CE 311: Architectural Engineering

Fall 2017, T/TH: 13:30 to 14:45 – ARMS 1103

Instructor: Dr. Brandon E. Boor
Office: HAMP G241
E-mail: bboor@purdue.edu
Web: Piazza Course Homepage: https://piazza.com/purdue/fall2017/ce311/home
Office Hours: T: 14:45 to 16:00, TH: 14:45 to 15:30, F: 12:30 to 13:30 or by appointment.

Prerequisites: ME 200: Thermodynamics or permission from the instructor.
Concurrent Prerequisites: CE 340: Hydraulics or ME: 309 Fluid Mechanics or permission from the instructor.

Textbook – Required
Architectural Engineering. McGraw-Hill Create, Custom-Made Book, ISBN-1307118186.

Additional References
American Society of Heating, Refrigerating, and Air Conditioning Engineering (ASHRAE). (2017). *ASHRAE Handbook – Fundamentals*. SI Edition (selected chapters posted to Piazza).

Bergman, T.L., Lavine, A.S., Incropera, F.P., and DeWitt, D.P. (2011). *Fundamentals of Heat and Mass Transfer*, 7th Edition. Wiley.

Kuehn, T.H., Ramsey, J.W., Threlkeld, J.L. (1998). *Thermal Environmental Engineering*, 3rd Edition. Pearson.

Course Objectives
The objective of this course is to introduce the engineering fundamentals required for the design and analysis of building environmental systems, such as thermodynamics and psychrometrics, fluid mechanics, heat transfer, and mass transfer. The course also presents engineering principles and selected applications related to hygrothermal analysis of building enclosures, air conditioning processes, ventilation, and indoor air quality.

Course Outcomes
Upon completion of this course, the students will be able to:
1. Demonstrate knowledge of thermodynamics and psychrometrics; fluid mechanics; heat transfer via conduction, convection, and radiation; and mass/moisture transfer for use in building design.
2. Identify and analyze the characteristics of building environmental loads, building construction, and building operations as they define the requirements for a comfortable and healthy indoor environment.
3. Identify, formulate, and solve realistic Architectural Engineering problems related to hygrothermal analysis of building enclosures, air conditioning processes, and ventilation.
4. Demonstrate an understanding of building systems integration to achieve efficient operation.

The learning process includes:
1. Reading: The textbook is a comprehensive source of information on fundamental thermal science topics. Readings on green building technologies will engage you with industry applications.
2. Lectures: supplement fundamental concepts from the readings. In-classroom example problems will emphasize application of these concepts to the analysis of heating, ventilation, and air conditioning (HVAC) systems and building enclosures.
3. Homework: designed to reinforce the concepts presented during lectures. Students shall become familiar with analytical and computational methods for quantifying building performance.
4. Course Project: students will work as teams to design and evaluate an energy efficient Tiny House.

Grading
The overall course grade will be weighted as follows:
Homework Assignments (6): 20%
Mid-Term Exams (2): 15% each, total: 30%
Final Exam: 15%
Course Project – Tiny Houses: 30%
Readings & Discussion on Green Building Technologies: 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-).

Attendance
Regular attendance and participation are essential and expected. If you are unable to attend a lecture due to illness, personal or family emergency, or observance of a holiday, please contact the instructor via e-mail in a timely manner. The use of laptops, tablets, and cell phones during lecture is prohibited.

Homework Assignments
Homework will be assigned approximately every two weeks (six assignments in total). Assignments should be done neatly on engineering quadrille paper and stapled in the upper left-hand corner. All calculations must be shown to get full credit. Final solutions should be clearly summarized and marked with a clear box around the answer. 1-2 sentences of discussion should follow each solution. Assignments are to be turned in at 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.

Mid-Term & Final Exams
There will be two mid-term exams (see course outline): the first will cover psychrometric processes in HVAC systems and the second will cover heat transfer in buildings. 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. The final exam date, time, and location will be announced.

