# ME 401 Refrigeration and Cryogenics
# Fall 2024

**Instructor: Prof. Ke Tang**
Office: 2144 Mech Engr Lab (MEL)
E-mail: ketang@illinois.edu
Office Hours: 10:00 am – noon, F, 2144 MEL

**Lectures:** 9:00 – 9:50 am, MWF, 410C1 Engineering Hall

**Course Website:** via Canvas https://canvas.illinois.edu/

**Reference Books:**
(1) Refrigeration Systems and Applications, Ibrahim Dincer, 3rd edition, Wiley
(2) Cryogenic Engineering, Thomas M. Flynn, 2nd edition, Marcel Dekker
(3) Cryogenic Systems, Randall F. Barron, 2nd edition, Oxford University Press
(4) Fundamentals of Engineering Thermodynamics, Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, 9th edition, Wiley
(5) Fundamentals of Heat and Mass Transfer, Theodore L. Bergman, Adrienne S. Lavine, 8th edition, Wiley

**Course Description:**
Refrigeration and Cryogenics are widely involved in engineering applications and scientific research and are closely related to the issues of energy and climate change. This course focuses on the principles of refrigeration and corresponding equipment, as well as special topics of cryogenic systems and engineering, for various applications. Thermodynamics and heat transfer will be applied to analyze the thermal processes. The pedagogies of student-centered learning, learning community, active learning, and research-based learning will be used to help students build their knowledge and skills with a pleasant and engaging learning experience.
Prerequisite: ME 200 and ME 320

**Topics:**
1) Introduction to Refrigeration and Cryogenics
    - Concepts: refrigeration and cryogenics
    - Production of the decrease in temperature
2) Python for Thermal Analysis
3) Principles and Equipment of Refrigeration
    - Vapor-compression refrigeration
        - Typical vapor-compression refrigeration cycles
        - Refrigerants
        - Typical equipment of vapor-compression refrigeration systems
    - Absorption refrigeration
    - Ejector and Refrigeration

- Evaporative cooling systems
- Applications of refrigeration

4) Cryogenic systems and engineering
   - History of cryogenics
   - Cryogenic fluids
   - Cryogenic refrigerator and liquefier
     - Linde-Hampson (Joule-Thomson) systems and modifications
     - Claude systems and modifications
     - Regenerative cryocoolers
   - Thermal insulation
   - Cryogenic engineering materials
   - Air liquefaction and separation
   - Cryobiology and cryopreservation
   - Safety of cryogenic systems

**Learning Objectives:**

At the end of this course, students will be able to:

1) identify and explain the concept of refrigeration and cryogenics;
2) identify, explain, and analyze the typical vapor-compression refrigeration cycles and corresponding equipment;
3) identify and explain the principle of absorption refrigeration, refrigeration systems with ejectors, and evaporative cooling systems;
4) identify, explain, and analyze the properties of typical cryogenic fluids;
5) identify, explain, and analyze the typical cryogenic refrigeration and liquefaction cycles;
6) identify, explain, and analyze the thermal insulations for cryogenic applications;
7) identify, explain, and analyze the properties of cryogenic engineering materials;
8) identify and explain the typical cryogenic applications, e.g. air liquefaction and separation, cryobiology and cryopreservation, etc.;
9) identify and explain the typical safety issues of cryogenic systems;
10) Apply Python for thermal analysis of refrigeration and cryogenic systems.

**Course Grading:**

| **3 Credit Hours** | | **4 Credit Hours** | |
|---|---|---|---|
| Classwork | 5% | Classwork | 5% |
| Homework and Mini-Project | 60% | Homework and Mini-Project | 45% |
| Midterm Exam | 35% | Midterm Exam | 25% |
| | | Special Topic | 25% |

The final letter grade will be assigned using the following numerical cutoffs:

| | | |
|---|---|---|
| 97 – 100 A+ | 93 – 97 A | 90 – 93 A- |
| 87 – 90 B+ | 83 – 87 B | 80 – 83 B- |
| 77 – 80 C+ | 73 – 77 C | 70 – 73 C- |
| 67 – 70 D+ | 63 – 67 D | 60 – 63 D- |
| 0 – 60 F | | |

The classwork will include regular in-class assignments and also in-class discussions. The classwork will be graded on completion. For the students in the asynchronous online section, classwork must be submitted via the Canvas course website for both the regular in-class assignments and the in-class discussions (present your idea about the topics discussed in class). The classwork submission must be on time and no late submission will be accepted. For in-person students, “on time” means at the end of the class. You can email me ahead of time to request a leave of excused absence and if your excused absence is approved, the corresponding classwork is allowed to be submitted the following day without penalty. For online students, please refer to the classwork assignment posted on the course website via Canvas.

