TO: The Faculty of the College of Engineering

FROM: The Faculty of the Lyles School of Civil Engineering

RE: New Undergraduate Course CE 21100 Thermal and Energy Sciences for Civil Engineers

The faculty of the Lyles School of Civil Engineering have approved the following new undergraduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Course no. **CE 21100 Thermal & Energy Sciences for Civil Engineers**
Terms offered 1 and 2. Lecture 3, Cr. 3.
Prerequisites:
(Undergraduate level CHM 11500 Minimum Grade of C- or Undergraduate level CHM 12300 Minimum Grade of C- or (Undergraduate level CHM 11100 Minimum Grade of C- and Undergraduate level CHM 11200 Minimum Grade of C-) **and** (Undergraduate level MA 26100 Minimum Grade of C- [may be taken concurrently] or Undergraduate level MA 26300 Minimum Grade of C- [may be taken concurrently] or Undergraduate level MA 18200 Minimum Grade of C- [may be taken concurrently] or Undergraduate level MA 27100 Minimum Grade of C- [may be taken concurrently]).

Description: This course includes applications of thermal science and energy fundamentals to civil engineering topics. Emphasis is placed on fundamental concepts of properties of materials, work, heat, internal energy, entropy, equilibrium, and relations derived from the first and second laws of thermodynamics. Example applications include: power plants; fluid flow in ducts/pipes; thermal properties of building/construction materials and processes; geothermal systems; heating, ventilation, and air conditioning (HVAC) processes; energy balances in buildings; refrigeration; hydroelectric power; contaminant transport in air, water, and soil; climate change; the urban heat island effect; and energy use in the transportation sector.

Learning outcomes: Upon completion of this course, students will be able to:
1. Explain the principles of mass and energy conservation and their use in civil engineering applications.
2. Evaluate thermodynamic systems and several forms of work, energy, and heat transfer.
3. Apply conservation of mass and energy for closed systems and control volume processes.
4. Explain the second law of thermodynamics, entropy changes, and device efficiencies.

Reason: This course has been offered as CE29900 Thermal/Energy Sciences for Civil Engineers three times: Fall 2018, Spring 2019, and Fall 2019. The enrollments were 31, 47, and 92 students, respectively. As part of its curriculum review, the Civil Engineering faculty have determined that this course will best serve the needs of CE students.

Rao S. Govindaraju
Bowen Engineering Head and Christopher B. and Susan S. Burke Professor
Lyles School of Civil Engineering

Schedule of topics covered in CE29900:

Lecture	Topics Covered	Reading
1	Course introduction.	1.1-1.2
2	Basic thermodynamics terminology.	1.3-1.5
3	Processes, properties, and units.	1.6-1.9, 2.1
4	Mechanical concepts of energy.	2.2-2.4
5	Additional forms of work and energy.	2.5-2.7
6	Heat transfer and conservation of energy for closed systems.	-
7	Conservation of energy for closed systems example problems.	3.1-3.3
8	Conservation of energy for closed systems example problems, thermodynamic cycles.	3.3-3.5
9	Evaluating thermodynamic properties.	-
10	Evaluating thermodynamic properties.	-
11	Evaluating thermodynamic properties.	3.6-3.11
12	Specific heats.	3.12-3.15
13	Real and ideal gases.	-
14	Ideal gas law.	-
15	Ideal gas example problems.	4.1-4.3
16	Conservation of mass for control volumes.	-
17	Practice problems for Mid-Term Exam 1.	-
-	No lecture: optional review period for Mid-Term Exam 1.	-
18	Conservation of mass for control volumes.	4.4-4.7
19	Conservation of energy for control volumes.	4.8-4.10
20	Analyzing control volumes at steady state.	4.11-4.12
21	Analyzing control volumes at steady state.	-
22	Transient control volumes and system integration.	-
23	Control volume example problems.	-
24	Control volume example problems.	12.1-12.3
25	Ideal gas mixtures.	12.4-12.5
26	Mixture processes and psychrometrics.	12.6-12.7
27	Psychrometric parameters.	-
28	Psychrometric chart.	12.8
29	Psychrometric chart.	12.9
30	Psychrometric processes in HVAC systems.	-
31	Psychrometric processes in HVAC systems.	-
32	HVAC system example problems.	-
33	Practice problems for Mid-Term Exam 2.	
-	No lecture: optional review period for Mid-Term Exam 2.	
34	The 2nd law of thermodynamics.	5.1-5.10
35	The 2nd law of thermodynamics.	5.10-5.11
36	Entropy.	6.1-6.5
37	The 2nd law of thermodynamics for closed systems and control volumes.	6.7-6.10
38	Steady-state entropy balance.	-
39	Entropy balance example problems.	-
40	Entropy balance example problems.	-
41	Isentropic processes and isentropic efficiencies.	6.11-6.12
42	Practice problems for Final Exam.	-

CE 29900: Thermal & Energy Sciences for Civil Engineers
Fall 2019, MWF: 14:30 – 15:20, WALC 3087

Instructor: Dr. Brandon E. Boor
Office: HAMP G241
E-mail: bboor@purdue.edu
Office Hours: MWF: 15:20 – 16:30, or by appointment.

Lyles Teaching Assistant: Jie Ma
Office: HAMP 1119
E-mail: ma319@purdue.edu
Office Hours: T & TH: 10:00 – 12:00, or by appointment.

Teaching Assistant: Motasem (Mo) Qadan
Office: HAMP 1119
E-mail: mqadan@purdue.edu
Office Hours: T & TH: 13:30 – 15:30, or by appointment.

