

# ARC 523 Course Syllabus

## ARC 523 – Building Energy Modeling & Simulation

### Section 001

FALL/SPRING 20xx

3 Credit Hours

### Course Description

The purpose of this course is to provide fundamental knowledge of building sciences for the development of high-performance buildings utilizing energy modeling and simulation technology as an energy performance analysis. Occupant comfort is also assessed using the simulation technology.

Students calculate the energy consumption of heating, cooling, lighting, and other equipment by hand to understand the energy & thermal behavior of buildings, then compare and analyze these calculations with others calculated using energy modeling and simulation programs.

Architecture and engineering students work together in this course, exchanging knowledge and collaborating to develop high-performance buildings, resulting in energy savings and environmental protections through greenhouse gas emission reductions.

This course is open to all senior and graduate students, both in and outside North Carolina State University.

### Learning Outcomes

By the end of the course, the students will be able to:

- Discuss building sciences in terms of energy systems such as heating, cooling, lighting, and other mechanical equipment
- Utilize energy modeling and simulation technologies to analyze the energy and thermal performance of buildings
- Develop energy simulation models for design projects
- Discuss building Heating, Ventilating, and Air-Conditioning (HVAC) systems
- Analyze interactions between the HVAC and other energy systems

### Course Structure

- Lecture and/or Presentations
- Seminars
- Field trip to visit a building: HVAC systems, mechanical systems, and electrical systems

### Course Policies

Personal laptop computers: Students are required to bring their laptop computers to the class throughout the whole semester.

Computer operating system and software programs: Students are required to have the "Windows" operating system installed in their laptop computer, as well as the MS Office suite, including Word, Excel, and Power Point programs.

Cell phones: Students are not allowed to use their cell phones during class. This includes conversations, texting, internet access, and email.

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## Instructors

**Soolyeon Cho** - Instructor

**Email:** [soolyeon\\_cho@ncsu.edu](mailto:soolyeon_cho@ncsu.edu)

**Web Page:** <http://design.ncsu.edu/BETlab>

**Phone:** 919-513-8061

**Office Location:** Kamphoefner Hall 304

**Office Hours:** Tuesdays 10:00AM-12:00PM

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## Course Meetings

### Lecture

**Days:** Thursday

**Time:** 1:30pm - 4:15pm

**Campus:** Main

**Location:** Brooks Hall 203B

*This meeting is required.*

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## Course Materials

### Textbooks

No textbook is required. Instead, class notes developed by the instructor will be provided and available in the class folder for the students.

### Expenses

Most class resources are available through the university library system and online. There are no required expenses expected for this course.

### Materials

Up-to-date reading materials, such as research papers, journal papers, and news articles, will be provided by the instructor throughout the semester.

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## Requisites and Restrictions

### Prerequisites

None.

### Co-requisites

None.

## Restrictions

Restricted to Senior and Graduate students in and outside university.

## General Education Program (GEP) Information

### GEP Category

This course does not fulfill a General Education Program category.

### GEP Co-requisites

This course does not fulfill a General Education Program co-requisite.

## Transportation

Students will be required to provide their own transportation for this class and a scheduled field trip. Non-scheduled class time for field trips or out-of-class activities is NOT required for this class.

## Safety & Risk Assumptions

None.

## Grading

### Grade Components

| Component                  | Weight (%) | Details  |
|----------------------------|------------|--|
| <b>Class Participation</b> | <b>20</b>  | <ul style="list-style-type: none"><li>▪ Come to the class in time</li><li>▪ Develop and answer questions</li><li>▪ Be involved in class discussions</li></ul>                  |
| <b>Homework</b>            | <b>20</b>  | <ul style="list-style-type: none"><li>▪ Submit weekly assignments on time</li><li>▪ Answer the questions in the assignment sheet</li><li>▪ Summarize lessons learned</li></ul> |
| <b>Exam-1</b>              | <b>15</b>  | <ul style="list-style-type: none"><li>▪ Heating and cooling energy calculation</li><li>▪ Loads simulation modeling</li></ul>   |
| <b>Exam-2</b>              | <b>15</b>  | <ul style="list-style-type: none"><li>▪ Energy supply systems</li><li>▪ Systems simulation modeling</li></ul>  |
| <b>Exam-3</b>              | <b>15</b>  | <ul style="list-style-type: none"><li>▪ Whole building simulation modeling</li><li>▪ Energy performance analysis</li></ul>   |
| <b>Final Presentation</b>  | <b>15</b>  | <ul style="list-style-type: none"><li>▪ Final project presentation about simulation modeling and energy performance analysis</li></ul>   |

