# NE 433/533 Course Syllabus

## NE 433/533 – Nuclear Fuel Performance

**Spring 2023**

**3 Credit Hours**

### Course Description

In this course we will study the basic role of fuel in reactor operation and understand how the fuel impacts heat generation and transport to the coolant. The course will begin with an overview of different fuels and the fabrication processes required to construct nuclear fuel. This will include various fuel types and geometries, with a focus on light water reactor fuel and cladding. Thermal transport, mechanics, and thermomechanics affecting fuel behavior will be introduced, and methods to solve the governing equations numerically and analytically will be developed. Subsequently, changes in the fuel and cladding material that degrade the performance of the fuel will be examined. Finally, the knowledge gained throughout the course will be utilized to conduct fuel performance simulations with MOOSE.

### Learning Outcomes

By the end of this course, the student should be able to:

a) Summarize the basics of fuel fabrication

b) Evaluate traditional and alternative nuclear fuel types and their application

c) Determine the rate at which heat is transported to the coolant from the fuel

d) Determine the stress state within both the fuel and the cladding

e) Describe the most important microstructural changes that take place in the fuel and cladding and how they impact fuel performance

f) Use an existing fuel performance code

### Course Structure

Two lectures per week, four exams per semester, one presentation during class hours, and a computational project.

Course schedule is subject to change with appropriate notification of students.

a. Introduction and Overview

b. Fuel types, Heat generation, Reactor systems, Fuel fabrication, Heat transport – 4 weeks

c. Mechanical behavior, Thermomechanics, Materials issues in the fuel – 4 weeks

d. Materials issues in the clad, Advanced fuels materials issues – 4 weeks

e. Overview and utilization of fuel performance codes – 2 weeks

### Instructors

**Benjamin Beeler** (bwbeeler) - *Instructor*  
**Email:** [bwbeeler@ncsu.edu](mailto:bwbeeler@ncsu.edu)   
**Phone:** 919-515-3737   
**Office Location:** Burlington Laboratory 1110C   
**Office Hours:** Wed. 10-11

### Course Meetings

#### Lecture

**Days:** TH   
**Time:** 3:00pm - 4:15pm   
**Campus:** Main   
**Location:** 331 111 Lampe Drive

### Course Materials

#### Required Textbooks

None.

#### Supplemental Materials

Light Water Reactor Materials, Vol. 1 Fundamentals, D. Olander and A. Motta

Nuclear Fuel Elements, B. Frost

Fundamentals of Radiation Materials Science, G. Was

### Requisites and Restrictions

#### Prerequisites

NE409

### Grading

#### Grade Components – NE533

| **Component** | **Weight** | **Details** |
| --- | --- | --- |
| **Exams** | **64** | Four exams, each worth 16%. |
| **Presentation** | **16** | Presentation during class summarizing an assigned paper on nuclear fuel performance. |
| **MOOSE Project** | **20** | Project conducted throughout the class utilizing a fuel performance software. |

#### Grade Components – NE433

| **Component** | **Weight** | **Details** |
| --- | --- | --- |
| **Exams** | **80** | Four exams, each worth 20%. |
| **MOOSE Project** | **20** | Project conducted throughout the class utilizing a fuel performance software. |

#### Letter Grades

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

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

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

Performance in research, seminar and independent study types of courses (6xx and 8xx) is evaluated as either "S" (Satisfactory) or "U" (Unsatisfactory), and these grades are not used in computing the grade point average. For credit only courses (S/U) the requirements necessary to obtain the grade of "S" must be clearly outlined.

#### 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 3.17.G at <http://www.ncsu.edu/grad/handbook/index.php>

#### Late Assignments

All course work must be submitted no later than the due date unless prior arrangements are made with the professor and a new due date is established. If a student submits an assignment after the due date without having made arrangements with the professor, ten points will be deducted (based on a grading scale of 100) for each day that the assignment is late, with a maximum late turn-in of 5 days past due.

### Attendance Policy

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

### 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>. Violations of academic integrity will be handled in accordance with the Student Discipline Procedures (NCSU REG 11.35.02).

#### Honor Pledge

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

### Digital Course Components

Students may be required to disclose personally identifiable information to other students in the course, via digital tools, such as email or web-postings, where relevant to the course. Examples include online discussions of class topics and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

**Digital Course Components:** The course will be hosted on Moodle, and lectures may be available via Zoom. Links for the Moodle page and/or Zoom links will be made available.

### Accommodations for Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, 2751 Cates Avenue, Campus Box 7509, 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 (NCSU REG 02.20.01) (<https://policies.ncsu.edu/regulation/reg-02-20-01/>)

### Non-Discrimination Policy

NC State provides equal opportunity and affirmative action efforts, and prohibits all forms of unlawful discrimination, harassment, and retaliation ("Prohibited Conduct") that are based upon a person's race, color, religion, sex (including pregnancy), national origin, age (40 or older), disability, gender identity, genetic information, sexual orientation, or veteran status (individually and collectively, "Protected Status"). Additional information as to each Protected Status is included in NCSU REG 04.25.02 (Discrimination, Harassment and Retaliation Complaint Procedure). 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 [https://oied.ncsu.edu/divweb/.](https://oied.ncsu.edu/divweb/) Any person who feels that he or she has been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Institutional Equity and Diversity (OIED) at 919-515-3148.