Homework must be computer-generated and submitted to our course website in an electronic format as a single PDF file. Homework must be submitted on time. An extension of two days can be granted automatically, but it will be accompanied by a 20% reduction in your score. No homework will be accepted after an extension. If you need an extension of more than 2 days, you must contact the instructor to ask for an extra extension by email in advance. It will be considered on a case-by-case basis. Please see more details in the Instructions and Guidelines of each homework assignment.

All the mini-projects are team projects. The teams will be assigned by the instructor based on the criterion that students can collaborate with as many different team members as possible. The work of the mini-project must be computer-generated. Each team must have one student submit the work to our course website in an electronic format as a single PDF file. The mini-project work must be submitted on time. An extension of two days can be granted automatically, but it will be accompanied by a 20% reduction in your score. No submission will be accepted after an extension. If you need an extension of more than 2 days, you must contact the instructor to ask for an extra extension by email in advance. It will be considered on a case-by-case basis. Each team member must fill out and submit the Project Individual Effort Evaluation Form individually for peer evaluation. An extension of two days can be granted for the submission of the Project Individual Effort Evaluation Form, but it will be accompanied by a 5% reduction in the score of the individual team members involved. Missing the submission of the Project Individual Effort Evaluation Form will lead to a 10% reduction in the score of the individual team members involved. Individual grades in the team project may differ up to 30% based on the peer evaluation by team members. Please see more details in the Instructions and Guidelines of each project.

The midterm exam will be a closed-book exam. The tentative schedule for the exam can be found in the teaching calendar.

The students for 4 credit hours must complete the study of a special topic. The students must sign up for one special topic from the topic bank provided by the instructor. After the study of the topic, the student must prepare a PowerPoint presentation to share the learning of this topic. The presentation will be presented in class by the student and the slides will be posted on the course website. The students working on the special topic

must meet with the instructor to discuss the contents of the presentation. The presentations must be submitted on time as per the schedule shown in the spreadsheet to sign up for the topics. No late submission will be accepted. Please see more details in the special-topic assignment.

The excused absence from class and the late submission beyond a 2-day extension can be considered only if you ask for a leave or an additional extension in advance. It is students' responsibility to make sure of the successful submission of their work. After the submission of your work on the Canvas course website, please immediately check if your work has been submitted successfully. If not, please redo the submission. If the resubmission online fails also, you must email me your work for submission, as well as the evidence of the work completion on time, by the following day of the due date. The instructor will decide whether the work can be accepted or not.

**Do not duplicate anyone's work. Any duplication identified during the grading process will result in sanctions according to the Academic Integrity Policy in the Student Code.**

**ADDITIONAL INFORMATION FOR THE UNIVERSITY OF ILLINOIS AND THE GRAINGER COLLEGE OF ENGINEERING**

**Academic Integrity**

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in 1-404 of the Student Code (https://studentcode.illinois.edu/article1/part4/1-404/). Every student is expected to review and abide by the Academic Integrity Policy as defined in the Student Code: https://studentcode.illinois.edu/article1/part4/1-401/. As a student, it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found at https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/. Ignorance of these policies is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

**Anti-Racism and Inclusivity Statement**

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to Campus Belonging Resources (https://diversity.illinois.edu/diversity-campus-culture/belonging-resources/). Based on your report, Members of the Office of the Vice Chancellor for Diversity, Equity & Inclusion staff will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

**Community of Care**

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or http://odos.illinois.edu/community-of- care/referral/). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at McKinley Health Center (https://mckinley.illinois.edu/). Or the Counseling Center (https://counselingcenter.illinois.edu/). For urgent matters during business hours, no appointment is needed to contact the Counseling Center. For mental health emergencies, you can call 911.

**Disruptive Behavior**

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution (https://conflictresolution.illinois.edu; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

**Emergency Response Recommendations**

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/.

**Family Educational Rights and Privacy Act (FERPA)**

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

**Mental Health**

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700
- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911

*This statement is approved by the University of Illinois Counseling Center

**Religious Observances**

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

**Sexual Misconduct Reporting Obligation**

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: https://wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: https://wecare.illinois.edu/.

**Students with Disabilities**

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the as soon as possible. To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail disability@illinois.edu. http://www.disability.illinois.edu/.