## Letter Grades

**This Course uses Standard NCSU Letter Grading:**

|    |   |           |   |     |
|----|---|-----------|---|-----|
| 97 | ≤ | <b>A+</b> | ≤ | 100 |
| 93 | ≤ | <b>A</b>  | < | 97  |
| 90 | ≤ | <b>A-</b> | < | 93  |
| 87 | ≤ | <b>B+</b> | < | 90  |
| 83 | ≤ | <b>B</b>  | < | 87  |
| 80 | ≤ | <b>B-</b> | < | 83  |
| 77 | ≤ | <b>C+</b> | < | 80  |
| 73 | ≤ | <b>C</b>  | < | 77  |
| 70 | ≤ | <b>C-</b> | < | 73  |
| 67 | ≤ | <b>D+</b> | < | 70  |
| 63 | ≤ | <b>D</b>  | < | 67  |
| 60 | ≤ | <b>D-</b> | < | 63  |
| 0  | ≤ | <b>F</b>  | < | 60  |

## Requirements for Credit-Only (S/U) Grading

N/A

## Requirements for Auditors (AU)

Information about and requirements for auditing a course can be found at <http://policies.ncsu.edu/regulation/reg-02-20-04>.

## Policies on Incomplete Grades

If an extended deadline is not authorized by the Graduate School, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) by the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at <http://policies.ncsu.edu/regulation/reg-02-50-03>. Additional information relative to incomplete grades for graduate students can be found in the Graduate Administrative Handbook in Section 3.18.F at [http://www.fis.ncsu.edu/grad\\_publicns/handbook/](http://www.fis.ncsu.edu/grad_publicns/handbook/)

## Late Assignments

Students will be given detailed assignment descriptions in class. Assignments will be due on the dates listed in the handouts. Assignments must be posted or turned in according to the stated requirements for the assignment. Failure to turn in your work on time will result in a grade of zero.

## **Attendance Policy**

For complete attendance and excused absence policies, please see <http://policies.ncsu.edu/regulation/reg-02-20-03>

## **Attendance Policy**

Full attendance of all classes is a course requirement. It is each student's responsibility to inform the instructor about any circumstance that prevents him/her from attending class. Students shall receive excused absences for a reasonable number of anticipated absences as well as for emergencies as specified in the "university attendance regulation." See <http://policies.ncsu.edu/regulation/reg-02-20-03>. Unexcused absences will result in a reduction of grade for the class.

## **Absences Policy**

Absences are excused only if they are caused by circumstances outside of the student's control. Students must notify the instructor in advance of the class meeting if an excused absence is applicable. Details are as follows:

### **Unexcused Absence:**

- One week (3 hours) of unexcused absence will result in the student's assessment for the semester being lowered one letter grade.
- Two weeks (6 hours) of unexcused absences will result in the student's assessment for the semester being lowered two letter grades.
- More than two weeks (7 hours or more) of unexcused absences will result in a failing grade for the class.
- Three times of being late (10 minutes x 3) to the class will be counted as a one hour absence.

### **Excused Absence:**

- Although the student may qualify for multiple excused absences, having more than two weeks (7 hours or more) of absences would result in the withdrawal of the student from the class. This situation is at the discretion of the instructor and will be determined on a case by case basis.

## **Makeup Work Policy**

Students with excused absence must make up work within one week of returning to class. Students are responsible for collecting all necessary assignments, lecture notes, and readings.

## **Additional Excuses Policy**

None.

## **Academic Integrity**

### **Academic Integrity**

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at <http://policies.ncsu.edu/policy/pol-11-35-01>

## **Academic Honesty**

See <http://policies.ncsu.edu/policy/pol-11-35-01> for a detailed explanation of academic honesty.

