

**Course:** ME 497 System Thermal Management, 3 Credit Hour, Lecture  
**Prerequisite:** ME 325

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**Office Hours:** MTW: 8:30 – 10:30 am via ZOOM

**Textbook:** Currently, a single textbook is not available for this class. Lecture materials will be provided, and additional materials will be distributed on the course Blackboard Intranet Site. Additional reading assignments and reference materials will also be provided throughout the course.

The goal of the course is to develop a basic understanding of thermal management, design, and control of electro-mechanical systems by exposure to the fundamental engineering sciences with application to waste heat removal to ensure reliable systems performance. The course will provide an analytical background and methods of analysis and design required to predict the thermal behavior of electro-mechanical components and systems. An overview of applicable topics in fluid mechanics and heat transfer will be provided so interest and desire to learn about this important aspect of design is all that is required of the student. Topics will include design and analysis methods of forced and buoyancy-driven systems, as well as conduction, natural and forced convection, and radiation heat transfer. Methods to enhance thermal management such as localized cooling, direct air cooling and fan selection, finned extended surfaces and cold plates, and interstitial materials (i.e., gap fillers and thermal pads) will be included.

1. Explain the terminology and principles of fluid mechanics and heat transfer as applied to thermal management of electro-mechanical systems.
2. Understanding whether thermal design equilibrium is achieved and optimized, or if a thermal management strategy is required.
3. Explain basic concepts of thermal management, design, and control of electro-mechanical systems.
4. Be able to design and control electro-mechanical systems through a comprehensive approach to thermal management and component derating to ensure reliable system operation.
5. Understand forced air-cooling techniques, calculate fan performance in thermal management and cooling applications, and determine fan performance impact on heat sink thermal resistance.

6. Know what heat sinks (finned and extended surfaces) and cold plates are, understand their design features and mounting/installation techniques, and know how to choose them for proper thermal management and cooling.
7. Understand thermal interface materials - used to couple heat sinks and cold plates to the thermal energy dissipators - their types and characteristics.
8. Use empirical data in the form of tables and figures to solve open-ended problems.

### **KNOWLEDGE, SKILLS, AND ABILITIES STUDENTS SHOULD HAVE BEFORE**

**ENTERING THIS COURSE:** Communicate technical information accurately and concisely – both orally and in writing, use analysis, computer software, word processors, etc., to define and develop solutions to technical problems in engineering.

### **CLASS FORMAT:**

- Course material will be delivered online via our Blackboard Intranet Site asynchronously. However, as I am converting this course from my traditional face-to-face to a fully online class, I will incorporate synchronous meetings delivered by ZOOM sessions. All students must be online at that exact same time to participate in these class sessions. Synchronous ZOOM sessions are outlined in our tentative course schedule. These segments of the class will be taught during the TopNet designated Day(s) and Time slots.
- **What does this mean?** It means that this is **NOT** exclusively a WEB based course so you are expected to attend, and your grade will include participation during our scheduled ZOOM sessions on Tuesday and Thursday from 11:10 – 12:30 pm. **Do not schedule other commitments during these TopNet designated days and time slots.**

### **CLASS RULES:**

- This syllabus is a contract between the instructor and student. Be sure that you are familiar with the syllabus. Most classroom management questions can be answered by reading the syllabus.
- You are expected to be prepared for class. This means reading assigned material and reviewing previous class notes before coming to class.
- You are expected to attend all class sessions and will be responsible for material presented during these sessions. It is expected that you are professionals who can understand the importance of attendance.
- To be courteous to your classmates, it is important that there be no talking during class unless in discussion or breakout rooms. Otherwise, mute your microphone.
- The class will proceed at a very fast pace. To optimize your learning, it is important that you keep up with the assignments and readings.
- **Emails (from Blackboard) will routinely be sent to your WKU email address regarding assignments and class information.**
- Remember email can be used as a professional form of communication. I will not respond to unprofessional emails.
- It is perfectly acceptable to ask questions regarding your grades. **Discussions about grades will not be conducted via email.** You may schedule an appointment during my Zoom office hours with me to discuss grades.

