EGR 2500: Introduction to Thermal Engineering
Winter 2018

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Office Hours: M, W, after class, or by arrangement.

Class Times: M, W, 10:00- 11:47AM, Rm. 207 MUC, Bldg. 2

Laboratory Times: (MUC, Bldg.2, Rm 135) **M: 11:50AM-12:50PM**; **W: 11:50AM-12:50PM**
(356 EC) R: 1:00PM-2:47AM

Course Web Site: The Moodle course management system will be used this semester. You may access the EGR 2500 website using your OUCA name and password at: https://moodle.oakland.edu. Homework assignments and solutions, announcements, interesting web links and handouts can be found on this site. **Please visit the website on a regular basis for course updates. Note: Course handouts and HW assignments will *not* be distributed in class.**

Teaching Assistant: Natalia Reinberg, nataliareinberg@oakland.edu (please check website for information & office hours)

Texts: *Fundamentals of Thermal-Fluid Sciences, 5th ed., Yunus Cengel, McGraw-Hill, 2017*
Access Card standalone: 9781260271034 e-book only
COMBO ISBN: 9781260277722 National LL with 720 day access card
COMBO ISBN: 9781260277739 National HardCover with 720 day access card

Course Prerequisites: CHM 143, PHY 151, and EGR 141; pre/co-requisite: APM 255

University Catalog Description:
EGR 2500 - Introduction to Thermal Engineering (4): Introduction to the fundamentals of classical thermodynamics and heat transfer; first and second laws of thermodynamics; thermodynamic property relationships; application to engineering systems and processes, steady and transient conduction in solids; introduction to convection heat transfer correlations. Offered fall and winter.
Prerequisite(s): (CHM 143 or CHM 144 or CHM 157), (PHY 161 or PHY 151), and EGR 141 Prerequisite or corequisite: APM 255

General Education Student Learning Outcomes:
This course will satisfy the Oakland University Natural Science and Technology general education requirement. As such, students will demonstrate:

1. knowledge of major concepts from natural science or technology, including developing and testing of hypotheses, drawing conclusions, and reporting of findings and some laboratory experience or an effective substitute
2. how to evaluate sources of information in science or technology

General Education Cross Cutting Capacities:

- Effective Communication
- Critical Thinking

ABET Course Objectives:

The primary objectives of this course are to teach the fundamental concepts, principles and engineering applications of classical thermodynamics and to introduce the rate equations and physical mechanisms associated with heat transfer. The laboratory component is intended to reinforce these basic concepts, teach principles of experimentation and experiment design, and improve teamwork and communication skills. An additional goal of the course is to assist the student in developing the ability to analyze and solve engineering problems using logical reasoning and mathematical principles. By the end of the course, the successful student will be able to:

1. List and describe relevant thermodynamic terminology related to thermodynamic systems and properties. Demonstrate proficiency in performing unit conversions. (a)[1]
2. Design and perform experiments. Formulate, evaluate and calculate experimental uncertainties of indirect measurements. Analyze experimental data and write technical reports. (b, d, f, g, i, k)
3. Interpret thermodynamic property tables and graphs. Calculate property values, and apply to various thermodynamic systems and equations of state. (a, e)
4. Explain and apply the Conservation of Energy and the Conservation of Mass Principles to a variety of open and closed thermodynamic systems such as nozzles, turbines, throttling valves, heat exchangers, refrigeration systems, vapor cycle power plants. (a, e, k)
5. Explain and apply the Second Law of Thermodynamics to a variety of thermodynamic processes and to model a variety of open and closed thermodynamic systems. Describe its implications and influences. (a, e, k)
6. Describe the physical mechanisms associated with the three fundamental heat transfer modes. (a)
7. Apply the concepts of one-dimensional steady conduction to the solution of problems involving plane, curved and composite walls; use the thermal resistance concept to model and solve thermal network problems. (a, e, k)
8. Evaluate the steady rate of heat transfer, efficiency and effectiveness of finned surfaces (a, e, k)
9. Formulate and apply the lumped capacitance method for the solution of transient heat transfer problems. (a, e, k)

Student Outcomes: ABET (a-k)

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environ., social, political, ethical, health, safety, manufactured ability, sustainability
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global economical, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

[1] The 'a-k' letters in parentheses designate the applicable ABET Student Outcomes

Course Topic Outline (Order subject to change)