## **Honor Pledge**

Your signature on any test or assignment indicates "I have neither given nor received unauthorized aid on this test or assignment."

## **Electronically-Hosted Course Components**

There are no electronically-hosted components for this course.

## **Accommodations for Disabilities**

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, student must register with the Disability Services Office (<http://www.ncsu.edu/dso>), 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation at <http://policies.ncsu.edu/regulation/reg-02-20-01>.

## **Non-Discrimination Policy**

NC State University provides equality of opportunity in education and employment for all students and employees. Accordingly, NC State affirms its commitment to maintain a work environment for all employees and an academic environment for all students that is free from all forms of discrimination. Discrimination based on race, color, religion, creed, sex, national origin, age, disability, veteran status, or sexual orientation is a violation of state and federal law and/or NC State University policy and will not be tolerated. Harassment of any person (either in the form of quid pro quo or creation of a hostile environment) based on race, color, religion, creed, sex, national origin, age, disability, veteran status, or sexual orientation also is a violation of state and federal law and/or NC State University policy and will not be tolerated. Retaliation against any person who complains about discrimination is also prohibited. NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at <http://policies.ncsu.edu/policy/pol-04-25-05> or [http://www.ncsu.edu/equal\\_op/](http://www.ncsu.edu/equal_op/). Any person who feels that he or she has been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Equal Opportunity (OEO) at 919-515-3148.

## Course Schedule

**NOTE:** The course schedule is subject to change.

Following is the anticipated schedule for the semester.

### Week-1

**Week 1: Introduction**

Overview: Energy consumption of buildings in the US; Energy modeling & simulation; Energy systems in buildings

### Week-2

**Week 2: Energy Calculation and Simulation**

Software programs for energy simulation modeling (EnergyPlus, OpenStudio & SketchUp); Geometry modeling

### Week-3

**Week 3: Energy Use in Buildings: Peak Heating Loads Calculation**

Peak heating loads calculation; Loads simulation modeling-1

### Week-4

**Week 4: Energy Use in Buildings: Annual Heating Energy Calculation**

Annual heating energy calculation; Loads simulation modeling-2

### Week-5

**Week 5: Energy Use in Buildings: Peak Cooling Loads Calculation**

Peak cooling loads calculation; Loads simulation modeling-3

### Week-6

**Week 6: Energy Use in Buildings: Annual Cooling Energy Calculation**

Annual cooling energy calculation; Loads simulation modeling-4

### Week-7

**Week 7: Exam-I & Student Project Presentation**

Heating and cooling energy calculations & Simulation modeling

### Week-8

**Week 8: Tour: Facility Visit**

Visit one of the NC State campus buildings; Guided tour by a mechanical engineer; HVAC systems, mechanical systems, and electrical systems

## **Week-9**

### **Week 9: Energy Supply in Buildings: Heating, Ventilating, and Air-Conditioning (HVAC) Systems**

Heating supply systems; Cooling supply systems; Ventilation systems; Air handling systems; Systems simulation-1

## **Week-10**

### **Week 10: Energy Supply in Buildings: Psychrometrics Analysis**

Building energy use characteristics; Psychrometric analysis for thermal energy analysis; Systems simulation-2

## **Week-11**

### **Week 11: Energy Supply in Buildings: Weather Analysis**

Weather data analysis: Weather normalization; Energy consumption prediction; Energy performance evaluation; Systems simulation-3

## **Week-12**

### **Week 12: Exam-II & Student Project Presentation (Exam-II)**

Energy supply systems & Systems simulation modeling

## **Week-13**

### **Week 13: Energy Performance Analysis: Energy Codes, Guidelines, and Standards**

Energy Use Intensity (EUI) analysis; CBECS/RECS, ASHRAE 90.1, LEED, & IPMVP; Whole building simulation-1

## **Week-14**

### **Week 14: Energy Performance Analysis: Regression Analysis**

Regression analysis of energy consumption; Energy use models (1P-5P) and analysis; Whole building simulation-2

## **Week-15**

### **Week 15: Energy Performance Analysis: Energy Savings Analysis**

Energy savings analysis; Performance evaluation; Human comfort analysis