### **ASSIGNMENT RULES:**

The following rules apply to our performance measures. You may discuss alternatives and methods for the performance measure problems with me and your peers, but you must create your own work, which reflects your own independent thought process and efforts:

- A cover page must be included with each assignment. The cover page must include **course number and title, semester and year, performance measure title/number, date and your name.**
- Work must be neat. Presentation will affect your grade!
- Numerical solutions should be clearly labeled with a box or circle around the answer.
- **No late performance measures will be accepted.** You will be given ample time to complete the performance measure and ask questions prior to submission. Some are lengthy so I strongly suggest that you do not begin them the night before they are due.
- You will be instructed on any special format or file requirements for the performance measure.
- Performance measure problems will be weighted (i.e., some problems will count more than others).
- Performance measures not submitted according to instructions will not be graded.
- **All performance measures must be submitted using the Blackboard Assignment Feature; therefore, do not email assignments to me.**

**Performance measures not meeting these standards may not receive credit.** If the problem is not clearly organized and does not follow a logical path or if the solution is incomplete, no points will be awarded.

### **BLACKBOARD INTRANET SITE:**

There is a Blackboard intranet site available for the course, <http://blackboard.wku.edu>. To login use your username (NetID) and password.

- Blackboard will be used extensively throughout this course.
- Performance measure assignments will be posted in the Topics Section of the Blackboard site with due dates provided.
- Class material will be posted in appropriate Blackboard folder.
- Student grades may be posted in the Grade Center.

### **PROFESSIONAL CONDUCT:**

It is expected that all students be present in each Zoom session, will be courteous of others' ideas, and otherwise will conduct themselves in a professional manner. Other activity that diminishes the professional quality of the Zoom class-room session will not be tolerated, and you will be removed from the session.

### **COURSE GRADE:**

<i>Component</i>	<i>Weight</i>
In Class Problems/Examples and Participation	10%
Performance Measures (Four @ 22.5%)	90%

Grades on performance measures will be assigned based on a weighted average of the levels of performance demonstrated throughout the semester. Scores for your performance will be based on the following rubric:

<b>Letter Grade</b>	<b>Numeric Equivalent</b>	<b>Qualitative Description (Typical)</b>
A	> 90%	Exemplar; no to minor mistakes; proper units.
B	> 80%	Proficient; several minor/units mistakes; almost no conceptual mistakes.
C	> 70%	Apprentice; several mistakes, some major or improper units; conceptual mistakes.
D	> 60%	Novice; many significant mistakes, incorrect units and conceptual errors.
F	< 60%	Non-response or completely incorrect response.

### **PERFORMANCE MEASURES:**

The timing of the performance measures (in class and/or take-home exam type or applied research investigations reports/presentations) are shown below on the tentative course schedule. These are fixed in time, and I will adjust material covered on each if we are ahead or behind schedule. This will be announced in class. **No makeup performance measures will be given. No early performance measures will be given. No late performance measures will be given.**

**No communication on your final performance measure and your final grade** will take place through email since this violates FERPA (Family Educational Rights and Privacy Act) guidelines. Performance measures and final grades are available for review during my Zoom office hours. Schedule an appointment and have a prepared explanation of the item of interest.

**A grade of zero will be given for all performance measures not submitted on time. If you have a legitimate excuse, let me know in advance via email. No make-up work will be given except as required by University Policy. See me prior to any anticipated issues with your submissions.**

### **Academic Dishonesty:**

As an engineering student at WKU, you are expected to refrain from any form of academic dishonesty or deception such as cheating, stealing, plagiarism or lying on assignments, homework, quizzes, tests or exams. Furthermore, you understand and accept the potential consequences of punishable behavior, as stated in the WKU Catalog under Academic Dishonesty.

**WKU Covid-19 Mask Statement:**

Out of respect for the health and safety of the WKU community and in adherence with the CDC guidelines, the University requires that a cloth face covering (reusable or disposable) that covers both the nose and mouth must be worn at all times when in public areas within all buildings. Students must properly wear face coverings while in class regardless of the room size or the nature of the classroom activities. Students who fail to wear a face covering as required will be in violation of the WKU Student Code of Conduct and will be asked to comply or will face disciplinary action, including possible dismissal from the University. Accommodations to face coverings must be determined by the Student Accessibility Resource Center and documented before a student may attend class.

**Ogden Student Course Attendance Statement:**

The faculty and staff of Ogden College of Science and Engineering are committed to providing you with learning experiences and opportunities. You must assume ownership of your education and be an active participant in the classroom and laboratory to take advantage of these opportunities. **Active participation requires you to attend.** Scientific studies have shown that attendance during scheduled classroom and laboratory meetings is directly correlated to your performance on assignments and exams and the potential to earn higher grades. Additionally, if you do not regularly attend class, you are missing important information about course topics, due dates, and assignment details that are crucial to your success in the course. Therefore, as a student enrolled in an Ogden course, you are expected to attend every class meeting and to inform your instructor regarding the reasons for any absences as soon as practical. **Your instructor may incorporate class attendance/participation as part of the grading criteria.**

**ADA Accommodation Statement:**

In compliance with University policy, students with disabilities who require academic and/or auxiliary accommodations for this course must contact the Student Accessibility Resource Center located in Downing Student Union, 1074. SARC can be reached by phone number at 270-745-5004 [270-745-3030 TTY] or via email at [sarc.connect@wku.edu](mailto:sarc.connect@wku.edu). Please do not request accommodations directly from the professor or instructor without a faculty notification letter (FNL) from The Student Accessibility Resource Center.

