MAE 423 - HEAT TRANSFER

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Office hours: T 2-2:50 PM, R 10:00-10:50 AM.

Lecture: TR 11:00 AM – 12:15 PM Room ESBG102 or on Ecampus Collaborate Blackboard Collaborate Link will be on Ecampus. Lectures will be live and recorded on Collaborate and can be access after lecture on Collaborate.

Text: Introduction to Heat Transfer, Incropera F.P., DeWitt, D.P., Bergman T.L. and Lavine, A.S., John Wiley & Sons

You can purchase a back-edition of either Introduction to Heat and Mass Transfer or Introduction to Heat Transfer. Just make sure it was written by Incropera and DeWitt.

References: Basic Heat & Mass Transfer, A.F. Mills, Prentice Hall, 1999
Principals or Heat Transfer, Kreith, Manglik and Bohn, Cengage, 2011

Pre-requisites: MATH 261 with a grade of C- or better and MAE 320 and (MAE 331 or MAE335).

Course Objectives: The objective of this course is to provide students with the necessary knowledge of the three modes of heat transfer – conduction, convection and radiation. The course will focus on one-, two-, three-dimensional steady state conduction, transient conduction, free and forced convection, radiation, heat exchangers, heat and mass transfer, and design of thermal systems.

Learning Outcomes: This course supports the following ABET Learning Outcomes:

2 An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

4 An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Grading:

Exam #1	20%
Exam #2	20%
Final Exam	35%
HT Design Project	10%
Homework	15%

(Final Exam will be comprehensive)

A final letter grade will be assigned on the following basis:

90 - 100	A
80 - 89	B
70 - 79	C
60 - 69	D
Below 59	F

Class Rules:

1. A professional attitude in class is expected from all students.
2. No use of cell phones is allowed during exams.
3. Attendance is mandatory. Attendance points may be given as an additional homework assignment grade. Class attendance will be taken with Google Spreadsheet.
4. Homework assignments will be submitted on ecampus on or before the due date. You will have unlimited submission attempts up to the deadline. Preview submitted PDF for corruption after uploading. PDF format is required. Note: maximum upload size is 15Mb on ecampus. A corrupt file is considered a non-submission.
5. All homework assignments must follow the template provided on ecampus. All work must be written on engineering paper or white paper printed with engineering pad grid. Engineering pad template is provided on ecampus.
6. Make-up exams will be strongly discouraged and will only be allowed in the event of an excused absence or illness. In these instances, the make-up will be given at the instructor's convenience.
7. Completeness, neatness, and legibility in assignments, exams, and projects are mandatory. If I cannot read your writing, you will get zero. If file is corrupt, you will receive a zero. All assignments will be submitted on ecampus. No assignments will be accepted over email.
8. **NO LATE HOMEWORK ASSIGNMENTS WILL BE ACCEPTED.** Ecampus submission links will close promptly at due dates and times. If you are part of a student organization or become ill, you must notify before due date to submit lab assignment.
9. If you submit late lab reports because of excused absence, they may not be graded until the end of the semester.
10. Hats must be removed during exams. Book bags need to be zipped and placed under chairs.
11. All exams will be in person unless otherwise noted by the instructor.
12. In the event we have remote exams, you are not allowed to take exam remotely at library without prior approval. Exam should be taken in a place that is free from distraction. No one should be walking around you in background or foreground. No one else taking the same exam should be in same room, unless you are roommates.

Academic Integrity: The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, instructors will enforce rigorous standards of academic integrity in all aspects and assignments of their courses. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the WVU Academic Standards Policy

(http://catalog.wvu.edu/undergraduate/coursecreditstermsclassification/). Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at academic dishonesty, please see your instructor before the assignment is due to discuss the matter. In addition, The Statler Policy of Academic Integrity will be used to address instances of academic dishonesty according to the following table:

STATLER POLICY OF ACADEMIC INTEGRITY
(Approved by the Statler College Academic Standards Committee, 28 March 2019)

Case	Violation	Penalty
1	Cheating or plagiarism on minor course element (e.g. quiz, weekly lab report, homework as specified in the syllabus).	Report of academic dishonesty. Grade of zero on the entire minor course element. Possible one-letter reduction in final grade.
2	Cheating or plagiarism on a major course element (e.g. exam, project).	Report of academic dishonesty. Grade of zero on the entire major course element. Possible additional one-letter reduction in final grade. Possible UF † recommendation. Possible exclusion from further participation in class.
3	Collusion on major course element.	Report of academic dishonesty. Exclusion from further participation in class. Failure of the course. Recommendation for UF †.
4	Other (document alteration, tampering with records, etc.).	Report of academic dishonesty. Grade of zero on the entire major course element. Possible additional one-letter reduction in final grade. Possible failure in the course. Possible exclusion from further participation in the class. Possible UF † recommendation.

* Dismissal from the Statler College is permanent for Academic Integrity violations. Student conduct violations can be considered dismissal. † UF– Unforgivable F Grade, cannot be replace under D-F repeat policy. π Separable sanctions (e.g. dismissal from Statler College, suspension, or expulsion from WVU) will be recommended for aggravated or second Academic Integrity offenses. § Warning letters may be issued from the Statler College or the WVU Office of Student Conduct.
Sanctions will be assessed at the instructor and at the college/university levels. Additional sanctions may be assigned at the level of the instructor, college, and/or university.
Statler Policy on Smart Devices: The use of programmable calculators or smart devices (including smart-phones, smart watches, tablets, cameras, wearable devices, etc.) is prohibited unless specifically indicated by the instructor.