Prerequisites: N/A

Textbook (Required): Moran, M.J., Shapiro, H.N., Boettner, D.D., and Bailey, M.B. (2018). *Fundamentals of Engineering Thermodynamics, Enhanced eText, 9th Edition.* John Wiley & Sons, Inc, ISBN-13:978-1-119-39138-8. Available as eText via *VitalSource Bookshelf* app or through *WileyPLUS*. The hard copy of the 9th edition is also acceptable.

Course Materials: Purdue University Learning Management System

Course Objectives
The objectives of this course are: (1) to introduce fundamental concepts of properties of materials, work, heat, internal energy, entropy, equilibrium, and relations derived from the first and second laws of thermodynamics and (2) to learn how to apply these principles towards civil engineering applications.

The course will include applications of thermal science and energy fundamentals to civil engineering topics. These will be distributed throughout the semester. Examples include: power plants; fluid flow in ducts/pipes; thermal properties of building/construction materials and processes; geothermal systems; heating, ventilation, and air conditioning (HVAC) processes; energy balances in buildings; refrigeration; hydroelectric power; contaminant transport in air, water, and soil; climate change; the urban heat island effect; and energy use in the transportation sector.

Learning Outcomes
Upon completion of this course, students will be able to:
1. Explain the principles of mass and energy conservation and their use in civil engineering applications.
2. Evaluate thermodynamic systems and several forms of work, energy, and heat transfer.
3. Apply conservation of mass and energy for closed systems and control volume processes.
4. Explain the second law of thermodynamics, entropy changes, and device efficiencies.

The learning process includes:

1. Reading: The textbook is a comprehensive source of information on fundamental thermal/energy science topics. Selected readings on contemporary energy issues in civil engineering will engage you with industry applications.
2. Lectures: supplement fundamental concepts from the readings. In-classroom example problems will emphasize applications of thermal/energy science concepts in civil engineering.
3. Homework Assignments: designed to reinforce the concepts presented during lectures. Students shall become familiar with computations for evaluating thermodynamic systems and retrieving thermodynamic property data.
4. Quizzes and Exams: intended to evaluate comprehension of topics covered in homework assignments.

Grading and Assessment

The overall course grade will be weighted as follows:
Mid-Term Exam 1: 20% (October 01, 2019, 20:00 – 22:00, LYNN 1136)
Mid-Term Exam 2: 20% (November 11, 2019, 20:00 – 22:00, LYNN 1136)
Final Exam: 20%
Quizzes: 20%
Homework Assignments/Readings: 15%
Attendance: 5%

The plus/minus grading system will be used (e.g. 96.7% and up = A+; 93.3% to 96.7% = A; 90.0% to 93.3% = A-; 86.7% to 90.0% = B+; 83.3% to 86.7% = B; 80.0% to 83.3% = B-). Modifications to this breakdown will be made at the instructor's discretion.

Mid-Term and Final Exams

There will be two mid-term exams and a final exam. No make-ups will be allowed unless arrangements have been made at least one week prior to the scheduled time. Make-up exams will be given only in the event of a verified emergency or doctor-verified sickness. Crib sheets will not be allowed on exams, but appropriate equation sheets will be supplied. This same policy will apply to the in-class quizzes. The final exam date, time, and location will be announced. On the exam date, the formal lecture period will be cancelled; however, an optional review period will be held with the instructor and teaching assistants.

Homework Assignments

Homework will be assigned approximately every week. Assignments should be done neatly on engineering quadrille paper and submitted to Blackboard as a PDF. All calculations must be shown to get full credit. Every number representing a physical quantity must have units with it. Final solutions should be clearly summarized and marked with a clear box around the answer. Assignments are to be turned in prior to the beginning of the lecture on the date due. Late assignments will not be accepted unless a specific arrangement has been made with the instructor at least a day prior to the due date. Put your name on everything you hand in. Cheating and plagiarism on the homework is absolutely not permitted. It is an act of academic dishonesty at Purdue University and a violation of the Purdue Honors Pledge.

Quizzes
Quizzes will be given in class on a regular basis. The quizzes will closely mirror homework assignments and are intended to help students and the instructor identify topics that require further clarification. Quizzes will be announced at least one class period in advance.

Attendance
Regular attendance and participation are essential and expected. If you are unable to attend a lecture due to illness, personal or family emergency, university-sponsored activity, or observance of a holiday, please contact the instructor via e-mail in a timely manner. The use of cell phones during lecture is prohibited. Tablets with a stylus (e.g. iPad Pro or Microsoft Surface) are permitted for notetaking. Fall 2019 semester holidays (no lecture): Labor Day (September 02), October Break (October 07-08), and Thanksgiving Break (November 27-29).

Lecture Notes
Basic lecture PDFs will be prepared and uploaded to Blackboard prior to each class together with blank space for hand-written notes given in real-time by the instructor using an iPad Pro. You are responsible for printing and bringing the lecture PDFs to class and documenting all hand-written notes by the instructor during lecture as this material will not be uploaded to Blackboard. It is recommended that you print the notes (1 slide per page) ahead of class or use a tablet with a stylus for note-taking (PDF Expert or similar is recommended).

E-mail Communication
All e-mails directed to the instructor and teaching assistants must be written in a professional manner.

Academic Integrity
Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.

Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty" [Part 5, Section III-B-2-a, University Regulations]. Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest" [University Senate Document 72-18, December 15, 1972].

Purdue Honors Pledge
As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do.
Accountable together - we are Purdue.

Grief Absence Policy for Students
Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missing assignments or assessments in the event of the death of a member of the student's family.

Counseling and Psychological Services (CAPS)
Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Students with Disabilities
Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let the instructor know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Emergencies
In the event of a major campus emergency, course requirements, deadlines, and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted on Blackboard or can be obtained by contacting the instructor via e-mail.

Diversity and Inclusion
Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit http://www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.