Week of:	**Topic**	**Reading**
1/3/2018	Course Mechanics; Introduction, dimensions and units	1.1-1.6
1/8	Basic concepts: continuum, open/closed system, intensive/extensive properties, process/cycle, density, pressure and pressure measuring devices, temperature	2.1-2.8
1/15	Uncertainty Analysis (in lab); Energy and energy transfer; Forms of energy; Energy transfer by heat; heat transfer modes. No class on 1/15, MLK day.	3-1-3.4
1/22	Energy transfer by work; moving boundary work, including polytropic process; Internal energy; First Law of Thermodynamics	3.4-3.6; 5.1
1/29	Properties of a pure substance; property diagrams for phase change processes; Saturation pressure and temperature	4.1-4.4
2/5	Property tables (water and refrigerants)	4.5
2/12	Ideal gas law; incompressible substances; Energy analysis of closed systems	4.6-4.7; 5.3-5.5
2/19	Winter Recess	Dr. Seuss: *Oh, the Places You'll Go!*
2/26	Conservation of mass and energy for control volumes; flow work	6.1-6.3
3/5	Application of the conservation of mass and energy principles to steady-flow engineering devices (nozzles, diffusers, turbines, compressors, pumps, heat exchangers, valves)	6.4
3/12	Mechanisms of heat transfer: Conduction, convection and radiation; Steady one-dimensional heat conduction; Temperature distribution in a plane wall	16.1-16.5
3/19	Thermal resistance; Multilayer plane walls; Thermal contact resistance; Heat conduction in cylinders; critical radius of insulation; Lumped system analysis; criteria for lumped system analysis: Biot number	17.1-17.5; 18.1
3/26	Heat transfer from finned surfaces; fin efficiency and fin effectiveness; fin arrays; The second law of thermodynamics; Cycle efficiency and coefficient of performance; irreversibility; Kelvin-Planck and Clausius Statements of the second law; Carnot cycle	7.1; 17.6-7.11
4/2	Entropy; Evaluating entropy as a property; 2nd Law for a Closed System; Heat Engines	8.1-8.10
4/9	Isentropic processes; Isentropic efficiencies of steady flow devices (nozzles, pumps, compressors, turbines);	8.11; 8.12
4/16	Review; Clean-up on remaining Topics	

Homework:

• Homework is an indispensable part of this course. **The principles and concepts introduced in this course can only be learned by practicing their application and solving multiple problems**. Besides, the material on the quizzes and exams will be similar to the assigned problems!
• Homework will be assigned weekly using the McGraw-Hill Connect™ system, both online and turned in on paper. Homework will be discussed as needed, and solutions will be made available to students after the due date. Help is available before and after due dates. Problems should be neatly written on one side of the page, beginning each new problem on a new page. Assumptions, diagrams (when applicable), and analyses should be presented in a clear and logical fashion and final answers must be underlined or boxed. This will be discussed in class on the first day.
• You are encouraged to consult with the instructor or others on homework assignments. Each student is, however, expected to turn in an assignment that represents their own work. If you study with others, you required to hand in your individual assignment with the names of students who provided assistance clearly indicated on the front page. Failure to give proper credit for assistance received will be considered plagiarism and will be dealt with in accordance with university policies.

• Copying homework solutions from a solution manual or from solutions found online or through other means is strictly prohibited. If any kind of copying behavior is found, zero points will be given for the homework and the assignment will be submitted to the Academic Conduct Committee for possible further action.

Laboratory:

• There will be about four laboratory experiments beginning the week of January 8, 2018 in room 135 (MUC, Bldg.2). The laboratory is an integral part of the course and allows students to both witness and apply the fundamental concepts and principles being studied in class.
• Students are required to register for one lab section, which will meet every other week for about 1 hours. The scheduled lab time will be used about every other week to demonstrate the experiment and cover relevant background information. Instructions, handouts, and other information will be provided at that time. On alternating weeks, lab lecture time might be used to supplement the course material with such things as MS-Excel demos, as well as example problems.
• Students will perform the lab experiments in teams of four. Teams of three might be allowed under certain circumstances and require instructor approval. If possible, teams should include at least one member from a different major to provide multi-disciplinary team experience. You will select the people in your team!
• Teams will schedule a time to conduct the experiments using a sign-up sheet posted on the lab door by the lab teaching assistant. Most labs can be completed in two hours or less. A team lab report is usually due within one to two weeks of the lab assignment and must follow the lab report guidelines. Lab reports are to be submitted in electronic form on Moodle by 11:59PM on the Saturday that they are due. A complete draft of the lab report must be uploaded to Moodle no later than 11:59PM on the Thursday (i.e, 2 days) before the due date in order to allow enough time for the whole team to review and edit the final report. Failure to turn in a lab report may result in a failing course grade. **In order to pass this course, *students must pass the laboratory portion*.**
• Team members will have the opportunity to evaluate the performance and contribution of fellow team-members for each lab. An individual student's cumulative laboratory grade will be adjusted at the end of the course based on individual contribution to the lab assignments, as well as based on these evaluations. If repeated efforts to improve team functioning (including faculty intervention) fail, a non-participant may be fired by unanimous consent of the rest of the team, and a team member doing essentially all the work may quit. This however requires prior instructor approval. Individuals who quit or are fired must find a team of three unanimously willing to accept them; otherwise they will receive zeros for the remainder of the labs.
• I reserve the right to adjust the grade of any lab based on the written communication skills demonstrated in the lab report. A poorly written lab can lose up to half the total possible points.