Inclusive Statement: The West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion. If you are a person with a disability and anticipate needing any type of accommodation in order to

participate in this class, please advise me and make appropriate arrangements with the Office of Accessibility Services (293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives.

COVID-19 Statement: WVU is committed to maintaining a safe learning environment for all students, faculty, and staff. Should campus operations change because of health concerns related to the COVID-19 pandemic or other campus-wide emergency, it is possible that this course will move to a fully online delivery format. If that occurs, students will be advised of technical and/or equipment requirements, including remote proctoring software.

In a face-to-face environment, our commitment to safety requires students, staff, and instructors to observe the social distancing and personal protective equipment (PPE) guidelines set by the University at all times. While in class, students will sit in assigned seats when required and will wear PPE according to current University guidelines. Students who fail to comply may be referred to the Office of Student Conduct for sanctions.

COVID related absences fall under the University attendance policy. As detailed in the policy, a student who becomes sick or is required to quarantine during the semester should notify the instructor. The student should then work with the instructor to develop a plan to complete the course learning outcomes while he or she is absent.

Adverse Weather Statement: In the event of inclement or threatening weather, everyone should use his or her best judgment regarding travel to and from campus. Safety should be the main concern. If you cannot get to class because of adverse weather conditions, you should contact your instructor as soon as possible. Similarly, if I am unable to reach the class location, I will notify you of any cancellation or change as soon as possible, to prevent students from embarking on any unnecessary travel. If you cannot get to class because of weather conditions, instructors will make allowances relative to required attendance policies, as well as any scheduled exams, or other assessments.

Fundamentals of Engineering (FE) Exam: I strongly encourage all students to sign up and take the FE exam this semester. You will be excused from homework assignment (not exams) due the week before when you take FE exam. Please send me an email notifying me when you are taking the exam.

PLANNED COURSE CONTENT

1. Introduction to Heat Transfer

A. Modes of Heat Transfer: Conduction; Convection; Radiation
B. Fundamental Mechanisms of Heat Transfer

2. Conduction

A. Fourier's Law of Heat Conduction
   i. Definitions: Thermal conductivity, Thermal diffusivity
   ii. Applications to a steady one-dimensional slab, hollow cylinder
   iii. Electrical analogy

B. Heat Conduction Equation
   i. Derivation in Cartesian coordinates

C. Steady One-Dimensional Heat Conduction Equation
   i. Heat conduction across:
      Plane slab, cylindrical shell, spherical shell - Governing equations, boundary conditions, temperature profiles, heat loss
   ii. Thermal Contact Resistance
   iii. Composite slabs, shells
   iv. Heat conduction with internal heat generation - slab, cylinder

D. Fins (Steady, One-Dimensional Heat Conduction)
   i. Constant area rectangular fin
   ii. Pin fin
   iii. Three cases: short fin, infinitely long fin, and insulated fin
   iv. Fin efficiency, Fin resistance, Total surface efficiency

E. Multi-dimensional Steady Heat Conduction
   i. Review three-dimensional heat conduction equation
   ii. Boundary conditions and initial conditions
   iii. Solution to a two-dimensional heat conduction equation (also, handouts on Separation of Variables)
   iv. Conduction shape factors
   v. Numerical analysis - Finite Difference Methods Discretization

F. Transient Conduction
   i. Review three-dimensional heat conduction equation
   ii. Semi-infinite slab
   iii. Numerical analysis - Finite Difference Methods
      Explicit and Implicit Methods
      Discretization Schemes

EXAM #1

3. Convection

A. Introduction
   i. Types of convection: Forced and Natural; Internal and External; Laminar and Turbulent; Fully developed flow and Entrance effects

C. Boundary Layers
   i. Basic concepts; Thermal and Hydrodynamic BL
   ii. BL equation and boundary conditions

D. Fundamentals of Convection
   i. Dimensional analysis

ii. Internal flows
Determination of mixed mean temperatures (inlet/outlet)
iii. Corrections for variable property effects

E. Forced Convection (Internal Flows)
i. Tubes and Ducts (circular
ii. Entrance effects
iii. Ducts (various cross-sections)
Correlations for internal duct flows will be covered for laminar and turbulent flows (for various Pr number fluids)

F. Forced Convection (External Laminar and Turbulent Flows)
i. Flow over (a) Flat plate, (b) Circular cylinder and (c) Sphere

G. Convection analysis
i. Derivation of the continuity, momentum and energy equations.
ii. Boundary layer equations (laminar) and an introduction to turbulent BL Equation

H. Natural Convection (Laminar and Turbulent)
i. Heat and Cooled Surfaces
ii. Inclined Surfaces

F. Boiling and Condensation
i. Boiling Modes
ii. Pool Boiling Correlations

EXAM #2

4. Heat Exchangers

A. Introduction
i. Types of heat exchangers
ii. Configurations
iii. Temperature profiles

B. Heat Exchanger Concepts
i. Overall heat transfer coefficient
ii. Log Mean temperature difference

C. Heat Exchanger Design Approach
i. LMTD factor approach
ii. Effectiveness-NTU approach

5. Radiation

A. Introduction to radiation physics
i. Electromagnetic spectrum
ii. Planck's Blackbody Spectral Energy Distribution

iii. Wien's Displacement Law
iv. Stefan-Boltzman Law

B. Radiation exchange between surfaces
i. Exchange between black bodies
ii. Shape factors
iii. Electrical network analogy (blackbodies)
iv. Exchange between diffuse gray surfaces

FINAL EXAM