**Title IX Misconduct/Assault Statement:**

Western Kentucky University (WKU) is committed to supporting faculty, staff and students by upholding WKU's Title IX Sexual Misconduct/Assault Policy (#0.2070) at <https://wku.edu/eoo/documents/titleix/wkutitleixpolicyandgrievanceprocedure.pdf> and Discrimination and Harassment Policy (#0.2040) at [https://wku.edu/policies/hr\\_policies/2040\\_discrimination\\_harassment\\_policy.pdf](https://wku.edu/policies/hr_policies/2040_discrimination_harassment_policy.pdf).

Under these policies, discrimination, harassment and/or sexual misconduct based on sex/gender are prohibited. If you experience an incident of sex/gender-based discrimination, harassment and/or sexual misconduct, you are encouraged to report it to the Title IX Coordinator, Andrea Anderson, 270-745-5398 or Title IX Investigators, Michael Crowe, 270-745-5429 or Joshua Hayes, 270-745-5121.

Please note that while you may report an incident of sex/gender based discrimination, harassment and/or sexual misconduct to a faculty member, WKU faculty are “Responsible Employees” of the University and MUST report what you share to WKU’s Title IX Coordinator or Title IX Investigator. If you would like to speak with someone who may be able to afford you confidentiality, you may contact WKU’s Counseling and Testing Center at 270-745-3159.

**KEY 2021 SPRING SEMESTER ACADEMIC CALENDAR DATES:**

**January 26:** Last day to add a class. Last day to drop a class without a grade. Last day to receive 100% refund for a class.

**March 25:** Last day to drop a class with a W. Last day to change a class from credit to audit.

**Tentative Course Schedule**

<b>Week</b>	<b>Topics</b>
1	Zoom Session: Why Thermal Management? Thermal Design Considerations and Formulation
	Zoom Session: Direct Air and Liquid Cooling – Background and Theory
2	Zoom Session: Direct Air and Liquid Cooling – Background and Theory
	Zoom Session: Direct Air and Liquid Cooling – Applications and Problems
3	Zoom Session: Direct Air and Liquid Cooling – Applications and Problems
	Zoom Session: Direct Air and Liquid Cooling – Applications and Problems
4	<b>Performance Measure #1, Tuesday, February 9<sup>th</sup> by midnight</b>
	Zoom Session: Heat Sinks – Background and Theory
5	Zoom Session: Heat Sinks – Background and Theory
	Zoom Session: Heat Sinks – Applications and Problems
6	Zoom Session: Heat Sinks – Applications and Problems
	Zoom Session: Heat Sinks – Applications and Problems
7	<b>Performance Measure #2, Tuesday, March 2<sup>nd</sup> by midnight</b>
	Zoom Session: Heat Exchangers and Cold Plates – Background and Theory

8	Zoom Session: Heat Exchangers and Cold Plates – Background and Theory
	Zoom Session: Heat Exchangers and Cold Plates – Applications and Problems
9	Zoom Session: Heat Exchangers and Cold Plates – Applications and Problems
	Zoom Session: Heat Exchangers and Cold Plates – Applications and Problems
10	Zoom Session: Heat Exchangers and Cold Plates – Applications and Problems
	<b>Performance Measure #3, Thursday, March 25<sup>th</sup> by midnight</b>
11	Zoom Session: Thermal Interface Resistance – Background and Theory
	Zoom Session: Thermal Interface Resistance – Background and Theory
12	Zoom Session: Thermal Interface Resistance – Applications and Problems
	Zoom Session: Thermal Interface Resistance – Applications and Problems
13	Zoom Session: Thermal Interface Resistance – Applications and Problems
	Zoom Session: Thermal Interface Resistance – Applications and Problems
14	Zoom Session: Open Discussion – Systems Thermal Management
	Zoom Session: Course Assessment
15	<b>Performance Measure #4, Tuesday, April 27<sup>th</sup> by midnight</b>