Tentative Lab Schedule (subject to change – guest speaker visits may be added)

Lab	**Introduced week of**	**Due Date: Saturday,**
Lab Report Preparation;	1/8	
Uncertainty analysis	1/17	
Lab 1 - Flow Rate Measurement and Calibration	1/22	2/10
Lab 2 – Measuring the Energy Content of Food	2/5	3/3
Lab 3 - Heat Exchanger	2/26	3/17
Lab 4 – Refrigeration/Heat Pump Systems	3/12	3/31
Lab Presentations - tentative	4/2	

Exams:

There will be about three exams given during the semester and a cumulative, three-hour final exam at the end of the term. When necessary, you will be provided with a formula sheet during certain exams. NO other materials such as class notes, textbook, homework sets, or old exams will be allowed during the tests. Cellular phones, pagers, wireless devices, headphones and hats are also prohibited during tests. If you miss a test without either a valid medical excuse or prior instructor approval, you will be assigned a grade of zero on the test. Short online quizzes and/or in-class 2-5 minute quizzes may also be randomly given during class and will be included in the homework grade. Students requiring special arrangements for tests should notify the instructor of the needed accommodations (along with letter from DSS office) at the beginning of the semester.

In-Class Activities:

Some activities will be assigned in the class, and then collected by the instructor at the end of the class. Student should prepare a piece of paper for the in-class activities. Activities will be randomly graded - **no late activities will be accepted**.

Course Grade: (may be adjusted slightly)

Laboratory	20 %
Homework	5 %
Connect™ Quizzes	5 %
In-Class Quizzes	3%
Tests	45 %
Final Exam	25 %

It is possible for every student to obtain an A for the course. There is no fixed grading scale for this course; a conversion formula from your percentage score to Oakland University grades will be determined at the end of the course. However, the following "standard scale" shows the lowest possible grade that a given percentage score will generally earn (the grade may be higher than this): 95%→4.0, 80%→3.0, 68%→2.0, 50%→0.0.

Important Dates: (https://www.oakland.edu/registrar/important-dates/)

- ✓ Monday, January 15th – **No classes (MLK Day)**
- ✓ Wednesday, January 17th - Last day for "no-grade" drop and last Day 100% Tuition Refund
- ✓ Friday, January 26th - Last day to file application for degree for Winter 2018
- ✓ Wednesday, February 7th - Last day for official withdrawal (W)
- ✓ Monday, April 16th - Last EGR 2500 class meeting
- ✓ Tuesday, April 17th, Winter classes end at 10 pm.
- ✓ Monday, April 23 - **Final Examination** –12:00 noon – 3:00PM - tentative

Academic Conduct: All students are expected to read, understand, and comply with the *Academic Conduct Policy* found on the OU web site and in the *Oakland University Undergraduate Catalog*. The policy applies to testing, homework and laboratory work, and is taken very seriously by the instructor. Perceived violations of this policy will be taken before the OU Academic Conduct Committee. Any student found to be cheating by the Academic Conduct Committee will receive a zero in the course. Engineering is a profession that serves the public and demands integrity within its membership.

Please note that the use of cell phones, text messaging and laptops is not allowed in this class unless you receive special permission from the instructor.

PEER RATING OF TEAM MEMBERS[2]

Name_____ Group #_____

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing the laboratory assignments. The possible ratings are as follows:

Excellent: Consistently went above and beyond - tutored teammates, carried more than his/her fair share of the load, very cooperative.
Very good: Consistently did what he/she was supposed to do, very well prepared and cooperative.
Satisfactory: Usually did what he/she was supposed to do, acceptably prepared and cooperative.
Ordinary: Often did what he/she was supposed to do, minimally prepared and cooperative.
Marginal: Sometimes failed to show up or complete assignments, rarely prepared.
Deficient: Often failed to show up or complete assignments, rarely prepared.
Unsatisfactory: Consistently failed to show up or complete assignments, unprepared.
Superficial: Practically no participation.
No show: No participation at all.