Course Project
You will work in teams of five students to design and evaluate an energy efficient Tiny House in a specific city in the world. Interdisciplinary teams are encouraged, e.g. Architectural, EEE, Mechanical, Structures, CEM. The project will include several deliverables to be submitted throughout the semester. Teams will complete background research on state-of-the-art building technologies to be integrated into their Tiny House; climatic factors and country-specific building codes; prepare 2D and 3D renderings of their design; integrate fundamental thermal science concepts into evaluating the energy performance of their Tiny House; and conduct energy simulations with an appropriate software (e.g. WUFI, DesignBuilder). Factors such as annual energy consumption, ventilation performance, occupant thermal and visual comfort, indoor air quality, novel and creative architectural design elements, and construction feasibility will be evaluated. A final written report will be due at the end of the semester. Each team will give an oral presentation to their classmates on the last day of class.

Readings & Discussion on Green Building Technologies
Four to five readings on green building technologies will be assigned throughout the semester. You will have one week to complete each reading and prepare a one paragraph reflection on the topic. You will then discuss the reading with group of three to four other students in class. Guided discussion questions will be handed out with each reading. The aim of these assignments are to encourage you to think about architectural engineering principles within a broader scientific and societal context and introduce you to industry applications of building technologies and systems.

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

Academic Dishonesty
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 through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.

Students with Disabilities
If you have a disability that requires special academic accommodation, please make an appointment to speak with the instructor during the first week of the semester in order to discuss any adjustments. It is the student's responsibility to notify the Disability Resource Center http://www.purdue.edu/drc of an impairment/condition that may require accommodations and/or classroom modifications.

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 Piazza or can be obtained by contacting the instructor via e-mail.

Nondiscrimination
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.

Note: This syllabus is subject to change. Current version: August 21, 2017.

Course Outline [*Updated: August 21, 2017*]

Lectures	Days	Topics Covered	Reading	Homework
1	Aug. 22	Course introduction	--	HW0
2	Aug. 24	Thermal sciences review	--	--
3, 4	Aug. 29, 31	Psychrometrics: gas-vapor mixtures	*ArchE*: Ch. 14(1), Gas-Vapor Mixtures & Air Conditioning *ASHRAE*: Ch. 1, Psychrometrics	HW1
5, 6	Sept. 5, 7	The psychrometric chart: what is it and how to use it?		--
7, 8, 9, 10	Sept. 12, 14, 19, 21	Analyzing heating, cooling, humidification, and dehumidification processes in HVAC systems; components of Air Handling Units (AHUs)		HW 2
11	Sept. 26	Fluid mechanics review: fluid viscosity, shear stress, internal vs. external flows, Reynolds number, laminar vs. turbulent flows	*ArchE*: Ch. 14(2), Internal Flow	--
Sept. 28		**Mid-Term Exam 1**		
12, 13, 14	Oct. 3, 5, 12	Conduction heat transfer across building envelopes: Fourier's Law, thermal conductivities and diffusivities of building materials, resistor network method for solving conduction problems	*ArchE*: Ch. 16, Mechanisms of Heat Transfer *ArchE*: Ch. 17, Steady Heat Conduction	HW3
Oct. 9-10		October Break – No Class		
15, 16, 17, 18, 19	Oct. 17, 19, 24, 26, 31	Convection heat transfer in buildings: Newton's Law of Cooling, Nusselt number correlations, heat transfer coefficient, the velocity and thermal boundary layers above surfaces, natural convection, stack effect, Grashof and Rayleigh number correlations	*ArchE*: Ch. 19, Forced Convection *ArchE*: Ch. 20, Natural Convection	HW4
20, 21	Nov. 2, 7	Radiation heat transfer in buildings: blackbody radiation, radiation heat transfer coefficient, radiative properties of materials, view factors	*ArchE*: Ch. 21, Radiation Heat Transfer	HW5
22	Nov. 9	Mass transfer: diffusion and convection, Fick's Law, mass transfer coefficient, Sherwood number correlations, heat-mass transfer analogy	*ArchE*: Ch. 14(3), Mass Transfer	--
Nov. 14		**Mid-Term Exam 2**		
23, 24	Nov. 16, 21	Hygrothermal analysis: combined heat and mass transport in wall assemblies, moisture control	*ASHRAE*: Ch. 25, Heat, Air & Moisture Control	HW6
Nov. 22-25		Thanksgiving Vacation		
25, 26	Nov. 28, 30	Healthy buildings: indoor air quality, exposure to indoor air pollutants, mechanical/natural ventilation strategies	--	--
27	Dec. 5	New sensor technologies for occupant thermal and visual comfort	--	--
Dec. 7		**Course Project Presentations & Final Reports Due**		