASME Steam Tables for Industrial Use, 2000.

C.Y. Ho, *Thermal conductivity of the elements: a comprehensive review*, 1975.

NIST chemistry web book: http://webbook.nist.gov/

Some Useful Physical Constants

1998 CODATA with (1 sigma) uncertainty	
Avogadro's number	6.02214199(47) x 10^{26} molecules/kmol
Boltzmann's constant	1.3806503(24) x 10^{-23} J/K
Ideal gas constant	8314.472(15) J/kmol-K
Speed of light	2.99792458(0) x 10^{8} m/s
Gravitational acceleration	9.80665(0) m/s^2
Stefan-Boltzmann constant	5.670400(40) x 10^{-8} W/m^2-K^4

Some Useful Conversion Factors

Quantity	S.I. Units	=	Multiplier	x	Other Units
Density	Kg/m^3	=	16.018	x	lbm/ft^3
	kg/m^3	=	10^3	x	g/cm^3
Diffusivity	m^2/s	=	0.092903	x	ft^2/s
	m^2/s	=	10^{-6}	x	centistokes
energy	J	=	1055.04	x	Btu
	J	=	4.1868	x	calorie
flow rate	m^3/s	=	6.3090×10^{-5}	x	gal/min (gpm)
	m^3/s	=	4.7195×10^{-4}	x	ft^3/min (cfm)
heat flux	W/m^2	=	3.154	x	$Btu/hr\text{-}ft^2$
heat transfer coefficient	$W/m^2\text{-}K$	=	5.6786	x	$Btu/hr\text{-}ft^2\text{-}F$
length	m	=	0.0254	x	inches
	m	=	0.3048	x	feet
power	W	=	0.022597	x	ft-lb/min
	W	=	0.29307	x	Btu/hr
	W	=	745.700	x	horsepower
pressure	Pa	=	248.8	x	in. H_2O
	Pa	=	6894.8	x	psi
	Pa	=	101325.	x	atm
specific heat	J/kg-K	=	4186.9	x	Btu/lbm-F
	J/kg-K	=	4186.8	x	cal/g-C
thermal conductivity	W/m-K	=	1.7307	x	Btu/hr-ft-F
	W/m-K	=	418.68	x	cal/s-cm-C
dynamic viscosity	Pa-s	=	10^{-3}	x	centipoise
	Pa-s	=	1.4881	x	lbm/ft-s
	Pa-s	=	47.8803	x	$lbf\text{-}s/ft^2$
temperature	K	=	5/9	x	R
	K	=	273.15 + C		
	K	=	(459.67 + F)/1.8		
Quantity	**S.I. Unit**	**=**	**Multiplier**	**x**	**Other Unit**