These ratings should reflect each individual level of participation and effort and sense of responsibility, ***not*** *his or her academic ability.*

Name of Team Member	Rating	Comments (do not leave blank)

Your signature:_____

[2] Adapted from R.M. Felder & R. Brent, *Effective Teaching*, North Carolina State University, 2000.

Coping with Hitchhikers and Couch Potatoes on Teams[†]

You will usually find your university teammates as interested in learning as you are. Occasionally, however, you may encounter a person who creates difficulties. This handout is meant to give you practical advice for this type of situation.

To begin with, let's imagine you have been assigned to a combined homework and lab group this semester with three others: Mary, Henry, and Jack. Mary is okay—she's not good at solving problems, but she tries hard, and she willingly does things like get extra help from the professor. Henry is irritating. He's a nice guy, but he just doesn't put in the effort to do a good job. He'll sheepishly hand over partially worked homework problems and confess to spending the weekend watching TV. Jack, on the other hand, has been nothing but a problem. Here are a few of the things Jack has done:

- When you tried to set up meetings at the beginning of the semester, Jack just couldn't meet, because he was too busy.
- Jack infrequently turns in his part of the homework. When he does, it's almost always wrong—he obviously spent just enough time to scribble something down that looks like work.
- Jack has never answered phone messages. When you confront him, he denies getting any messages. You e-mail him, but he's "too busy to answer."
- Jack misses every meeting—he always promises he'll be there, but never shows up.
- His writing skills are okay, but he can't seem to do anything right for lab reports. He loses the drafts, doesn't reread his work, leaves out tables, or does something sloppy like write equations by hand. You've stopped assigning him work because you don't want to miss your professor's strict deadlines.
- Jack constantly complains about his fifty-hour work weeks, heavy school load, bad textbooks, and terrible teachers. At first you felt sorry for him—but recently you've begun to wonder if Jack is using you.
- Jack speaks loudly and self-confidently when you try to discuss his problems–he thinks the problems are everyone else's fault. He is so self-assured that you can't help wondering sometimes if he's right.

Your group finally was so upset they went to discuss the situation with Professor Distracted. He in turn talked, along with the group, to Jack, who in sincere and convincing fashion said he hadn't really understood what everyone wanted him to do. Dr. Distracted said the problem must be the group was not communicating effectively. He noticed you, Mary, and Henry looked angry and agitated, while Jack simply looked bewildered, a little hurt, and not at all guilty. It was easy for Dr. Distracted to conclude this was a dysfunctional group, and everyone was at fault—probably Jack least of all.

The bottom line: *You and your teammates are left holding the bag. Jack is getting the same good grades as everyone else without doing any work. Oh yes—he managed to make you all look bad while he was at it.*

What this group did wrong: Absorbing

This was an 'absorber' group. From the very beginning they absorbed the problem when Jack did something wrong, and took pride in getting the job done whatever the cost. *Hitchhikers <u>count</u> on you to act in a self-sacrificing manner*. However, the nicer you are (or the nicer you think you are being), the more the hitchhiker will be able to hitchhike their way through the university—and through life. By absorbing the hitchhiker's problems, you are inadvertently training the hitchhiker to become the kind of person who thinks it is all right to take credit for the work of others.

What this group should have done: Mirroring

It's important to reflect back the dysfunctional behavior of the hitchhiker, so the hitchhiker pays the price—not you. Never accept accusations, blame, or criticism from a hitchhiker. Maintain your own sense of reality despite what the hitchhiker says, (easier said than done). *Show you have a bottom line: there are limits to the behavior you will accept.* Clearly communicate these limits and act consistently on them. For example, here is what the group could have done:

- When Jack couldn't find time to meet in his busy schedule, even when alternatives were suggested, you needed to decide whether Jack was a hitchhiker. Was Jack brusque, self-important, and in a hurry to get away? Those are suspicious signs. Someone needed to tell Jack up front to either find time to meet, or talk to the professor.
- If Jack turns nothing in, his name does not go on the finished work. (Note: if you know your teammate is generally a contributor, it is appropriate to help if

[†] This essay is a brief, adapted version from "It Takes Two to Tango: How 'Good' Students Enable Problematic Behavior in Teams," Barbara Oakley, *Journal of Student Centered Learning*, Volume 1, Issue 1, Fall, 2002, pp. 19-27.

something unexpected arises.) Many professors allow a team to fire a student, so the would-be freeloader has to work alone the rest of the semester. Discuss this option with your instructor if the student has not contributed over the course of an assignment or two.

- If Jack turns in poorly prepared homework or lab reports, you must tell him he has not contributed meaningfully, so his name will not go on the submitted work. *No matter what Jack says, stick to your guns!* If Jack gets abusive, show the professor his work. Do this the *first time* the junk is submitted, before Jack has taken much advantage—not after a month, when you are really getting frustrated.
- Set your limits early and high, because hitchhikers have an uncanny ability to detect just how much they can get away with.
- If Jack doesn't respond to e-mails, answer phone messages, or show up for meetings, don't waste more time trying to contact him. (It can be helpful, particularly in industry, to use e-mail for contacting purposes, because then a written record is available about the contact attempt. Copying the e-mail to Jack's supervisor or other important people can often produce surprisingly effective results.)
- Keep in mind the only one who can handle Jack's problems is Jack. You can't change him—you can only change your own attitude so he no longer takes advantage of you. Only Jack can change Jack—and he will have no incentive to change if you do all his work for him.

People like Jack can be skilled manipulators. By the time you find out his problems are never-ending, and he himself is their cause, the semester has ended and he is off to repeat his manipulations on a new, unsuspecting group. Stop allowing these dysfunctional patterns early in the game—before the hitchhiker takes advantage of you and the rest of your team!

Henry, the Couch Potato

But we haven't discussed Henry yet. Although Henry stood up with the rest of the group to try to battle against Jack's irrational behavior, he hasn't really been pulling his weight. (If you think of yourself as tired and bored and really more interested in watching TV than working on your homework—everyone has had times like these—you begin to get a picture of the couch potato.)

You will find the best way to deal with a couch potato like Henry is the way you deal with a hitchhiker: set firm, explicit expectations—then stick to your guns. Although couch potatoes are not as manipulative as hitchhikers, they will definitely test your limits. If your limits are weak, you then share the blame if you have Henry's work to do as well as your own.

But I've Never Liked Telling People What to Do!

If you are a nice person who has always avoided confrontation, working with a couch potato or a hitchhiker can help you grow as a person and learn the important character trait of firmness. Just be patient with yourself as you learn. The first few times you try to be firm, you may find yourself thinking—'but now he/she won't like me—it's not worth the pain!' But many people just like you have had exactly the same troubled reaction the first few (or even many) times they tried to be firm. Just keep trying—*and stick to your guns!* Someday it will seem more natural and you won't feel so guilty about having reasonable expectations for others. In the meantime, you will find you have more time to spend with your family, friends, or schoolwork, because you aren't doing someone else's job along with your own.

Common Characteristics that Allow a Hitchhiker to Take Advantage

- Unwillingness to allow a slacker to fail and subsequently learn from their own mistakes.
- Devotion to the ideal of 'the good of the team'—without common-sense realization of how this can allow others to take advantage of you. Sometimes you show (and are secretly proud of) irrational loyalty to others.
- You like to make others happy even at your own expense.
- You always feel you have to do better—your best is never enough.
- Your willingness to interpret the slightest contribution by a slacker as 'progress.'
- You are willing to make personal sacrifices so as to not abandon a hitchhiker—without realizing you are devaluing yourself in this process.
- Long-suffering martyrdom—nobody but you could stand this.
- The ability to cooperate but not delegate.
- Excessive conscientiousness.
- The tendency to feel responsible for others at the expense of being responsible for yourself.

A related circumstance: you're doing all the work

As soon as you become aware everyone is leaving the work to you—or doing such poor work that you are left doing it all, you need to take action. Many professors allow you the leeway to request a move to another team. (You cannot move to another group on

your own.) Your professor will probably ask some questions before taking the appropriate action.

Later on—out on the job and in your personal life

You will meet couch potatoes and hitchhikers throughout the course of your professional career. Couch potatoes are relatively benign, can often be firmly guided to do reasonably good work, and can even become your friends. However, hitchhikers are completely different people—ones who can work their way into your confidence and then destroy it. (Hitchhikers may infrequently try to befriend you and cooperate once you've gained their respect because they can't manipulate you. Just because they've changed their behavior towards you, however, doesn't mean they won't continue to do the same thing to others.) Occasionally, a colleague, subordinate, supervisor, friend, or acquaintance could be a hitchhiker. If this is the case, and your personal or professional life is being affected, it will help if you keep in mind the techniques suggested above.